Marine Policy 62 (2015) 116–124

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Building an indigenous evidence-base for tribally-led habitat conservation policies

Lily Gadamus [a,*], Julie Raymond-Yakoubian [a], Roy Ashenfelter [a], Austin Ahmasuk [a], Vera Metcalf [b], George Noongwook [c]

[a] Kawerak Inc., PO Box 948, Nome, AK 99762, USA
[b] Eskimo Walrus Commission, Kawerak Inc., PO Box 948, Nome, AK 99762, USA
[c] Savoonga Whaling Captain Association, Native Village of Savoonga, PO Box 202, Savoonga, AK 99769, USA

ARTICLE INFO

Article history:
Received 18 May 2015
Received in revised form
8 August 2015
Accepted 5 September 2015

Keywords:
Qualitative methods
TEK
Traditional ecological knowledge
Environmental social science
Marine mammals
Climate change
Habitat conservation

ABSTRACT

Habitat conservation is a priority for many tribes, and indigenous local experts develop environmental policy goals based on their traditional knowledge of animal habitat use and habitat change. An indigenous evidence-base for ice seal and walrus habitat conservation in the Bering Strait region of Alaska was built by using qualitative methods to document the knowledge of 82 local expert seal and walrus hunters. Local experts produced detailed descriptions of seal and walrus habitat use and drivers of change in key habitat features, as well as policy goals based on indigenous evidence. These indigenous habitat policy goals are compared to U.S. government policies and differences are explored in terms of the indigenous evidence-base.

1. Introduction

Habitat destruction is widely recognized as the greatest driver of species extinctions worldwide. As such, identifying and protecting crucial habitat areas is a major strategy for biodiversity conservation (e.g., [58]). Habitat conservation is also a priority for many tribes, who depend on the traditional harvest of wild resources for food, culture, personal well-being, and family connectedness (e.g. [3,22,53]). In spite of the shared desire for healthy wildlife in healthy environments, tribes and government agencies often have conflicting policy goals, usually due to different environmental values, resource use priorities, and ways of knowing the environment (e.g. [18,21][49,52,67]). This case study provides an example of a detailed indigenous environmental evidence base and demonstrates how it generates a distinct approach to habitat conservation.

Although habitat conservation is a priority for many Western scientists and managers, it can be an extremely complicated and legally fraught process [47]. One major weakness can be overgeneralization due to a lack of fine-scale and long-term observation of species interacting with their environments [63]. The amount of information needed to comprehensively document resource use and environmental occupation across time and space is prohibitive for most species [19]. As such, habitat delineation often includes generalizations about appropriate environmental conditions based on empirical data, theory, and expert judgment [35]. Due to biotic factors such as competition [48], as well as differing combinations of environmental features, habitat use differs by place and generalizations about the same species, based on observations from different places or times, can lead to different conclusions [19]. Finally, ecological data are scale-specific, and generalizations made from data collected at one scale may not hold at others [63]. As such, indigenous communities often find that government habitat policies may be a poor fit for their local environments (e.g. [50]).

In contrast, indigenous resource users have a wealth of long-term, fine-scale, place-based knowledge that comes from generations of resource use, and that can detect processes and changes not documented in management policies or the scientific literature (e.g. [1,8,50]). This living body of knowledge is known as traditional ecological knowledge (TEK), and it combines personal experience with oral traditions, a holistic perspective, and strategies

* Corresponding author. Fax: +1 907 443 4458.
E-mail addresses: lilygadamus@gmail.com (L. Gadamus), juliery@kawerak.org (J. Raymond-Yakoubian), nr.advoc@kawerak.org (R. Ashenfelter), austin_ahmasuk@yahoo.com (A. Ahmasuk), vmetcalf@kawerak.org (V. Metcalf), gnunguk@hotmail.com (G. Noongwook).

http://dx.doi.org/10.1016/j.marpol.2015.09.008
0308-597X/

for resource conservation (e.g., [9]). While TEK has driven indigenous environmental decision-making for many generations, government resource management policies have historically preferred information produced through Western science [11,46].

Now, studies that draw productively on TEK are appearing more regularly in the published literature (e.g. [6,26]) and there is greater recognition that policy-processes should provide room for stakeholder knowledge as well as values (e.g. [68]). Additionally, while frequently not carried out properly from the perspective of tribes, in the United States, federally recognized tribes have the right to "meaningful" formal government-to-government consultation on policies that "have tribal implications" [17], and tribes are actively working towards enforcing true implementation of this relationship. While this is a marked improvement over colonialist policies that degraded local knowledge and lifestyles, integrating TEK into science and policy can still be a frustrating process for indigenous communities, who often have different values and knowledge systems than scientists and resource managers (e.g. [4,33,36,49,66]). Research projects and policy processes are frequently designed to meet non-local objectives and to promote Western paradigms (e.g. [44,57]). Additionally, TEK is often context-dependent, and, when extracted from context, can be misinterpreted and used to support policies that indigenous communities may oppose [20,44].

Collaborating on science or policy projects can be very frustrating when indigenous communities have little control over the goals, major decisions, and final products. Often, indigenous knowledge and values are judged against Western standards rather than respected on their own terms (e.g., [67]). Additionally, indigenous organizations can end up associated with decisions and products that are actually detrimental to indigenous interests [52,54]. There are several approaches that tribes and collaborators have taken to produce work that avoids these pitfalls. One approach is to argue for broader acceptance of very different approaches to knowledge, based on completely different ontologies and epistemologies, and transmitted in non-traditional formats (e.g., [37,56,67]). Another is to directly address issues of power and the role scientific research has played in colonialism (e.g. [61]). A third approach is to document TEK within more traditional scientific frameworks, but to do so on terms acceptable to tribes (e.g. [23,60]).This paper fits within the third approach. The authors recognize that while some TEK, such as that presented here, translates more easily into Western-science friendly frameworks, other, equally valid TEK does not. As part of this project, a separate paper was produced highlighting Bering Strait indigenous traditions of respect for seals and walruses, which are epistemologically distinct from Western science and management [24].

This case study addresses the following objectives:

Objective 1: Demonstrate a systematic method for generating an indigenous evidence base and show what an indigenous evidence base can look like. This case study features indigenous knowledge of habitat use and observed drivers of habitat change for four species of marine mammals in the northern Bering Sea: Pacific walruses (*Odobenus rosmarus divergens*), bearded seals (*Erignathus barbatus*), ringed seals (*Phoca hispida)*, and spotted seals (*Phoca largha)*. This TEK was systematically documented using qualitative methods.

Objective 2: Demonstrate how the indigenous evidence-base leads to policy goals that differ from government resource management: Policy goals arising from the indigenous evidence-base are compared with existing policy in the region to demonstrate how the indigenous evidence-base drove a different approach.

2. Study area

The Bering Strait hosts an extraordinary marine mammal migration. During the spring, hundreds of thousands of seals, walruses, and whales pass through the Strait heading north for the summer and in the fall they head south to overwinter in the Bering Sea and beyond [38]. Indigenous communities in the Bering Strait region have harvested marine mammals for millennia and they continue to be a major part of local diets [3]. Marine mammal hunting is an important part of Indigenous identity; the preparation, sharing, and consumption of marine mammal foods are important social activities; and the foods themselves are healthy and culturally preferred. As such, Indigenous residents have indicated that the loss of marine mammal food sources due to changes in ice or increasing development would be disastrous for local communities [22].

Sea ice drives marine mammal cycles in the Bering Strait region. Sea ice in Alaska's Arctic has undergone a dramatic decline in areal extent, thickness, and age, and summer sea ice has receded to record lows [59]. Changes in sea ice may affect ice seal and walrus populations because these species use sea ice for pupping and calving, resting, and migrating [62]. Additionally, increasing marine traffic and resource development activities, a result of receding ice, may stress marine mammal populations [2]. National concern about potential climate change-induced habitat loss has prompted Endangered Species Act (ESA) status reviews for the Pacific walrus population and all four species of ice-associated seals, commonly known as "ice seals" and ESA threatened listings for several distinct population segments and subspecies of spotted, ringed, and bearded seals.

Understanding marine mammal habitat use and response to change can help communities, governments, and conservation organizations mitigate potential harmful effects from Arctic sea ice loss and marine development. Arctic marine mammal life cycles and habitat use are incompletely documented in the scientific literature and historical baseline data is often unavailable [38,39]. Indigenous communities in the Arctic, however, have long-term, detailed observations of marine mammals [38,42].

3. Methods

Nine of twenty Bering Strait and Norton Sound region federally recognized tribes participated in this project: Nome, King Island, Diomede, Savoonga, Elim, Koyuk, Shaktoolik, Stebbins, and Saint

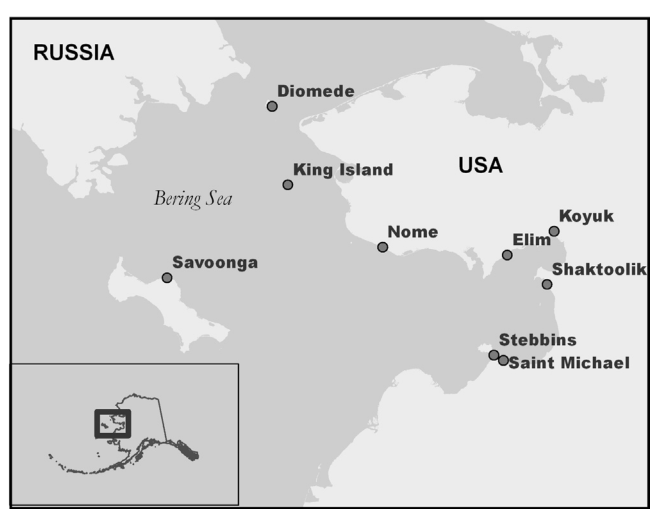

Fig. 1. Study area, showing participating communities.

Michael (Fig. 1). Interviews and focus groups were conducted with a purposive sample of 82 Indigenous hunters and elders, from the nine participating tribes, who were identified by tribal governments as local experts on ice seals and walruses [16]. These local experts had lived in their communities for most of their lives, hunted seals and/or walruses regularly, and were recognized by their tribe as highly knowledgeable.

Interview topics covered seal and walrus habitat, the effects of environmental and other changes on seals and walruses, and community concerns about threats to seal and walrus persistence. Tribal governments, community members, and project partners the Eskimo Walrus Commission and the Ice Seal Committee helped select these topics during participatory research design meetings. Interviews and focus groups were conducted in a semi-structured format, allowing participants to introduce new topics and interviewers to add follow-up questions [10]. Some interviews and focus groups in Savoonga were conducted in Saint Lawrence Island Yupik and all other interviews and focus groups were conducted in English. Focus groups and interviews were audio recorded and transcribed.

Interview and focus group transcripts were coded in Atlas.ti 6.2.28 using a mix of inductive and deductive codes [43]. Most deductive codes were derived from the participatory design process. Coded information was summarized and organized into tables and charts for habitat-related topics [43]. In order to distinguish between common, uncommon, and community-specific observations, summary statements were categorized into four classes. Class 1 statements, "Widely shared" came from many observations and expert generalizations reported across the region. Class 2 generalizations were "place-specific", and were well-accepted in the community that generated them. Class 3 statements, "Somewhat common" were reported by various participants. Class 4 statements, "Less common" were reported by one or a few local experts, and, while not commonly reported by other experts, were not contradicted by other observations and were not flagged for removal during the review processes. An "E" was used to designate those observations that came mainly from elders.

Draft results were mailed to all participating local experts for review and review meetings were held in all communities. A regional level review workshop was also held in Nome with 1–2 local experts from each participating community.

4. Results

Local experts described four factors that determined seal and walrus habitat quality: ice conditions, disturbance, prey, and landscape. Landscape and bathymetry were noted to influence but not control ice and prey distributions.

4.1. Ice

4.1.1. Ice use

Walruses and adult bearded and ringed seals are observed primarily during ice covered times, and their timing and distribution vary considerably depending on ice conditions. As such, ice is considered a major habitat component for all species. Local experts described how different species have different strategies for accessing open water during ice covered times, and use ice differently to avoid predators, calve or pup, and passively migrate by resting on ice that is traveling with the wind and/or currents (Table 1 for summary, ESM S1–S4 for details).

Although seals and walruses demonstrate ice use preferences, local experts noted that seals and walruses become flexible in their ice use as needed. For example, as the spring season progresses and northward moving ice becomes scarce, walruses haul

Table 1
Ice Use by Species. Observation rankings: 1=widely shared, 2=place specific, 3=somewhat common, 4=less common. *E*=observation mainly reported by elders.

	Access to open water during ice covered times	Rest	Solitary and Group Behavior	Predation	Spring Migration	Birthing
Walruses	Not found in most of the region during winter as pack ice is too dense. (1)	Prefer thick, moving ice. (1) Will haul out on land or shorefast ice when moving ice is unavailable.(1)	Prefer to haul out and swim in groups. (1)	Will haul out on moving ice to avoid killer whales. (1) Occasionally avoid humans by selecting areas of moving ice inaccessible to boats. (4)	Mostly travel with the pack ice but have been seen swimming north after ice retreat. (2, E) Walruses present around Diomede islands in summer. (2)	Females calve alone and prefer thinner, moving ice. (4,E)
Bearded Seal	Found throughout the region in winter, primarily at smaller scale areas of open water such as capes or ice edges. (1)	Haul out on moving ice. (1) Juveniles haul out on land in summer. (1)	Most commonly seen alone or in pairs when hauled out on ice. (1)	Avoid extremely thick ice where they cannot punch a hole or leave the ice to escape from polar bears. (4,E) Will stay on ice when killer whales are nearby. (1)	Mostly travel with the pack ice but have been seen swimming north after the ice retreats.(2,E) Juveniles present in summer. (1)	Females pup on thinner moving ice with good access to open water. (4,E)
Ringed Seals	Found throughout the region in winter. Maintain holes in shorefast ice. (1)	Seal holes in shorefast ice often include a large subnivean lair where seals rest. (1)	Tend to be solitary or with a pup. (1)	Preyed on by polar bears (1) and are more wary when on the ice. (3) Will stay on ice to avoid killer whales. (1) Will avoid walruses. (3)	In spring, most go north with the retreating ice ice. (1) Juveniles present in summer. (1)	Den in shorefast ice, in areas with piled ice and drifted snow. (1)
Spotted Seals	Less common in the Bering Strait region in winter, but present in smaller numbers around Saint Lawrence Island. (1)	In summer, regularly haul out on land. (1)	Tend to gather in large groups on the ice and on land. (1)	Will stay on ice to avoid killer whales. (1) Will avoid walruses. (3)	Arrive from the south in the spring. (1) Some stay for the summer (1) and some continue north. (3)	No observations documented.

Table 2
Observations of seals and walruses adapting to or negatively affected by changing conditions observations not ranked because perspectives varied widely among local experts.

	Observed and predicted adaptations to changing conditions	Observed and predicted negative effects of changing conditions
Pupping and calving	• One year of poor recruitment can be overcome. • Very low snow years have not caused observed ringed seal declines. • Ringed seals can move to areas with more snow. • Speculation that walruses could calve on land.	• Poor ice and snow conditions during birthing may cause calf/pup mortality. • Ringed seal pups are exposed to cold and predation if snow lairs are unavailable. • Ringed and spotted seal pupping is displaced when shorefast ice is lost.
Migration	• Spring migration starts earlier. • In Little Diomede, walruses and seals arrive from the north earlier in the fall, before the ice. • Pinnipeds are highly mobile and will leave areas with poor ice conditions. • Walruses can carry calves on their backs. • Male walruses inflate air sacks in their necks and float to rest.	• Fewer larger ice floes with big walrus herds. • Accelerated seasonal ice retreat, quicker migration, and migration without ice could tire pinnipeds.
Food chain	• Adult seals and walruses are water adapted; survival will be tied to food sources more than ice conditions.	• Warmer water and other changes could affect fish and the food chain. • Changes in currents and ice conditions may move feeding areas and cause hardship for marine mammals.
Habitat	• Expanded wintering areas for walruses. • Seals and walruses are water-adapted, they can swim after the ice retreats and live under the ice using breathing holes. • Walruses can haul out on land. • Walruses and seals, on rare occasion, will travel across land when trapped by ice. • Walruses are hauling out on thinner ice than in the past. • Shorefast ice is less common at Saint Lawrence Island but ringed seals are still abundant.	• Thinner ice is less preferred. Less ice means less rest. • Some spotted seal haulouts on Saint Lawrence Island are now submerged due to rising sea level, and are now unused.
Population size and health	• Ice conditions have deteriorated but seals and walruses are abundant and healthy. Hunters have more difficulty accessing animals. • Populations have varied naturally. • It is normal to occasionally see skinny seals or walruses.	• Population Size and Health • Some areas seem to have less seals or walruses than in the past. • More wildlife diseases observed. • Occasional thin animals observed, possibly due to environmental changes.
Development	• No observations documented	• Ice decline could lead to industrialization, noise, habitat destruction, and pollution.

out on thinner ice, shorefast ice, or land, and juvenile bearded seals haul out on shorefast ice or land. Although most walruses and adult ringed and bearded seals travel north with or shortly after the ice, spotted seals as well as juvenile ringed and bearded seals remain throughout the region during summer when ice is largely absent. Walruses have been observed feeding near and hauling out on Big Diomede Island in summer.

4.1.2. *Ice drivers*

Local experts explained that ice formation, deformation, and retreat are greatly influenced by temperature, winds, tides, snowfall amount, and currents, as well as bathymetry and landscape features, and can vary from year to year (ESM S5–S7). They noted these physical and environmental influences vary by community depending on the relative strength of currents, tides, and winds, as well as local bathymetry and the orientation of the coastline in relation to the direction of prevailing winds and currents.

4.1.3. *Response to changing ice conditions*

Local experts almost universally observed changing ice conditions over their lifetimes. Overall, hunter access to seals and walruses is more difficult than in the past due to increasingly unpredictable and unstable weather, more wind, thinner ice, and a shorter ice-covered period. Some local experts expressed concern that changing ice conditions could stress seals and walruses due to longer swim durations, and that thinning or absent sea ice could negatively affect pupping and calving success and the survival of young (Table 2).

Other local experts were optimistic about the adaptability of seals and walruses to different environmental conditions (Table 2). During the study period, many local experts noted an abundance of healthy seals and walruses and explained that seals and walruses are highly mobile, accustomed to long periods in the water, and able to adapt to changing conditions. Local experts also noted that in the past, large walrus haulouts on land were occasionally observed in summer and fall. They also noted that it was normal to find dozens of dead walruses on the Punuk Islands after fall haulouts. As such, some local experts felt that media reports describing large haulouts and haulout mortality as negative effects of climate change were lacking in historical context.

4.2. *Prey*

Local experts explained that seals and walruses follow their prey. Except for open water periods, seal location is determined by both prey location and ice conditions. Even walruses, which move closely with the ice floes during spring migration, have been observed swimming to good feeding areas.

In summer and fall, seals primarily follow prey. In order to hunt successfully, local experts learned, through repeated observation, the location and timing of fish runs and also noted rich benthic feeding areas. Since seals feed in areas where fish concentrate, local experts sometimes use seals to indicate good fishing spots, although others noted that seals can compete with people for fish. When fish runs were poor, experts noted fewer seals present as well as thin seals. Local experts noted that the taste of seal meat is regionally variable, due to regional prey differences.

Local experts learned about seal and walrus prey types by observing stomach contents during the butchering process. Ringed seals, spotted seals, and juvenile bearded seals are primarily pelagic feeders that consume various kinds of fish, but ringed seals eat crabs and juvenile bearded seals eat clams (ESM S8). Walruses and adult bearded seals are primarily benthic feeders but adult

Table 3
Locations and features associated with seal and walrus prey. Observation rankings: 1=widely shared, 2=place specific, 3=somewhat common, 4=less common. E=observation mainly reported by elders.

	Place
Nearshore and inland features	**Rivers** with fish runs. River mouths have strong currents and concentrate fish. (1) **Deep river bends** concentrate fish. (1) **Bays** with large watersheds support fish runs and clams (Imuruk Basin, Grantley Harbor, Norton Bay, Golovnin Bay). (1) **Lagoons** are good fish habitat. Ocean areas near lagoons concentrate fish. (1) **Capes and points** have open water in winter, stronger currents, deep water close to shore, and rocky places for seals and walruses to haul out. Capes offer fish as well as shrimp and clams and will have seals even when there are no seals elsewhere. (1) **Islands** have eddies and currents, sheltered coves for herring spawning, open water in winter, abundant clams and shrimp on the seafloor, and may have fish runs. (1) **Coves** have calmer water that provides shelter to fish and seals. (1) **Coastal and nearshore** areas offer shallow water, abundant fish, and haulouts. (1) **Bottlenecks** including entrances to bays, lagoons, sounds, inlets, channels, and rivers all concentrate fish. (1) **Bird rookeries** indicate that fish are abundant in the area. (4) **Currents (1) and nutrient upwellings** (4) have abundant fish. **Offshore rocks** attract schools of small fish. (4)
Benthic features	**Sandy, muddy seafloor** areas are good clam habitat. (3) **Intermediate depth** best for clam/shrimp feeding. Extremely deep or shallow areas not used for benthic feeding. Depth variability seems to increase richness. (3)
Ice features	**Ice edge and open water** in winter often have abundant fish and benthic feeding areas. Areas of winter open water appear to be biologically rich year-round. (3) **Early open water** at river mouths at break-up provides feeding opportunities. (4) **Floating ice** may have herring, cod or other fish underneath. (3) **Place** **Multi-year ice** is nutrient rich. (3)

bearded seals also consume fish (ESM S8). Local experts noted that adult and juvenile bearded seals have different habitat use patterns due to diet. In winter, adult bearded seals are observed in deeper areas away from shore or near capes, while juveniles are found closer to shore. In summer and fall, juvenile bearded seals inhabit rivers, coves and nearshore areas, while adult bearded seals are less commonly seen and only inhabit larger lagoons.

4.2.1. *Prey locations*

Although marine mammal prey are highly mobile, certain environmental features are associated with good feeding areas (Table 3).

4.2.2. *Prey drivers*

Local experts were most concerned about bottom-trawling and other forms of industrial fishing permanently damaging the seal and walrus food chain through fish stock depletion as well as destruction of sensitive benthic habitat. The second most common concern was that pollution could negatively affect the food chain. Less commonly noted concerns included prey depletion due to deteriorating ice conditions and/or the increasing presence of Stellar sea lions in the area. Some local experts noted that there is natural variability, and fish populations can go up and down in cycles.

4.3. *Disturbance*

Local experts noted that seals and walruses have very good hearing, both in and out of the water, are acutely sensitive to noise and smell, and will flee if they sense danger. Elder local experts described how hunters traditionally approached very quietly and noted that in the past, seals and walruses seemed tamer and were

Table 4
Factors influencing seal and walrus response to disturbance. Observation rankings: 1=widely shared, 2=place specific, 3=somewhat common, 4=less common. E=observation mainly reported by elders.

Factors	
Species	Bearded, ringed, and spotted seals are all very sensitive. Spotted seals are shy, hard to approach, and most likely to abandon haulouts, feeding, or pupping areas. Seals are generally harder to approach than walruses. (1)
Numbers	Large groups of walruses in the water are less sensitive to disturbance. (3)
Season/Weather	Seals are more sensitive in winter than in spring. (3) Walruses are least alert in warm and sunny weather, and are more sensitive in overcast or foggy weather. (3) Walruses may stay on ice if a storm is coming. (4,E)
Location	Seals and walruses are more wary on the ice than in the water. (3)
Wind direction	Seals and walruses are sensitive to smell and should be approached from downwind. (1)
Type of Noise	Slow, steady approach with no sudden or loud noises less likely to disturb seals and walruses. Banging and scratching makes seals curious and may sound like a pup calling its mother. (3)
Prior experience with hunters	“Educated walruses” have been hunted before and are more skittish. Walruses are more wary during times of active hunting. (4)
Age	Younger walruses are more alert and aggressive. (1)
Factors	
Alertness	Full, sleepy, or lethargic seals are more approachable. (3) Walrus alertness can vary unpredictably. (3)
Killer whales	Seals and walruses are more afraid of killer whales than other disturbances and will not flee humans when killer whales are present. (1)
Settlement	Seals are often more skittish near human settlements due to noises (4,E)
Health	Sick seals and walruses are less alert and more approachable. (3)

Table 5
Drivers of seal and walrus disturbance. Observation rankings: 1 = widely shared, 2 = place specific, 3 = somewhat common, 4 = less common. E = observation mainly reported by elders.

Disturbance	Reaction
Planes/helicopters	• Seals and walruses will react to planes and leave the ice. (1) Flights at or lower than 1500 feet most problematic. (4) • Seals and walruses abandoned certain areas when overflights became regular. (3) • Flying over walrus haulouts can cause panic and trampling. (3)
Large ships transiting the area	• Noise and smell can displace seals and walruses. (1) Occasionally they will ignore ships. (4)
Seismic vessel with acoustic array	• Walruses with calves and small seals could get overtaken and end up among the acoustically powerful seismic array. (4)
Tenders/processors	• Variable reactions; spotted seals may be displaced or may ignore tenders. (3)
Barges	• The loud noises and smoky engine exhaust can disturb seals and walruses. (3) • Some areas have less pinnipeds due to increased barge traffic, but barges supply communities regularly and seals are still present. (3) • Most barge traffic is in summertime when seals are less numerous. (3)
Offshore mining	• Mining has displaced seals from nearby rivers.(3)
Icebreakers	• Seals and walruses most concentrated and vulnerable during ice-covered times. (1) • Mammals could be caught in propellers, or that icebreakers could change ice habitat. (3)
Outboard motors	• Pinnipeds will flee when they sense danger. Successful hunters approach carefully. (1)
Settlement noise	• Elders notice less game near villages and settlements now that there are generators, cars, planes, all-terrain vehicles, snow machines, and high powered rifles. (3,E)
Human voices	• It is important to be quiet when hunting, as voices can scare animals, but seals occasionally get curious and approach voices. (1)
Subsistence approaches	• Smell and noise can disturb seals and walruses. Quiet, downwind approaches are most successful. (1)
Human thought and speech	• More traditional hunters avoid certain kinds of thought or speech (generally disrespectful or boastful) about animals because the animals are aware and will stay away. (3,E)

found in abundance closer to villages. They felt that the increasing noise of contemporary life made seals and walruses more skittish and scared them farther from villages. Experts noted that the effects of disturbance vary according to the location and number of animals, wind direction, weather, quality of the noise, past experiences of the animals, the presence of predators, and other factors (Table 4). Walrus haulouts were noted as particularly sensitive to disturbance, as frightened walruses may trample each other in their attempts to return to the water.

4.3.1. Drivers of disturbance

Although seals and walruses react to other animals, local experts generally described human noises, from planes, helicopters, ships, barges, mining, and settlement, as the primary sources of disturbance (Table 5) and expressed concern that shipping and increasing marine development could cause habitat loss. Participants noted that the spring migration, when seals and walruses are moving in dense concentrations with the ice, is the most vulnerable period.

4.4. Landscape features

Landscape features associated with seal and walrus concentrations are usually good feeding areas and are described in the earlier section on prey. Seals and walruses also use landscape features such as capes and islands for hauling out to rest. Local experts explained that walrus haulouts on land are determined by three main factors: abundant prey resources, the absence of disturbance, and the lack of sea ice. Although walruses occasionally haul out on sandy beaches, they most commonly haul out in rocky areas near good benthic feeding, often at uninhabited points, capes and islands, and are noted to be good climbers. Walruses prefer remote areas for hauling out, but will sometimes haul out near populated areas. During the summer, spotted seals regularly haul out in large groups in both sandy and rocky areas, with a preference for islands, capes, areas of rock that extend into the water, and river mouths. In summer, juvenile bearded seals regularly haul out alone along river banks. Adult bearded seals do not generally haul out on land in this region, although some are present in the larger lagoons in summer. Ringed seals, primarily juveniles, haul out along ocean beaches and at river mouths.

5. Discussion

5.1. What policies emerge from the indigenous evidence base?

As local experts identified drivers of habitat change, policies to address habitat loss are implied in the indigenous evidence base and were also discussed by local experts during the interviews. Local experts agreed that noise from shipping and development, prey depletion through industrial fishing, and environmental contamination through pollution all have negative effects on marine mammal habitat. As such, they almost universally recommended precautionary marine management, including the protection of the seal and walrus food chain and the prevention of pollution and excessive noise, to minimize these drivers of habitat loss (for more details, see [32]). Additionally, local experts described the importance of protected freshwater rivers and estuarine lagoons as habitat for marine mammal prey and as habitat areas for juvenile seals. This implies that protecting inland and near shore water features from the harmful effects of development is another important part of marine mammal habitat conservation.

5.2. How do the recommended policies emerging from the TEK-based qualitative habitat delineation compare with existing policies?

5.2.1. Many local experts had a greater focus on marine mammal adaptive capacity

Due to concerns about deteriorating ice conditions, the National Marine Fisheries Service has listed Alaskan bearded and ringed seals as threatened under the Endangered Species Act and the US Fish and Wildlife Service has listed walruses as "warranted but precluded". Although some local experts expressed concern that drastic changes in ice conditions will surpass seal and walrus ability to adapt, many local experts believe these animals are adapted to highly variable environments and can cope with changing conditions (Table 2). They support this theory of adaptive capacity with observations of seals and walruses adapting to existing changes, having flexible habitat use, and tolerating variable environmental conditions. Belief in the intelligence and adaptability of seals and walruses is consistent with broader indigenous views of animals as non-human persons (e.g. [21,23,24,51]). Although this theory of adaptive capacity differs from the agency positions, it is not without support in the scientific literature. Hof et al. [28] noted that rapid climate change has occurred in the past without causing mass extinctions, and they speculate that genetic and phenotypic variability may allow species to adapt in-place, rather than becoming extinct or shifting their ranges. Local expert observations indicate potential genetic and phenotypic variability: seals and walruses with different physical characteristics show regular patterns; for example, different types of walruses are seen on the north and south sides of Saint Lawrence Island (ESM S1). Additionally, local experts describe seals and walruses as intelligent animals, with the ability to learn from their experiences and to change their behavior and habitat use under different conditions and during different life phases. The Federally mandated population status reviews during the ESA listing process for both ringed and bearded seals also noted considerable variation in habitat use in different regions. For example, adult bearded seals in the Russian Okhotsk distinct population segment haul out on land, and ringed seals in Lakes Saimaa and Ladoga molt on shore rather than on ice; these behaviors are not observed in the Bering Strait region [15,34]. Finally, research indicates that some species of ice-associated marine mammals may be somewhat resilient to climate change due to current adaptation to highly variable environments, extensive ranges, large population sizes, varied diets, and diverse habitat use [39].

5.2.2. *Local experts and management agencies ranked threats differently*

In their status reviews for ice seals and walruses, the US Fish and Wildlife Service and the National Marine Fisheries Service both ranked climate change-induced future habitat loss as the greatest threat to the persistence of these species, and this predicted habitat loss was the basis for the listing of Alaskan ringed and bearded seals as threatened, and Pacific walruses as warranted but precluded. Generally, these federal agencies judged that other threats, such as industrial fishing or disturbance, are adequately managed, although it was noted that these threats could become greater under climate-change induced population declines [13–15,25,34,40]. In contrast, project participants expressed greatest concern about industrial fishing damaging the food chain and benthic habitat, as well as disturbance and pollution from shipping and marine development causing habitat loss. Bering Strait tribal concerns about the harmful effects of development are in line with broader indigenous concerns about human–environment ethics, and the danger of excessively extractive approaches to natural resource management (e.g. [67]). Participant concerns about anthropogenic effects other than climate change negatively affecting marine mammals are well supported in the scientific literature for both the Bering Strait region and other regions. Huntington [30] ranks climate change, offshore oil and gas development, and commercial fisheries as the greatest threat to Arctic marine mammals. Schipper and colleagues (2008) estimated that for marine mammals worldwide, the greatest threats are accidental mortality due to vessel strikes or bycatch, and pollution, which includes both chemical and noise pollution, as well as climate change. Considerable research indicates that human disturbance can cause habitat loss for marine mammals [31,41]. Prey depletion can also destroy habitat, as Arctic marine mammals require rich feeding areas to support their life cycles [12], and fisheries management plans that do not consider fish consumption by marine mammals and other predators may seriously underestimate mortality and thus be unsustainable [55]. Finally, research indicates that human development can have cumulative and interactive effects that complicate species' ability to adapt to climate change [27].

5.2.3. *Local expert observations did not lead easily to quantitative habitat parameters or fixed protected areas*

Local expert observations indicate that seal and walrus habitat use is the sum of various environmental, biological, oceanographic, and bathymetric factors and may be difficult to measure using quantitative habitat parameters such as percent ice cover or noise level. For example, seal and walrus response to disturbance is mediated by diverse factors including the weather, past experiences of the individual, and whether the animal has eaten recently. Seal and walrus ice use was noted to change with variable weather events, over the course of the season, and over the course of time, with seals and walrus using less preferred ice features when preferred ice conditions were not available. Additionally, most local experts found the idea of fixed protected areas difficult. Although one goal of project mapping was to identify important habitat areas for potential protection, local experts noted that habitat was largely determined by ice conditions, and ice conditions were driven by highly variable environmental factors such as wind and temperature. Additionally, seal and walrus use areas were influenced by prey concentrations and areas of disturbance, which were also dynamic. As such, many concentration areas varied annually, although some areas, such as rich benthic feeding spots, were fixed. Many communities felt concern about protecting specific areas and were more in favor of precautionary policies throughout the region. Indigenous mapping projects in other areas have also found that indigenous knowledge and use is too complex to represent in maps or to protect with policies based only on mapped areas (e.g. [65]). In contrast, many policy processes in the region were focused on the demarcation of specific marine areas or fixed habitat parameters such as percent moving ice cover, likely due to greater feasibility of implementation (e.g. [5,15,34][64]).

5.3. *The role of Alaska Native organizations and traditional knowledge holders*

The policy implications of this research are not new to seal and walrus hunters, as their traditional knowledge and ecosystem perspective have consistently driven a distinct approach to policy-making. Alaska Native Organizations (ANOs) including the Eskimo Walrus Commission (EWC), the Ice Seal Committee, and Kawerak have advocated for holistic management and have used traditional ecological knowledge to identify threats to seals and walruses and to advocate for policies that protect pinnipeds and their habitat, in many cases from activities conducted by federal managers or researchers. For example, during the ESA status reviews, the EWC opposed the listing of walruses as threatened or endangered, out of concern that this process (1) did not include sufficient traditional ecological knowledge to accurately assess the status of walruses and (2) would not address threats from commercial fishing and shipping, as well as oil and gas development, but would rather focus on regulating Alaska Native walrus harvests. Additionally, EWC has advocated for ecosystem-level walrus management (e.g., [42]) and has campaigned against bottom-trawling for commercial or research purposes, opposed disturbance to walruses by helicopters, advocated for tribal consultation in policies that could affect walrus or walrus habitat, and promoted local involvement in research. Similarly, Kawerak has promoted tribal consultation, the use of traditional knowledge, and precautionary Arctic management that mitigates noise and pollution and prevents industrial fishing in the northern Bering Sea (e.g., [52]), and the Ice Seal Committee has, among other things, advocated for better integration of traditional knowledge into the ESA process.

Research indicates that the effects of human activities on marine environments can have cumulative, variable, and unpredictable effects, and that management approaches that focus on a single species or stressor are unlikely to effectively conserve ecosystems [7,27]. Instead, the holistic, observation-rich, and often precautionary approach promoted by tribes and ANOs may be a more effective method for maintaining marine ecosystems. Studies have indicated the effectiveness of integrating traditional knowledge and science for marine conservations (e.g. [6,29]), but projects that genuinely reflect indigenous approaches, rather than trying to fit them within existing science and policy, are uncommon. Although co-management agreements bring tribal experts and agency scientists together, federal agencies still hold most decision-making power and control over funding, and research and policy often do not reflect indigenous knowledge or values (e.g. [42,45]). Inclusive processes that share actual resource-management decision-making power with tribes and ANOs are just [68] and have considerable potential to improve policies through the incorporation of detailed knowledge of human–pinniped–marine environment systems as well as indigenous environmental ethics that promote sustainability.

6. Conclusion

Qualitative methods allowed the systematic documentation of expert seal and walrus hunter knowledge, producing an indigenous evidence-base for habitat conservation policy-making: a detailed written description of Bering Strait region seal and walrus habitat and habitat use behaviors. Qualitative methods effectively preserved local expert perspectives, and participating tribes felt project results were a fair representation of traditional ecological knowledge. The TEK-based qualitative habitat delineation had clear policy implications, indicating that effective habitat protection in the Bering Strait region will extend past the physical structure of the icescape, and give serious consideration to the prey species of seals and walruses as well as the effects of marine disturbance and pollution. Generally, expert knowledge indicated the potential of region-wide precautionary management, rather than quantitative habitat parameters or fixed protected areas. Although this differs from some common management approaches, there is considerable scientific, as well as tribal, support for this holistic approach that recognizes natural variability and ecosystem complexity.

Acknowledgment

Local Experts

Diomede: Arthur Ahkinga, Alois Ahkvaluk, John Ahkvaluk, Jerry Iyapana, Patrick F. Omiak Sr., Frances Ozenna, Ronald Ozenna Jr., Edward Soolook, Robert F. Soolook Jr.

Elim: Wallace J. Amaktoolik Jr., Eric F. Daniels Sr., Fredrick L. Daniels, John Jemewouk, Elizabeth H. Kotongan, Kenneth L. Kotongan, Paul Nagaruk, Sheldon Nagaruk, Victor J. Nylin Sr., Charles F. Saccheus, Charles F. Saccheus Jr., Joel Saccheus, Ralph J. Saccheus, Russell M. Saccheus Sr.

King Island: Wilfed Anowlic, Jimmy Carlisle, Hubert Kokuluk, Joseph Kunnuk, John Penatac Sr., Vince Pikonganna, John I. Pullock

Koyuk: Georgianne Anasogak, Johnny Anasogak, Oscar D. Anasogak Sr., Clifford B. Charles, Kenneth W. Dewey Sr., Merlin Henry, Franklin Hoogendorn, Kimberly Kavairlook, Esther R. Kimoktoak, Patrick Kimoktoak, Sophie Milligrock, Roger Nassuk Sr., Ruby Nassuk

Nome: Austin Ahmasuk, Daniel Angusuc, Roy Ashenfelter, Bivers Gologergen, Albert Johnson, Frank L. Johnson II, Stan Piscoya

Saint Michael: Joe Akaran, Martin Andrews, Victor Joe, Nicholas Lupsin, James Niksik Sr., Damien A. Tom, Albert A. Washington

Savoonga: Arnold Gologergen, Larry Kava, Kenneth Kingeekuk, Chester Noongwook, George Noongwook, Morris Toolie Sr., Raymond Toolie, Clarence Waghiyi

Shaktoolik: Axel Jackson, Edgar M. Jackson Sr., Van Katchatag, Franklin Paniptchuk Jr., Reuben Paniptchuk, Hannah A. Takak

Stebbins: Allen M. Atchak Sr., Gabriel J. Bighead, Albert J. Bogeyaktuk Sr., Hermes Dan, Kellen Katcheak, Theodore Katcheak, Peter P. Martin Sr., Alexis Matthias, Isaac Nashoanak, Morris L. Nashoanak Sr., Ryan Nashoanak Sr., Anthony Niksik, Leonard L. Raymond Sr., Joseph Willie.

Terry Chapin, Gay Sheffield, and Raychelle Daniel reviewed previous versions of this paper. Many thanks to project research assistants and transcribers Freida Moon-Kimoktoak, Lisa Ellanna-Strickling, Helen Pootoogooluk, Edwina Krier, Maggie Kowchee, Jotilda Noongwook, Ruby Booshu, and Serena Walker. We thank the nine participating tribes: Stebbins Community Association, Native Village of Saint Michael, Native Village of Elim, Native Village of Koyuk, Native Village of Savoonga, Nome Eskimo Community, Native Village of Shaktoolik, Native Village of Diomede, and King Island Native Community. This work was supported by the Oak Foundation under Grant no. 2010-OUSA-073, the National Science Foundation under Grant no. ARC-1023686, and the National Fish and Wildlife Foundation under Grant no. 2010-0061-004 (project funding provided by Shell). The Eskimo Walrus Commission and the Ice Seal Committee were project partners. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the funders or project partners.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.marpol.2015.09.008.

References

[1] J.M. Acheson, J.A. Wilson, R.S. Steneck, Managing chaotic fisheries, in: F. Berkes, C. Folke (Eds.), Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience, Cambridge University Press, New York, 1998, pp. 390–413.
[2] ACIA, Impacts of a Warming Arctic: Arctic Climate Impact Assessment, Cambridge University Press, Cambridge, 2004.
[3] A. Ahmasuk, E. Trigg, J. Magdanz, B.A. Robbins, Comprehensive Subsistence Use Study of the Bering Strait Region. North Pacific Research Board Project 643 final report 2008 Kawerak, Inc. Nome, Alaska.
[4] A. Agrawal, C. Gibson, Enchantment and disenchantment: the role of community in natural resource conservation, World Dev. 27 (4) (1999) 629–649.
[5] J. Ayers, A. Blacow, B. Enticknap, C. Krenz, S. Murray, S. Roberts, G.Shester, J. Short, J. Warrenchuk, Important Ecological Areas in the Ocean: A Comprehensive Ecosystem Protection Approach to the Spatial Management of Marine Resources. Juneau: Oceana. 〈http://na.oceana.org/sites/default/files/reports/oceana_iea_discussion_paper.pdf〉, 2010.
[6] N.C. Ban, C.R. Picard, A.C. Vincent, Comparing and integrating community-based and science-based approaches to prioritizing marine areas for protection, Conserv. Biol. 23 (4) (2009) 899–910.
[7] N.C. Ban, H.M. Alidina, J.A. Ardron, Cumulative impact mapping: Advances, relevance and limitations to marine management and conservation, using Canada's Pacific waters as a case study, Mar. Policy 34 (5) (2010) 876–886.
[8] F. Berkes, Sacred Ecology: Traditional Ecological Knowledge and Resource Management, Taylor and Francis, Philadelphia, 1999.
[9] F. Berkes, J. Colding, C. Folke, Rediscovery of traditional ecological knowledge as adaptive management, Ecol. Appl. 10 (5) (2000) 1251–1262.
[10] H.R. Bernard, Research Methods in Anthropology, AltaMira Press, Lanham, Maryland, 2006.
[11] P. Blaikie, The Political Economy of Soil Erosion in Developing Countries, Longman, London, 1985.
[12] B.A. Bluhm, R. Gradinger, Regional variability in food availability for Arctic marine mammals, Ecol. Appl. 18 (Suppl. 2) (2008) S77–S96.
[13] Boveng, P.L., Bengtson, J.L., Buckley, T.W., Cameron, M.F., Dahle, S.P., Megrey, B.A., Williamson, N.J., Status Review of the Ribbon Seal (*Histriophoca fasciata*). US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 2008.
[14] Boveng, P.L., Bengtson, J.L., Buckley, T.W., Cameron, M.F., Dahle, S.P., Kelly, B.P., Williamson, N.J., Status Rreview of the Spotted Seal (*Phoca largha*). US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 2009.
[15] Cameron, M.F., Bengtson, J.L., Boveng, P.L., Jansen, J.K., Kelly, B.P., Dahle, S.P., Wilder, J.M., Status Review of the Bearded Seal (*Erignathus barbatus*).

Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 2010.
[16] N. Chalmers, C. Fabricius, Expert and generalist local knowledge about land-cover change on South Africa's Wild Coast: can local ecological knowledge add value to science, Ecol. Soc. 12 (1) (2007) 10.
[17] Consultation and Coordination with Indian Tribal Governments. Executive Order 13175. 65 (218) Fed. Reg. Nov 9, 2000, pp. 67249–67252.
[18] J. Cruikshank, Social Life of Stories: Narrative and Knowledge in the Yukon Territory, UBC Press, Vancouver, 2000.
[19] C.A. Drew, A.H. Perera, Expert knowledge as a basis for landscape ecological predictive models, in: C.A. Drew, Y.F. Wiersma, F. Huettmann F (Eds.), Predictive Species and Habitat Modeling in Landscape Ecology, Springer, New York, 2011, pp. 229–248.
[20] S.C. Ellis, Meaningful consideration? A review of traditional knowledge in environmental decision making, Arctic (2005) 66–77.
[21] A. Fienup-Riordan, Eskimo Essays: Yup'ik Lives and How We See Them, Rutgers University Press, New Jersey, 1990.
[22] L. Gadamus, Linkages between human health and ocean health: a participatory climate change vulnerability assessment for marine mammal harvesters, Int. J. Circumpolar Health (2013) 72.
[23] L. Gadamus, J. Raymond-Yakoubian, Qualitative participatory mapping of seal and walrus harvest and habitat areas: Documenting indigenous knowledge, preserving local values, and discouraging map misuse, Int. J. Appl. Geospatial Res. (IJAGR) 6 (1) (2015) 76–93.
[24] L. Gadamus, J. Raymond-Yakoubian, A Bering Strait indigenous framework for resource management: respectful seal and walrus hunting, Arct. Anthropol. 52 (2) (2015) (forthcoming).
[25] J. Garlich-Miller, J.G. MacCracken, J. Snyder, R. Meehan, M. Myers, J.M. Wilder, A. Matz, Status Review of the Pacific Walrus (*Odobenus rosmarus* divergens), US Fish and Wildlife Service, 2011.
[26] J.C. George, S. Braund, H. Brower Jr, C. Nicolson, T.M. O'Hara, Some observations on the influence of environmental conditions on the success of hunting bowhead whales off Barrow, Alaska, in: A.P. McCartney (Ed.), Indigenous Ways to the Present. Native Whaling in the Western Arctic, Canadian Circumpolar Institute and University of Utah Press, Edmonton and Salt Lake City, 2003, pp. 255–275.
[27] B.S. Halpern, K.L. McLeod, A.A. Rosenberg, L.B. Crowder, Managing for cumulative impacts in ecosystem-based management through ocean zoning, Ocean Coast. Manag. 51 (3) (2008) 203–211.
[28] C. Hof, I. Levinsky, M.B. Araujo, C. Rahbek, Rethinking species' ability to cope with rapid climate change, Global Change Biol. 17 (9) (2011) 2987–2990.
[29] H.P. Huntington, Using traditional ecological knowledge in science: methods and applications, Ecol. Appl. 10 (5) (2000) 1270–1274.
[30] H.P. Huntington, A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades, Mar. Policy 33 (1) (2009) 77–82.
[31] Inc Kawerak, Seal and Walrus Harvest and Habitat Area for Nine Bering Strait region communities, Kawerak Social Science Program, Nome, Alaska, 2013.
[32] Inc Kawerak, Policy-based Recommendations from Kawerak's Ice Seal and Walrus Project, Kawerak Social Science Program, Nome, Alaska, 2013.
[33] S.R. Kellert, J.N. Mehta, S.A. Ebbin, L.L. Lichtenfeld, Community natural resource management: promise, rhetoric, and reality, Soc. Nat. Resourc. 13 (8) (2000) 705–715.
[34] B.P. Kelly, J.L. Bengtson, P.L. Boveng, M.F. Cameron, S.P. Dahle, J.K. Jansen, J. M. Wilder, Status review of the ringed seal (*Phoca hispida*). Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, 2010.
[35] J.T. Kerr, M. Kulkarni, A. Alagar, Integrating theory and predictive modeling for conservation research, in: C.A. Drew, Y.F. Wiersma, F. Huettmann F (Eds.), Predictive Species and Habitat Modeling in Landscape Ecology, Springer, New York, 2011, pp. 9–28.
[36] G. Kofinas, The Cost of Power Sharing: Community involvement in Canadian Porcupine Caribou Co-management (Ph.D. dissertation), University of British Columbia Vancouver, 1998.
[37] M. Kovach, Indigenous Methodologies: Characteristics, Conversations, and Contexts, University of Toronto Press, Toronto, 2009.
[38] I. Krupnik, G.C. Ray, Pacific walruses, indigenous hunters, and climate change: bridging scientific and indigenous knowledge, Deep Sea Res. Part II: Top. Stud. Oceanogr. 54 (23) (2007) 2946–2957.
[39] K.L. Laidre, I. Stirling, L.F. Lowry, Ø. Wiig, M.P. Heide-Jørgensen, S.H. Ferguson, Quantifying the sensitivity of Arctic marine mammals to climate-induced habitat change, Ecol. Appl. 18 (Suppl. 2) (2008) S97–S125.
[40] J.G. MacCracken, Pacific Walrus and climate change: observations and predictions, Ecol. Evol. 2 (8) (2012) 2072–2090.
[41] Marine Mammal Commission, Marine Mammals and Noise: A Sound Approach to Research and Management, Marine Mammal Commission, Bethesda, Maryland, 2011.
[42] V. Metcalf, M. Robards, Sustaining a healthy human-walrus relationship in a dynamic environment: Challenges for comanagement, Ecol. Appl. 18 (Suppl. 2) (2008) S148–S156.
[43] M.B. Miles, M.A. Huberman, Qualitative Data Analysis, Sage, Thousand Oaks, California, 1994.
[44] P. Nadasdy, The politics of TEK: Power and the "integration" of knowledge, Arct. Anthropol. 36 (1–2) (1999) 1–18.
[45] P. Nadasdy, Reevaluating the co-management success story, Arctic 56 (2003) 367–380.
[46] P. Omara-Ojungu, Resource Management in Developing Countries, Longman Scientific and Technical, Essex, 1992.
[47] G.H. Orians, Endangered at what level? Ecol. Appl. 3 (1993) 206–208.
[48] R.T. Paine, Food web complexity and species diversity, The American Naturalist 100 (1966) 65–75.
[49] L. Ray, Using Q-methodology to identify local perspectives on wildfires in two Koyukon Athabascan communities in rural Alaska, Sustain.: Sci. Pract. Policy 7 (2) (2011) 1011–1061.
[50] L.A. Ray, C.A. Kolden, F.S. Chapin III, A case for developing place-based fire management strategies from traditional ecological knowledge, Ecol. Soc. 17 (3) (2012) 37.
[51] B. Raymond-YakoubianL. KaplanM. TopkokJ. Raymond-Yakoubian "The World has Changed": Ifalit Traditional Knowledge of Walrus in the Bering Strait. Final Report to the North Pacific Research Board for Project 1013, Kawerak Social Science Program, Nome, Alaska.
[52] J. Raymond-Yakoubian, Participation and resistance: Tribal involvement in Bering Sea fisheries management and policy, in: C. Carothers, K. Criddle, C. Chambers, P. Cullenberg, J. Fall, A. Himes-Cornell, J. Johnsen, E. Springer (Eds.), Fishing People of the North: Cultures, Economies, and Management Responding to Change, Alaska Sea Grant and University of Alaska, Fairbanks, Fairbanks, Alaska, 2012, pp. 117–130.
[53] J. Raymond-Yakoubian, When the Fish Come, We Go Fishing: Local Ecological Knowledge of Non-salmon Fish Used for Subsistence in the Bering Strait Region, Kawerak, Inc, Nome, Alaska, 2013.
[54] J. Raymond-Yakoubian, Conceptual and institutional frameworks for protected areas and the status of indigenous involvement: Considerations for the Bering Strait Region of Alaska, in: T.M. Herrmann, T. Martin (Eds.), Indigenous Peoples' Governance of Land and Protected Territories in the Circumpolar Arctic, Springer, New York, 2015 (forthcoming).
[55] A.J. Read, C.R. Brownstein, Considering other consumers: fisheries, predators, and Atlantic herring in the Gulf of Maine, Conserv. Ecol. 7 (1) (2003) 2.
[56] L. Richmond, B.R. Middleton, R. Gilmer, Z. Grossman, T. Janis, S. Lucero, T. Morgan, A. Watson, Indigenous studies speaks to environmental management, Environ. Manag. 52 (5) (2013) 1041–1045.
[57] D. Rocheleau, R. Slocum, Participation in context: key questions, in: R. Slocum, L. Wichhard, D. Rocheleau, B. Thomas-Slayter (Eds.), Power, Process and Participation: Tools for Change, Intermediate Technology Publications, London, 1995, pp. 17–30.
[58] J. Schipper, J.S. Chanson, F. Chiozza, N.A. Cox, M. Hoffmann, V. Katariya, P. S. Hammond, The status of the world's land and marine mammals: diversity, threat, and knowledge, Science 322 (5899) (2008) 225–230.
[59] J.C. Stroeve, M.C. Serreze, M.M. Holland, J.E. Kay, J. Malanik, A.P. Barret, The Arctic's rapidly shrinking sea ice cover: a research synthesis, Clim. Change 110 (2012) 1005–1027.
[60] T. Tobias, Living Proof: The Essential Data Collection Guide for Indigenous Use-and-occupancy Map Surveys, Union of BC Indian Chiefs and Ecotrust, Vancouver, 2009.
[61] L. Tuhiwai Smith, Decolonizing Methodologies: Research and Indigenous Peoples, Zed Books, New York, 1999.
[62] C.T. Tynan, D.P. DeMaster, Observations and predictions of Arctic climate change: potential effects on marine mammals, Arctic 50 (1997) 308–322.
[63] D. Urban, S. Goslee, K. Pierce, T. Lookingbill, Extending community ecology to landscapes, Ecoscience 9 (2002) 200–202.
[64] U.S. Coast Guard, Port Access Route Study: in the Bering Strait, 75, Federal Register (2010), p. 68568–68570.
[65] J. Wainwright, J. Bryan, Cartography, territory, property: postcolonial reflections on Indigenous counter-mapping in Nicaragua and Belize, Cult. Geogr. 16 (2) (2009) 153–178.
[66] A. Watson, Misunderstanding the "Nature" of co-management: a geography of regulatory science and indigenous knowledges (IK), Environ. Manag. 52 (5) (2013) 1085–1102.
[67] A. Watson, O. Huntington, Transgressions of the man on the moon: climate change, indigenous expertise, and the posthumanist ethics of place and space, GeoJournal 79 (6) (2014) 721–736.
[68] D. Western, R.M. Wright (Eds.), Natural Connections, Island Press, Washington D.C, 1994.