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Co-producing knowledge about the Pacific walrus and climate change

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Abstract

Pacific walruses (*Odobenus rosmarus divergens*, Illiger 1815) have long been vital to Indigenous communities along Alaska's west coast. Although current harvest rates are sustainable, climate change and increased industrial activity in the range of this species pose threats to the population and to hunting safety and success. To gather information relevant to addressing these concerns, the Eskimo Walrus Commission and the US Fish and Wildlife Service held a workshop in August 2023 in Nome, Alaska, with experienced Yupik walrus hunters from the communities of Gambell and Savoonga on St. Lawrence Island, Alaska, and Federal walrus biologists. The 3-day event documented extensive information about walrus biology and behavior, which was used to improve a walrus population model. Workshop discussions also addressed concepts of sustainability and the future of walrus hunting. The workshop benefitted from prior collaboration between the biologists and some of the hunters on a walrus research cruise in the Chukchi Sea earlier the same summer, creating a foundation of common experience and interpersonal relationships. In the longer term, the workshop helped demonstrate the value of equitable collaboration towards shared goals, in part by allowing for open conversations rather than, for example, an extended question-and-answer session regarding model parameters.

Key words: Pacific Walrus, St. Lawrence Island Yupik, Indigenous Knowledge, Alaska, sustainability

1. Introduction

Pacific walruses (*ayveq* in St. Lawrence Island Yupik; *Odobenus rosmarus divergens*, Illiger 1815) are vital for the cultural, nutritional, and spiritual well-being of Alaska and Chukotka Native communities (Metcalf and Robards 2008; Zdor et al. 2010; Kawerak 2013*a*). They have been harvested for thousands of years, and harvest continues to this day (EWC 2024). The walruses are also an iconic Arctic species known worldwide. Pacific walruses currently have a large population (95% CrI = 171 000–366 000 individuals; Beatty et al. 2022) that is thought to be stable (Taylor et al. 2018). Additionally recent harvest rates (limited by the U.S. Marine Mammal Protection Act to subsistence harvest by Indigenous hunters) are within a sustainable range (Johnson et al. 2024*b*). However, loss of sea ice and increased industrial activity, such as commercial shipping, in the Pacific Arctic pose threats to the walrus population and to hunting safety and success (Huntington et al. 2016, 2017; FWS n.d.). The Eskimo Walrus Commission (EWC, a tribally authorized organization) and the U.S. Fish and Wildlife Service (FWS) share a common goal of maintaining both a healthy population of Pacific walruses and the continued sustainable use of walruses by Alaska Native communities. The EWC and FWS have a formal co-management agreement through which they carry out research, education, and management activities in the interests of walrus and walrus-hunting communities (EWC 2019).

To this end, the FWS has developed a walrus population sustainability model based on the best available knowledge about walrus reproduction, migration and movement, behavior, reliance on sea ice, use of shore-based haulout sites, susceptibility to disturbance, energetics, and other factors that influence walrus well-being and population health. The model itself is described in other publications (Johnson et al. 2024*a*, 2024*b*; FWS n.d.). The model is intended to help Tribal and Federal officials assess current and potential management actions that could help to sustain the Pacific walrus population and support comanagement activities. The Indigenous Knowledge (IK) generated and held by Alaska Native walrus hunters, as with Indigenous hunters elsewhere in the Arctic, can provide detailed information that is unavailable from other sources and can help add confidence to Western scientific understanding about walruses (e.g., Krupnik and Ray 2007; Metcalf and Robards 2008; Gadamus and Raymond-Yakoubian 2015; Huntington et al. 2016, 2017; Martinez-

Levasseur et al. 2021). In addition, hunters' knowledge can improve other management-related efforts, such as Stock Assessment Reports (e.g., FWS 2023) and Species Status Assessments (SSAs; FWS 2016, n.d.) used to inform decisions about endangered species status.

The SSA process in particular involves compiling the best available knowledge to assess the current and future status of the subspecies. Building on earlier but often unfulfilled commitments to co-management and Tribal engagement, the US federal government recently strengthened its commitment to elevating IK in scientific and policy processes (Lander and Mallory 2021). The new guidance has outlined and updated minimum standards for tribal (government-to-government) consultation (2023; 88 FR 89467). However, in practice, these consultations may be brief (1–2 h), introduce technological or scheduling issues (e.g., a video chat meeting in the middle of a workday), overburden busy tribal government representatives (who see many tribal consultation requests every week), or otherwise limit the full participation of tribal representatives and IK holders (Huntington et al. 2012). While the idea of incorporating IK in research and management has a long history (e.g., Johannes 1981), and while research on IK of walrus in Alaska has been done (e.g., Gadamus and Raymond-Yakoubian 2015; Huntington et al. 2016, 2017), the population modeling effort and the SSA required up-to-date information on specific topics, some of which could not have been anticipated by prior studies.

To help provide such information for the modeling framework, the EWC organized a 3-day workshop in Nome, Alaska, in August 2023. The purpose of the workshop was to discuss current knowledge of walruses from both Indigenous and Western scientific perspectives to improve the foundation of the walrus population sustainability model. The effort built on prior EWC and related efforts to document and benefit Pacific walrus management through inclusion of IK (e.g., EWC 2003; Zdor et al. 2010; Kawerak 2013*a*, 2013*b*; Gadamus and Raymond-Yakoubian 2015). The St. Lawrence Island Yupik communities of Gambell and Savoonga (Fig. 1) have the highest walrus harvests in Alaska, constituting over 80% of the annual statewide harvest in the past two decades (FWS n.d.). They also share the same culture and language and communicate with each other about walrus hunting through various mechanisms, including at EWC meetings and St. Lawrence Island joint tribal meetings. To keep discussions focused and manageable, knowledgeable and experienced St. Lawrence Island Yupik hunters were selected by the EWC to participate in the workshop. This paper presents a summary of the information provided by hunters and discusses the ways that information could be incorporated into the walrus population model. The purpose of doing so is two-fold. First, documenting the hunters' knowledge in a peer-reviewed publication helps make sure their knowledge is part of the accessible record of information about the Pacific walrus. Second, the process of applying that knowledge to the population model, as described in detail in the second section of the Discussion, may be relevant to other efforts to connect Indigenous and Western scientific knowledge (e.g., Gryba et al. 2021). The implications of both purposes are considered further in the Discussion and Conclusions.

1.1. Research ethics

The involvement of Indigenous Peoples in research and management concerning the natural environment has a long and complicated history (Huntington 1992; Gadamus and Raymond-Yakoubian 2015; Haven 2022; Jacobs et al. 2022). In recent years, various Indigenous organizations have defined a number of ethical principles to guide the equitable inclusion of Indigenous Peoples and their knowledge in both research and management (e.g., ICC 2022; Kawerak et al. 2024). These and similar statements emphasize several points. Studies and actions involving IK are particularly deserving of attention to ethics. Some knowledge cannot be appropriately shared outside the community in which it has been created and used. Full credit for information and knowledge must be given to those who hold and share it. Use of IK should reflect principles of data sovereignty (Kukutai and Taylor 2016; ICC 2022) and should only be used in partnership between management agencies and Tribal governments or Tribally authorized organizations such as the EWC, or the equivalent Indigenous governments and organizations in places other than the U.S.

With these considerations in mind, the workshop began with a review of dialogue agreements created by First Alaskans Institute, a statewide Indigenous organization, which are a set of principles to support full and respectful participation in discussions. The Inuit Circumpolar Council's definition of IK and principles for equitable research (ICC 2022) were also provided to all participants and reviewed as a group. The EWC provided consent forms for the St. Lawrence Island Yupik participants, to ensure that free, prior, and informed consent (United Nations 2007) was obtained before the discussions began. When those drafting the report were unsure of a point, we consulted with participants for clarification. The full report was reviewed by all participants in draft form, so that any sensitive or inaccurate information could be removed or corrected prior to public distribution of the document. Participants were allowed to choose whether to be included as co-authors, or to be named in the acknowledgments, or to remain anonymous. All chose to be coauthors.

1.2. Participants and positionality

Workshop participants were five St. Lawrence Island Yupik hunters (Daniel Apassingok and Iver Campbell from Gambell, Arnold Gologergen and Edwin Noongwook from Savoonga, and Bivers Gologergen from Savoonga and currently residing in Nome), plus the Executive Director of the EWC (Vera Metcalf, St. Lawrence Island Yupik from Savoonga and currently residing in Nome), FWS biologists (Joel Garlich-Miller and Devin L. Johnson, non-Native), and a meeting facilitator with extensive experience in documenting IK (Henry P. Huntington, non-native; Table 1). The hunters were selected by EWC based on expertise and availability. They ranged in age from their 40s to 70s. Four other individuals joined the workshop at different times. They include Mary David, Executive Vice President at Kawerak Inc. (the Tribally authorized consortium serving the Bering Straits Region); Sierra Smith, Kawerak's Natural Resources Division administrative assistant; Anna Rose MacArthur, Kawerak's Marine Advocate; and Su-

Fig. 1. Map of the region showing the range of Pacific walrus, the locations of walrus hunting communities in Alaska and Chukotka, and the communities involved in this study.

san Apassingok, EWC Commissioner from Gambell and wife of Daniel Apassingok (Table 1).

2. Methods

The workshop was conducted in a semi-structured format (Huntington 1998). Topics for discussion were circulated to participants before the workshop and provided as part of the agenda. In addition, a presentation by JGM and DLJ about the walrus population model provided a reference point for discussion about specific information needs. That presentation took place on the second day, allowing the discussions to start more generally and give all participants a chance to share their thoughts before steering the conversation in a specific direction. Additional information was provided by Anna Rose MacArthur about Kawerak's work regarding vessel traffic in the region on the second afternoon of the workshop. The order of discussion was allowed to develop naturally from the conversations that took place. At times, certain topics were used as prompts to guide the conversation when a previous topic had been discussed in sufficient depth, and to make sure that all topics were covered at some point during the workshop. All discussions were held as a group. Most of the discussions were in English. At times, the hunters would discuss particular topics in St. Lawrence Island Yupik, and then provide a summary for the non-Yupik speakers (Noongwook et al. 2007). Participants were free to say what they wanted, to explore related topics as they saw fit.

An important aspect of the discussions was the participation of the two FWS biologists. Both of them have extensive field experience with walruses, and one (JGM) has spent considerable time in both Gambell and Savoonga, as well as in other walrus-hunting communities around Alaska and Canada. Both took part in a four-week research cruise in the Bering and Chukchi Seas in June 2023, which also included three Yupik hunters, two of whom participated in the Nome workshop. This shared field experience provided a foundational relationship among workshop participants and a common reference point for discussions, as all four who had been on the cruise were able to refer to what they had seen

Table 1. Summary of workshop participants, workshop contributors, and members of the Pacific walrus population sustainability model steering committee.

Name	Affiliation	Role
	Primary workshop participants	
Daniel Apassingok	Native Village of Gambell	IK holder, walrus hunter
Iver Campbell	Native Village of Gambell	IK holder, walrus hunter
Arnold Gologergen	Native Village of Savoonga	IK holder, walrus hunter
Bivers Gologergen	Nome (Savoonga)	IK holder, walrus hunter
Edwin Noongwook	Native Village of Savoonga	IK holder, walrus hunter
Vera Metcalf[1]	Kawerak, EWC (executive director)	Meeting facilitator, IK holder
Henry Huntington	Huntington Consulting	Meeting facilitator, social scientist
Joel Garlich-Miller[1]	FWS	Walrus biologist
Devin Johnson[1]	FWS	Walrus biologist
	Additional contributors to workshop	
Mary David	Kawerak (executive vice president)	Organization
Sierra Smith	Kawerak (administrative assistant)	Organization/administration
Anna Rose Macarthur	Kawerak (marine advocate)	Presenter (vessel traffic)
Susan Apassingok	EWC commissioner (Gambell)	IK holder
	Pacific Walrus Population Sustainability Model Steering Committee[2]	
Jen Cate	FWS[3]	Biologist
Rebecca Taylor	USGS	Biologist/statistician
Joseph Eisaguirre	USGS	Biologist/statistician
Jacob Martin	EWC commissioner (Nome)	IK holder
Brian Rookuk Jr.	EWC commissioner (Savoonga)	IK holder

[1]Workshop participants who were also part of the model steering committee.
[2]Note that these individuals were not present during the 2023 IK workshop.
[3]Formerly with FWS.

(Huntington et al. 2011). The biologists were also able to share their own knowledge and experience, both from their fieldwork and from what they have learned from formal scientific publications and other sources. The result was an exchange and co-production of knowledge rather than a one-way flow of information from hunters to visiting researchers.

A workshop report (Metcalf et al. 2024) was drafted by the meeting facilitator (HPH) based on written notes taken during the discussions. The draft was first circulated to the workshop organizers (VM, JGM, and DLJ) so they could add pertinent details and information and correct any mistakes. Then the revised draft was sent to the five hunter participants so they could add, remove, or correct material as needed prior to approving the report for public distribution. That report is the basis for this paper, which was written collaboratively by VM, JGM, DLJ, and HPH, and reviewed and approved by the five hunter participants.

We note that both the workshop format and the process of converting hunters' knowledge to written form introduce biases to the information reported here. A workshop is not the way that IK is transmitted among members of a culture or community. It is thus an artificial environment for doing so, the more so since most of the discussions were conducted in English. St. Lawrence Island Yupik has a rich and detailed vocabulary for sea ice, walruses, and other features of the environment and of human relationships with the environment, which may be difficult to translate into English, especially without a common basis of experience with those phenomena. English has technical terms and jargon that do not have commonly used equivalents in St. Lawrence Island Yupik. For example, as described below, the concept of "sustainability" resulted in a lengthy discussion in Yupik to identify an appropriate way to express the central idea.

In a similar way, a written report removes knowledge from its context, so nuance and detail can be lost in ways that would not occur if knowledge were being shared during walrus hunting activities or with others similarly experienced in the local environment. The fact that the report was drafted by those with academic backgrounds creates another potential source of bias in terms of what is understood and how it is expressed. As one way of reducing bias, we have presented a summary of all the topics that the hunter participants deemed worth reporting, rather than attempting to filter information according to its direct relevance to walrus ecology or to the walrus population model. Aware of these biases, we nonetheless hope that the information presented here is useful and interesting.

3. Results

The contents of the discussions have been organized thematically here, chiefly around topics that are relevant to the walrus population sustainability model. Additional information from the workshop discussions is also included where the authors believe it may be of interest to readers or is otherwise worth documenting to make it available in the future.

A small amount of information has not been included, either because it was not deemed to be of wider interest, or because it addressed sensitive topics that are best shared at the discretion of the communities and their Tribal governments. The omission of such information does not affect the accuracy of what is presented here.

3.1. The role of sea ice

Hunters identified the loss of sea ice as the major threat to the well-being of individual walruses as well as the walrus population. Sea ice is the preferred resting platform for walruses. Walruses are not usually seen when there is no ice, although some females are typically seen on or around the Punuk Islands in early fall before the ice comes, and some walruses haul out on land at that time. Females with calves used to arrive earliest in the fall, sometimes before the ice, but this is not seen any more. Now around St. Lawrence Island, more yearlings and bulls are seen in the fall (and fewer females with calves), and they come later. The biologists noted that over the past decade, large herds of walruses, including female walruses and their dependent young have occupied coastal haulouts in Chukotka Russia well into November and December, suggesting that the seasonal distribution of animals had shifted over time.

Hunters noted that in the winter of 2018–2019, when little sea ice was present in the Bering Sea even in mid-winter, walruses nonetheless found and used the ice that was available, in preference to hauling out on land. St. Lawrence Island hunters are aware of large walrus haulouts in late summer near Point Lay in Alaska and in Chukotka, Russia, but recognize that these are used when no sea ice is available. While walruses are known to haul out on St. Lawrence Island from time to time, this behavior typically involves only a few animals at a time. Hunters sometimes harvest walruses on land on St. Lawrence Island when they are in need, but otherwise leave the haulouts alone and do not publicize their whereabouts to avoid disturbance.

In spring, walruses are sometimes seen in the area after sea ice has melted, but again are seen swimming northwards in the direction of remaining sea ice. During the spring migration, sea ice provides both a resting platform and a way for walruses to be transported northwards by currents, sparing them the effort of swimming the entire distance.

In fall, walruses may arrive near St. Lawrence Island in advance of the formation of sea ice but are often seen swimming in the direction of sea ice. Hunters can follow them to the sea ice where they may find more walruses. When the ice arrives in fall, it brings lots of animals with it, including walruses.

Walruses are coming later in fall and moving north earlier in spring. Often, the walruses are gone from around St. Lawrence Island by mid-May, instead of staying through June as they used to.

There is concern that less ice will mean a northward shift in the distribution of walruses, away from St. Lawrence Island. There has been a shift toward more male walruses in October and November in recent years. Walruses in general are less abundant in fall around St. Lawrence Island than they were before sea ice patterns began to change.

Formerly, the ice would remain intact along the north shore of St. Lawrence Island into May, after which hunters in Savoonga could finally get out on the water. Hunters learned over time how to make use of the natural forces that create open leads in the ice. The Elders used to say that June was the best month for hunting walruses. Then May became the best month, and now it is not clear. There is less shorefast ice near Savoonga and the ice that is there is often not grounded firmly, and thus less reliable. As one hunter put it, today's ice is first-year ice, not "walrus ice". With thinner ice and more open water, a single warm spell in spring can cause the ice to melt, leading to a shorter hunting season and a greater need to travel far to find walruses.

Multiyear sea ice used to come south in October and into the fall and run aground near the island, remaining there all winter, but this is not seen any more. It used to be regarded as the first sign of winter. Hunters would know the ice was coming soon. Today's thinner ice does not stay as long in spring.

Walruses can maintain breathing holes in sea ice. Hunters used to go a few miles north of Sivuqaq Mountain in Gambell to find such holes and hunt walruses there. Some walruses would stay there for the winter. Today, it is unsafe to go out on the ice, which is too unstable.

Walruses have been known to get trapped out of the water when the ice freezes or closes in, especially on the north side of St. Lawrence Island when ice comes from the northwest in early winter. When trapped on top of the ice, walruses can be vulnerable to being buried by pressure ridges that are forming. (Hunters found many dead seals after a storm some years ago, perhaps crushed in the ice.) Some walruses have traveled overland to reach the south side of the island and open water. One walrus was seen on Sivuqaq Mountain a few years ago. Walruses can get frostbite if they are exposed to cold air. Their snouts sometimes show abrasions and cuts, perhaps from trying to maintain an opening in the ice. There has been no change noted in the frequency or number of stranded walruses. Instead of storms from the northwest, there are now sometimes winds from the south that bring warm water and air, melting snow and ice around the island.

Walruses may abandon the ice if there is a storm, especially if the ocean swell moves through the ice. Walruses will also use the ice for protection from big waves and wind, just as hunters do.

3.2. Walruses in open water

Although walruses generally haulout on sea ice or land to rest, walruses swimming in open water are able to rest when they need to. Males can inflate the air sacs in their throats to provide flotation as they rest. Females may come together with their calves to form a raft of animals as they rest. They rest face-down in the water in the same way that seals do, lifting their heads to breathe as needed. As noted earlier, walruses in open water are often seen swimming in the direction in which sea ice is expected. Agency biologists noted that telemetry data (tracking data from satellite linked transmitters) suggests that walruses (of both sexes) can stay at sea under open water conditions for more than a week before coming to shore to rest (Jay et al. 2022).

3.3. Female walruses and calves

Lone walrus calves are rarely if ever seen on sea ice (in contrast to bearded seal (*Erignathus barbatus*, Erxleben 1777) pups). Female walruses stay with the calves. Calves can ride on their mothers' backs when the mothers are swimming. Females are often seen in groups, raising the possibility that females may leave their calves with other walruses during the times the mother walruses are feeding. Hunters have not confirmed such behavior, however. Females are known to be protective of calves, and other females will protect a calf if its mother is taken. Females with young calves are often seen on the edge of groups of walruses, perhaps to reduce the risk that the young calf is trampled. Older calves may start to stray farther from their mothers, starting to separate and preparing to go on their own. Juvenile young past weaning age (up to 4–5 years old) occasionally stay with their mothers even when they are with their new calves.

Calving occurs in spring, as early as March and as late as June, with April and May being the main calving period. Walruses typically haul out onto sea ice to give birth to a calf. Twins are rare but not unheard of. No differences in the timing of calving have been noted by St. Lawrence Island hunters. Hunters had not seen evidence of calving occurring in open water or land, just on sea ice, however they speculate that birthing could theoretically occur on land if ice was not available. An agency biologist shared that he had been told by St. Lawrence Island hunters that walruses occasionally give birth in the water, and that you could identify a calf born in water by an unusually long umbilicus. Pregnant females can be identified because they are fat and wide. They fatten up before calving, to store energy they will need for nursing and for the period when they may not be able to feed as much as usual because they are tending their calf. Walruses are able to go long periods without eating.

Hunters have heard reports of more females with newborn calves around Diomede and Wales, suggesting that walruses are shifting northwards in response to less sea ice. Calving locations vary with the ice.

Some female walruses are almost as large as males, but these have not been seen for 10–15 years around St. Lawrence Island. One hunter noted that he saw several during the FWS walrus cruise in the Chukchi Sea in June 2023, near the village of Wainwright. Hunters have mistaken these large females for males and note that they have thick tusks and bumps (bosses) on their necks like the males do. Hunters wondered if these were females that were past reproductive age.

Hunters had no observations of breeding areas or breeding behavior or the timing of breeding. (It is presumed to take place south of St. Lawrence Island in January/February).

3.4. Feeding behavior and prey

Walruses feed primarily on clams, although other species are also found in walrus stomachs including tubeworms, sea peaches (tunicates, or *uupa* in Yupik), brittle stars, and even seabirds. Males and females appear to have the same diet. One hunter who now lives in Nome noted that the stomach contents of walruses taken near Nome are different from those taken near St. Lawrence Island, suggesting that walruses feed on what is available. Hunters are not aware of any major changes to the productivity of seafloor areas where walruses feed.

The bay between Gambell and Savoonga is a foraging ground for bull walruses. Walruses taken in this area have many clams in their stomachs. Females prefer the open sea rather than a bay where they could become trapped with their calves. Males may forage in riskier areas, deeper water, or rougher conditions.

St. Lawrence Island residents see fewer tunicates on the beaches. Less ice and more violent storms may be harming the tunicates in near-shore waters. Former hot spots for marine life are not as abundant as they were before sea ice patterns began to change.

Some walruses prey on seals and at times on other walruses. This feeding behavior is regarded as being limited to specific individuals, rather than as an occasional behavior by the majority of walruses. Hunters say this is done by walruses that were orphaned as calves, so their mothers never taught them how to forage on the seafloor. There is a specific word in Yupik for these walruses, *angeyeghaq*. Their tusks are yellowish and stocky. Stomachs of these walruses have strips of seal skin that look like they were cut by a knife. Hunters usually avoid taking these walruses, and they are more aggressive towards boats in the water than other walruses. Traditional lore says that eating these walruses may cause baldness, and also that the livers of these animals may not be safe to eat.

Biologists noted that there has not been a walrus diet study in the region for over 20 years.

3.5. Body condition and health

Hunters report that walrus body condition has been good in recent years. There are currently few concerns about the health of individual walruses in the St. Lawrence Island area, or about the population as a whole. Hunters occasionally see a sick or skinny walrus, but not often. One hunter said that the quality of walrus meat has gotten better and better over the past several years, an indication that the walrus population is doing well.

Some large male walruses have been seen without tusks. There is a word in Yupik for these walruses, and hunters say they have seen more in recent years. Walruses also occasionally have more than two tusks. A six-tusked female walrus was caught about 15 years ago.

3.6. Predation

Hunters see more killer whales (*Orcinus orca*, Linnaeus 1758) around St. Lawrence Island in the fall time than they used to. Walruses are scarce when killer whales are around. A few years ago, a walrus was found on the shore, nearly dead and looking badly beaten. The hunter thought it might have been done by a killer whale.

3.7. Disturbance

Hunters are concerned about disturbance to walruses from ships, offshore oil and gas activity, aircraft, and other industrial activity in the region. The presence of a research ice-

breaker south of St. Lawrence Island for several springs not long ago was seen to affect the migration routes of marine species near Gambell. When the vessel was moved to the north of the island, hunting returned to normal. Hunters see industrial disturbance as a potential threat to the well-being of the walrus population, and as something that can be addressed in part by appropriate regulation and governance of shipping as well as by technological advances such as quieter ships.

Military activity is also a concern, from both ships and the use of sonar.

Noise from jets can also disturb walruses, even if the jets are high above. Aircraft coming to the island can also disturb walruses in the local area, making them harder to hunt.

Walruses will get agitated if there are many boats nearby during a hunt. They will often get in the water if this happens. They seem to be easier to spook in cloudy weather or late in the evening. They are very vigilant in the fog. Females tend to be more alert than males, especially if they have calves. The females will tend to the calves first, pushing them into the water if there is a disturbance. Walruses are highly sensitive to both sounds and smells, and hunters always try to approach from downwind to avoid being detected. Walruses that have heard gunshots before may react more quickly to hunters. If there are many ice floes, walruses may first move from one floe to the next when disturbed, and then leave the area if they continue to be disturbed.

Elders would say to avoid an area for a few days after harvesting walruses there, to let the remaining animals calm down from the disturbance. Hunters who return the next day may get no harvest because the walruses remain wary. Increased or continued human activity in the region could cause the walruses to remain wary for most of the time, making them harder to find and to hunt.

Hunters expressed concern about disturbance from commercial shipping traffic, and wondered what if anything can be done to reduce such disturbance. Anna Rose MacArthur talked about the work that she does for Kawerak, at the International Maritime Organization and with the U.S. Coast Guard and others. She can represent hunters' concerns in those settings and help create opportunities for hunters to take part and speak for themselves. While it is unclear how much commercial shipping will increase, one concern is that the start of year-round shipping, rather than just during the ice-free season. There is also concern about bottom-trawlers and what they might do to walrus feeding habitat.

Much foreign marine debris is found on St. Lawrence Island beaches nowadays, and the trend is increasing. The effect on walruses is not known. Hunters have not noticed plastic or other debris in walrus stomachs, or walruses entangled in fishing gear.

3.8. Walrus harvest

Hunters are concerned that changing conditions, including the earlier and more rapid loss of sea ice as well as more frequent storms, may reduce their ability to provide sufficient walruses for their communities. Traveling through open water is more dangerous than traveling with ice around, since the ocean swells are larger and there is no protection if the weather and waves turn bad. If walruses are far away, trips take a long time and require a lot of costly fuel. This is becoming more common, as the period in which walruses are close to the island decreases. Some hunters report traveling very long distances (>80 miles) by boat and making overnight trips to reach walruses, which is much further than they have needed to go in the past. Hunters are sometimes only able to make two or three trips a season, which can undermine the communities' food security, since hunters provide for the whole community. Tribal ordinances established in 2010 limit hunters to four walruses per trip. This limit is for safety, since the boats used on St. Lawrence Island cannot transport more than four walruses at a time, and for conservation, to make sure the walruses are fully utilized. Hunters need to make best use of the suitable days for hunting during both spring and fall migrations. One hunter noted that his sons regard current conditions as normal, and he tells them that there used to be periods of good hunting weather lasting a week or longer, not just for a brief period as is typical nowadays. The cost of hunting, especially involving long trips, is increasing, leading to there being fewer hunters. Often hunters and their families have to give up a lot to pay the cost of hunting.

St. Lawrence Island hunters harvest males, females, and calves. Female walrus skins were used to cover the *angyapik*, or skin boats, used by St. Lawrence Island hunters. The skins of large females were preferred due to their combination of toughness and elasticity. Since these boats are no longer used, at least not as much, the demand for female walrus skins has diminished. Hunters did not note any trend in the age or sex composition of the harvest. One hunter noted that younger hunters today will take what they can find, rather than specifically seeking females and calves. It was also noted that although, due to changes in sea ice and the timing of the spring walrus migration, the spring harvest window is shorter in recent years when females and their calves are available, there may be more opportunity in the fall and winter to harvest males near the island.

Hunters do not anticipate an increase in harvest levels, though year-to-year variability is high since so much depends on weather and ice conditions and also on the distance from the communities to the animals. If anything, hunters think the harvest may decline as sea ice and weather conditions become less reliable, the cost and risk of harvesting increase, and as there is less interest in and knowledge of walrus hunting by future generations.

In the 1950s, 1960s, and 1970s, there was an abundance of solid ice, with minimal disturbance. Walrus hunting conditions were ideal. Today, less ice and more disturbance from ships and other sources makes it harder. Hunters like to look for solid ice to find walruses, but cannot find it nowadays. The key for the future is adaptability, by both walruses and hunters.

3.9. The concept of sustainability

The hunters in the workshop discussed the idea of "sustainability" in Yupik for some time. Translated into English, the

Yupik words that were used refer to "not going beyond" and "not wasting or causing harm" (*yayasigpenasi*).

St. Lawrence Island hunters pay close attention to the health of walruses and to the state of the population as a whole. Traditional ways say that hunters should only take what they need, and take good care of what they harvest before going out for more. Sharing is also an essential part of the relationship between people and walruses and also the relationships within the community. Sometimes other people would take everything the hunters returned with, if they needed it.

When assessing the sustainability of the walrus population and walrus hunting, workshop participants were concerned chiefly with the loss of sea ice and with disturbance from industrial activity. An additional idea was to be aware of places where walruses were near the limits of their range, for example on sea ice near the edge of the continental shelf, so as not to disturb them when they are most vulnerable.

Hunters also suggested that to protect the walruses, protecting their food would be essential. Hunting is not seen as a threat to the walruses, compared with other changes in the ecosystem. Protecting on-land haulouts is also seen as a priority for the well-being of the walrus population.

Some hunters remembered a period of relatively low walrus abundance in the 1950s, including one year when their boat took no walruses. It is important to keep the population stable. Too high a population could lead to a crash, which no one wants to see again.

The participating hunters also expressed appreciation for the walrus population sustainability model and the work that is going into it, noting that it will provide useful information for hunters and for Tribal governments to consider.

3.10. The future of walruses and walrus hunting

Hunters recognize many unknowns and many assumptions in thinking about the future of walruses and walrus hunting, including how walruses will respond to continued loss of ice, how harmful algal blooms (HABs) will affect walruses and their prey, how their feeding grounds will be affected, and more. Adaptation will be the key, for walruses and for walrus hunters.

For walrus hunting in particular, sustaining the knowledge that has been passed down and added to with each generation is essential. The ocean and sea ice can be hazardous, and knowing how to navigate and how to recognize danger is essential. Modern navigation and communication tools are helpful, but hunters still have to know what to do. This includes understanding wind and currents and signs from other animals, as well as understanding walruses. Sharing information among hunters has always been important and remains so today. Language is also important, such as the terminology for sea ice that allows hunters to communicate effectively and efficiently with one another by describing where they are in the ice.

There was some concern about younger hunters' interest in and knowledge of walrus hunting. Many Elders see this as a large issue and want to impart their knowledge and traditions on the next generation. This is why the EWC held a Young Hunters Summit and why they are seeking funding to do more work of this kind. Some hunters are concerned that fewer young people are interested in taking part, but there are also many young hunters who are helping their friends get involved in hunting.

3.11. Other observations

When there was more shorefast ice, hunters would see more bearded seals, which often had pups on the ice. Nowadays, this is not seen as often.

Harmful algal blooms are a concern for St. Lawrence Island hunters. No observations have been made of walruses that appear to be affected by neurotoxins. Hunters are aware that clams in the region may be affected by HABs, and that this could affect humans who consume clams from walrus stomachs. While hunters can send clams from walrus stomachs to be tested, there is no rapid analysis capacity in the Bering Straits region, so getting results may take months.

Hunters would like to learn the English and Latin names of the invertebrates they eat, so they can be sure they are discussing the right species with scientists, especially concerning potential exposure to HABs.

4. Discussion

4.1. Significance to the Eskimo Walrus Commission

Initially, the EWC was approached by FWS with a long list of questions about what their researchers wanted to know about Pacific walrus and our relationship with them to use in developing a "harvest risk assessment" computer model. This approach was fairly typical of the usual way business was done and the way Western scientific research, in general, has been conducted in the Arctic—one-sided and extractive (ICC 2022; Kawerak et al. 2024).

With this history in mind, the EWC proposed a different approach that could offer a much more successful result for the goals of Pacific walrus conservation and management. The Commission recommended creating a new initiative that would involve Alaska Native communities and IK experts from the beginning with the assumptions and questions that are necessary to consider in any modeling effort and on to examining the implications for the model. The commission suggested that even the term, "harvest risk assessment", negatively characterized the protected Indigenous right to harvest walrus for food security and cultural vitality.

A substantial advantage in this case was the long-standing collaborative and co-management agreement between the EWC and the FWS provided a foundation for a different approach. The Pacific walrus population sustainability model framework was identified as a shared research need between the two groups in 2020. A steering committee comprised of FWS, U.S. Geological Survey (USGS), and EWC representatives (Table 1) helped to guide the early development of the model and identified the need for the IK workshop described in the present study. FWS and EWC personnel (including DLJ, JGM, and VM) traveled to walrus-hunting communities (Gambell

and Savoonga) in Spring 2023 to present on the background of the model and invite participation in the workshop, and VM helped to identify interested IK holders as workshop participants. The semi-structured format and prolonged schedule of the 3-day workshop allowed time for FWS personnel to explain the model framework at length, and facilitated a stronger and more natural exchange of knowledge and ideas than may have been possible in a more abbreviated or official setting.

The longer-term importance of this work together is the increased confidence and acceptance of its potential implications to harvest management decisions. Many actions have been taken already, including Tribal rules concerning safety and the full use of harvested walrus (Demer 2017). More actions will likely be needed, regarding the walrus population and its habitat, as well as harvest levels and logistics. In the view of the EWC, the workshop and this paper reflect the value of taking time to collaborate properly on research and studies that directly affect Alaska Native communities. The EWC will continue to advocate for ongoing co-production research and discussions on walrus, the environment we share, and how Alaska Native communities will maintain their close dependent relationship with them. One workshop does not address all the needs of the walrus and the EWC, but a strong collaboration sets a good standard for future work together.

4.2. Relevance to population modeling efforts and other management applications

The Pacific walrus population sustainability model (Johnson et al. 2024*a*, 2024*b*) was designed to incorporate the best available knowledge of walrus biology and behavior to ultimately simulate the projected future status of the population and identify and promote subsistence harvest sustainability. In the development of this modeling framework, the FWS and Tribal partners identified key knowledge gaps in the formal scientific literature that could potentially be best addressed by experienced walrus hunters and IK holders. Thus, a primary goal of this workshop and study was to facilitate the co-production of knowledge relevant to this population model, providing an opportunity to (a) corroborate and compare knowledge and assumptions from Western science with IK; (b) solicit IK to fill key data gaps in the modeling framework; and (c) identify shared directions for future research.

The information generated at the workshop has been incorporated into two published walrus population models: a Population Consequences of Disturbance (PCoD) model (Johnson et al. 2024*a*) and a Harvest Sustainability Analysis (HSA) (Johnson et al. 2024*b*). As described below, IK directly informed bioenergetic model parameters, aided in the identification of key population stressors, and influenced the parameterization of those stressors in future scenarios (Johnson et al. 2024*a*, 2024*b*).

The information shared during the workshop is also being incorporated into an SSA for Pacific walrus (FWS n.d.), expected to be completed by summer 2025. The SSA provides an in-depth review of the best available information gathered from western science and IK sources related to the biology and ecology of the species, the current status of the species relative to historical conditions, and a forecast of future conditions likely to influence the status of the population over time. The SSA is intended to inform future management actions and policy decisions for Pacific walruses under the Marine Mammal Protection Act and Endangered Species Act.

Here, we assess the information in terms of corroborating documented knowledge about walrus, adding information that is new to the documented record (though of course not to the hunters), and suggesting productive lines for further research.

4.2.1. The role of sea ice

Corroboration: Generally, the formal scientific literature corroborates with the hunters' IK on both the importance of ice for walruses and recent trends in sea ice condition. Pacific walruses are well-known as an ice-associated species, using sea ice as a platform to rest on between foraging bouts and during migration and as a substrate on which to give birth (Fay 1982). Hunters note that sea ice is the preferred resting substrate for females, calves, and juveniles, and that land-based haulouts are only occupied in abundance when sea ice is not available, which is consistent with studies of walrus movement from satellite telemetry data (e.g., Jay et al. 2022). Hunters describe seasonal variability, a decline in multi-year ice, and a lengthening of the ice-free interval in recent years, which is also in agreement with the formal scientific literature (e.g., Jay et al. 2017; Udevitz et al. 2017).

Information new to the modeling effort: Hunters provided novel information regarding walrus behavior in and around the sea ice. Wintertime observations of walruses becoming trapped above the ice and being forced to make overland migrations may be novel information. Hunters raise concerns about changes to the distribution of walruses with a changing ice regime away from St. Lawrence Island. Hunters also note the importance of sea ice to aid migration: icebergs floating northward on strong currents may reduce the bioenergetic cost of migration for females and calves when ice is available. Hunters' comments generally underscore the importance of the sea ice stressor in the PCoD model from a bioenergetic standpoint.

Areas for future research: No specific areas for future research were identified related to walruses and sea ice.

4.2.2. Walruses in open water

Corroboration: It is known to both Western scientists (e.g., Fay 1982) and IK holders that male walruses possess pharyngeal sacs in their necks that provide floatation in the water, allowing them to rest and sleep at sea. However, since females lack this physiological adaptation, Western scientists assumed that females and calves must rest on ice or land more regularly (particularly to sleep) and cannot spend long periods of time in open water (e.g., a maximum of 4 days; Pryaslova et al. 2009). However, some satellite telemetry data may indicate adult females spending upwards of 7 days at sea (Jay et al. 2022).

Information new to the modeling effort: Hunters share that females, juveniles, and calves have been known to come together to form rafts which may allow resting behavior in open water, particularly for calves situated on top of the rafts. This directly informed our calculation of the "terrestrial haulout day" parameter in the PCoD model, which determines how many days simulated walruses can be in open water continuously before they need to rest at a terrestrial haulout (Johnson et al. 2024*a*). Following the workshop, this parameter was adjusted from 4 days to 7 days to reflect the ability of females and calves to rest in open water to some degree.

Areas for future research: Future satellite telemetry studies in conjunction with high-resolution sea ice data would provide more reliable information regarding the duration of time walruses can spend in open water, and any documentation (e.g., photos) of rafting behavior would be of particular interest.

4.2.3. Female walruses and calves

Corroboration: Little Western scientific information exists regarding behavioral observations of mothers with their calves on the sea ice, although hunter' observations of calving, twinning, and potential adoption behavior are consistent with the literature (e.g., Fay 1982).

Information New to the Modeling Effort: Hunters report that although young calves are never left alone on the sea ice, they could potentially be left with groups of other females while the mother goes in the water to forage. They also report young calves riding on their mothers' backs in the water, which has also been observed by the FWS biologists. For this reason, the biologists modified young calf activity budgets and metabolic rates in the PCoD model to assume that they spend the majority of their time resting for their first 90 days of life (Johnson et al. 2024*a*). After 90 days, they are assumed to accompany their mothers on all swimming and foraging bouts. Although hunters have never observed birthing on any substrate but sea ice, they speculate that birthing could theoretically occur on land if ice were not available. For this reason, we do not consider the birthing substrate component of sea ice availability to be a key factor in the PCoD model or SSA analysis.

Areas for future research: A satellite telemetry data/accelerometer study of female/calf pairs could provide much-needed data regarding differential activity/energy budgets between calves and their mothers.

4.2.4. Feeding behavior and prey

Corroboration: IK of walrus diet and foraging behavior closely mirrors what is known in the formal scientific literature (e.g., Fay 1982; Sheffield and Grebmeier 2009). A broad prey base and dietary flexibility are noted by the hunters, which coincides with recent diet studies (e.g., Clark et al. 2019; Sonsthagen et al. 2020).

Information new to the modeling effort: Hunters report a reduction in tunicates (*upaa*, also an important walrus prey item) available on St. Lawrence Island beaches in recent years, perhaps due to changes in the ice and storm regime. They also note that benthic hotspots generally seem less abundant than they have in the past, though still capable of supporting walruses. Information regarding prey availability and diet flexibility informed the parameterization of the "prey availability" stressor in the PCoD model and SSA analysis.

Areas for future research: Both IK holders and FWS scientists identify future walrus diet and foraging behavior studies to be very important for documenting the species' response to climate change, and propose that looking at diet in different regions and different seasons would be particularly informative.

4.2.5. Body condition and health

Corroboration: Hunters' characterization of walrus body condition and the health of the population is consistent with the most recent available population and demographic estimates (Taylor et al. 2018; Beatty et al. 2022), which point to a large and healthy population that is largely recovered from a decline the population experienced in the mid-late 1900s.

Information new to the modeling effort: There was no novel information on this topic.

Areas for future research: Continued monitoring of walrus body condition and screening for diseases and biotoxins (e.g., HABs, avian influenza such as H5N1) will be important to characterize the health of the population into the future.

4.2.6. Predation

Corroboration: Increased recent sightings of killer whales by hunters are consistent with a documented northward range shift for the species: killer whales are spending more time in the Chukchi Sea with diminishing sea ice (Stafford et al. 2022). They may thus represent an increasing source of predator-prey interactions for walruses.

Information new to the modeling effort: There was no novel information on this topic.

Areas for future research: None identified by this group.

4.2.7. Disturbance

Corroboration: Hunters' descriptions of walrus sensitivity and behavioral response to anthropogenic noise and vessel presence is corroborated by some Western behavioral studies (e.g., Fay et al. 1984; Garlich-Miller 2012), and contrasts with others. Notably, studies associated with documenting walrus behavioral response to oil and gas activities based on observations by shipboard observers report minimal response to vessels in close proximity (e.g., Ireland and Bisson 2016).

Information New to the Modeling Effort: Hunters report that walruses are very sensitive to both sounds and smells. Females with calves are more sensitive than males, and animals that have been disturbed recently (even several days after disturbance) remain wary and are disturbed more easily. Hunters also report that aircraft noise from jets is enough to

initiate disturbance events at haulouts. Overall, hunters are particularly concerned about the effects of increasing vessel traffic (particularly commercial shipping traffic) on the walrus population. In response, FWS biologists developed a protocol for characterizing the effects of vessel disturbance on walrus behavior and bioenergetics, and are incorporating it into the SSA analysis as a primary stressor (FWS n.d.).

Areas for future research: Further study documenting walrus behavioral response to different types of anthropogenic disturbance (e.g., drilling rigs, seismic vessels, icebreakers, vessels of different sizes, aircraft) at different ranges and in different situations (e.g., walruses in water, on ice, on land, with/without calf) would greatly aid future iterations of the modeling effort.

4.2.8. Walrus harvest

Corroboration: Hunters report that changing sea ice and storm regimes have contributed to a shorter springtime hunting season, and required them to travel further to harvest walruses at increased personal and financial risk. This pattern has been identified in previous IK studies (e.g., Metcalf and Robards 2008; Brinkman et al. 2016), and may be reflected in the relatively low harvest levels observed over the past decade (FWS 2023; Johnson et al. 2024*b*).

Information new to the modeling effort: Hunters note that the traditional springtime harvest season is shorter, a time when females and calves are more readily available than males. A changing ice regime may add opportunity for a larger harvest in the fall and winter, when males may be more available. Although calves and females remain a favorite food source for the people of St. Lawrence Island, there is less need to take females: their skins were traditionally used for skin boats which have largely been replaced by modern alternatives. Hunters predict that harvest levels are unlikely to increase and more likely to decline as sea ice and weather conditions become less reliable, the cost and risk of harvesting increase, and as there is less interest and knowledge of walrus hunting by future generations. This information was incorporated into the parameterization of the subsistence harvest stressor (and associated discussion) in the SSA future condition analysis (FWS n.d.).

Areas for future research: Continued monitoring of the walrus harvest will be particularly important to promote sustainable harvest levels into the future. Continued outreach and education programs for young hunters are also imperative so Elders may pass their knowledge of IK hunting on to the next generation.

5. Conclusions

The quantity and quality of information presented here suggests that the workshop, especially one involving Indigenous experts and Western scientists with existing relationships with those hunters, is an effective method for engaging IK holders and documenting at least some aspects of IK (Huntington et al. 2002). The format of the Nome workshop created a relaxed and congenial forum for conversations, building on established cooperative relationships among many of the participants. A 3-day event allowed time for travel delays or early departures in anticipation of bad weather, without creating a rushed feeling to the conversations. The available time also allowed for breaks and adjournments when the discussions slowed, which also gave participants time to think over the discussions and return with additional ideas.

That said, a 3-day workshop with a handful of participants cannot hope to document more than a small fraction of available knowledge about walruses or any other topic. The prior experience of the academically trained researchers in and around the communities was helpful in providing a basis of shared experience, allowing for more sophisticated discussions than might have been possible without that degree of shared context knowledge (Ferguson et al. 2022). Nonetheless, a great deal more in-depth and in-place research would be required to better understand and document more fully the relationship between St. Lawrence Islanders and the Pacific walrus. Indeed, documenting such knowledge in anticipation of future needs may be fruitless, insofar as it is impossible to fully document such an extensive and evolving system of knowledge. The inclusion of IK in research and governance thus requires the inclusion of IK holders in substantive and continuing roles. The Nome workshop was one example of doing so in relation to the walrus population model, but should not be understood as an attempt (much less a successful one) to document Yupik knowledge about walrus as a comprehensive and completed effort.

Calls for the inclusion of IK in research and management are not new (Johannes 1981; Johnson 1992; DeWalt 1994), but recently strengthened U.S. federal requirements and a growing body of practice have increased the need and desire to engage with IK holders. The Nome workshop described here is one example of collaborative engagement between a federal agency and a Tribally authorized organization. While the development of the walrus population model is a federal agency initiative, the workshop itself was designed and conducted collaboratively. The motivations of the government agency and the Indigenous organization differed but did not conflict. The FWS sought information that could help improve the model, as well as recognition of its willingness to engage substantively with holders of IK. The EWC sought to make sure the model included IK and reflected Native concerns, as well as broader recognition for the breadth and value of IK.

In broad terms, these ambitions were achieved (in part through publication of this paper), though perhaps not fully insofar as there is an inherent mismatch in attempting to convert IK developed to sustain the human-walrus relationship into the parameters for a quantitative model. Nonetheless, we hope the experience presented here offers one example of a reasonably successful and mutually respectful collaboration between IK holders and academically trained scientists, and between Tribal and other Indigenous organizations and government management agencies. We also hope that others will continue to carry out similar work, improving both the theory and the practice of ethical and effective engagement of IK and its holders in research and management.

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The data from this workshop are the information presented in the Results section of this paper, which were included separately in a report to the EWC (Metcalf et al. 2024).

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