"The Ocean Is Always Changing"

Nearshore and Farshore Perspectives on Arctic Coastal Seas

BY ANN FIENUP-RIORDAN AND EDDY CARMACK

ABSTRACT. This essay shares the broad outlines of Yup'ik and Inuit views of their coastal environment, with special emphasis on the role of sea ice and ocean swells. Nearshore conditions in the eastern Bering Sea and Canadian Arctic are used to show how shared knowledge can benefit both local residents and scientists working to better understand coastal processes. We propose a strategy that will allow integration of observations that occur at different scales, required to improve communication between stakeholders in a rapidly changing Arctic. The emerging question is how local observations can be linked to larger environmental issues in ways that speak to both indigenous and Western concerns.

Figure 1. Yup'ik elder Simeon Agnus sharing *qanruyutet* (instructions) during a trip with youth and elders around Nelson Island, July 2007. *Photo credit: Ann Fienup-Riordan*

INTRODUCTION

In a world repeatedly exposed to change and the collapse of crucial social and ecological systems, it is imperative to close the gap between indigenous and Western understandings of the coastal environment and nearshore waters[1] and to use this combined understanding in the development of new policies (e.g., basic rules upon which decisions are made). This is not easy; it means making full use of all forms of knowledge available to us as a species. In a positive light, the last decade has seen an exponentially expanded interest in the use of local and traditional knowledge, both to inform Western scientific observations and in its own right. The two approaches are complementary: The strong oral traditions of indigenous peoples carry a deep experiential understanding of the world that is passed on through narrative and demonstration, while Western science advances through measurement, hypothesis testing, and modeling. We show here that the two approaches, working alongside with trust, can be stronger than the sum of their parts. One of us (Fienup-Riordan) is an anthropologist who has sought out collaborations with Western scientists to inform our understanding of Yup'ik knowledge (Fienup-Riordan, 2007; Fienup-Riordan and Rearden, in press). The other (Carmack) is an oceanographer who represents the other side of that coin; while he has worked with an Inuit elder in Canada to inform understanding of physical and biological processes (cf. Carmack and Macdonald, 2008), most of his career has been spent in conventional Western investigation. While our experiences and understandings of the ocean are very different, each can enrich the other in important ways.

A large proportion of oceanographic investigations are carried out on large spatial scales far to sea, with less focus on the nearshore waters of small, coastal villages. Whereas oceanographers attempt a comprehensive understanding of the ocean, from the surface to the seafloor, Yup'ik and Inuit hunters are most concerned with surface features of the water and ice cover that impact hunting success and safe travel. Yet, coastal Yup'ik residents also see the ocean as an integral part of *ella*, a word that translates as weather, world, universe, and awareness, depending on context. Contemporary Yupiit may also use *ella* to denote atmosphere, environment, and climate. Clearly, the Western concept of the ecosystem as an integrated system of natural and cultural phenomena is not new to Yup'ik people (see Folke et al., 2004, for a "resilience" perspective). For example, Paul Tunuchuk of Chefornak exclaimed: "Everything inside *ella* has customary teachings and instructions attached to it—air, land, and water. And they [the ancestors] mention that we must treat it with care and respect. What will become of us if we don't treat it with care?" (March 2007:216)[2] The emerging question, then, that concerns both indigenous and Western ocean observers: How can we link local observations with large-scale environmental issues in ways that respect and build on both knowledge systems? We refer to activities that involve partnerships between traditional and Western approaches as co-science.

TOWARD A DEEPER UNDERSTANDING OF LOCAL AND TRADITIONAL KNOWLEDGE

For the purposes of this article, the term Western science refers to investigation based on the long-established scientific method, namely, a body of techniques or uniform rules for formulating, testing, and reformulating hypotheses based on systematic observation, measurement, and experiment (cf. Gauch, 2003). Western science is analytical, reductionist, positivist, objective, and quantitative. As a result, Western scientists typically put their objects of study into simplified, controlled experiments, thus isolating themselves from nature, a recurrent theme in the history of Western thought from the time of ancient Greece to the present day. For comparison, local and traditional knowledge refers to tacit knowledge embodied in life experiences and reproduced in everyday behavior and speech. As Julie Cruikshank (2005:9) points out, "local knowledge has become a common-sense term, couched in acronyms like TEK (traditional ecological knowledge) or IK (indigenous knowledge), gaining new visibility in management science studies, but too often depicted as static,

[1] Collaboration between indigenous experts and Western scientists to understand our changing world has been explored in other parts of the Arctic, including work by Gearheard et al. (in press); Huntington and Fox (2005); Krupnik and Jolly (2002); and Laidler (2006).

[2] Yup'ik observations cited in this article were recorded between 2006 and 2010 as part of a natural and cultural history project initiated by Bering Sea coastal communities in collaboration with the Calista Elders Council (CEC), the primary heritage organization for Southwest Alaska. CEC's primary information-gathering tool has been the topic-specific gathering during which specific questions are addressed by meeting with small groups of elder experts, accompanied by younger community members, for two or three days. Unlike interviews, often conducted by the uninformed, CEC gatherings (like academic symposia) encourage elders to speak among their peers at the highest level. Alice Rearden translated the comments of Yup'ik elders, and they are cited by name, CEC gathering date, and transcript page number.

timeless, and hermetically sealed" (see also Fienup-Riordan, 1990, pp. 167–191; Nadasdy, 2003, pp. 114–146; Scott, 1996). Yup'ik knowledge is, first and foremost, dynamic, changing, and socially situated. As such, it is best considered as a knowledge system embedded in a particular cultural context.

Local and traditional knowledge was passed on orally in the past; today, it can be found in bilingual publications and on the web. In either case, experience and "best practices" are encoded in language, narrative, and social rules, such as abstinence from the ocean in the wake of special or disruptive events. Together, this body of knowledge becomes the foundation for cultural identity. All components of this identity are subject to change over time, as culture change is the rule rather than the exception. In a given situation, change can be either positive or negative: it is not inevitably good or bad. One can view culture change as a negotiation process with creative, although not necessarily painless, outcomes. Instead of viewing individuals as responding to fixed cultural norms, in the last 20 years, anthropologists have shifted their emphasis to understanding how people continually reshape their lives in the course of everyday experiences. Some argue that it is in the discontinuities between the values people hold and the continually shifting circumstances of everyday life that we find the primary driving forces of change.

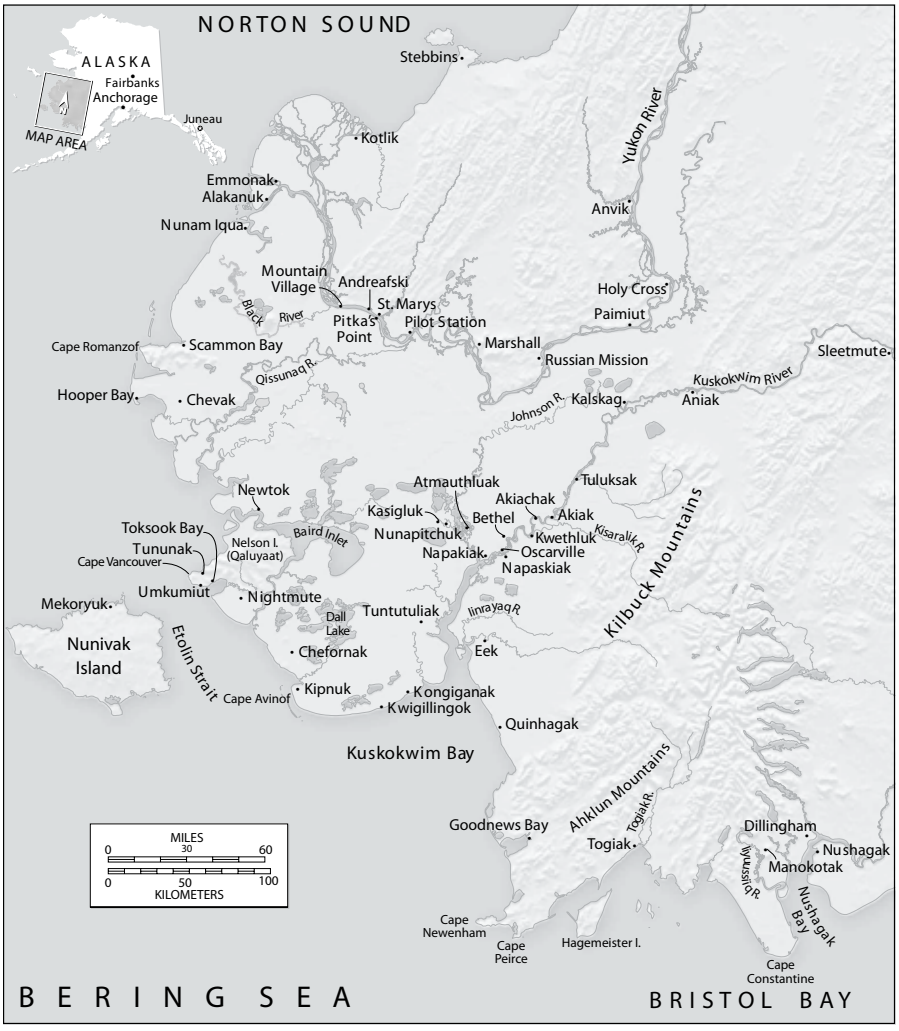

Figure 2. The Yukon-Kuskokwim delta, 2009. *Courtesy of Patrick Jankanish and Matt O'Leary*

THEY SAY THE OCEAN CANNOT BE LEARNED

Yup'ik residents of the Bering Sea coast early learned an attitude of humility and respect for the ocean, which sustained them—an attitude that went hand-in-hand with the practical skills of ocean hunting. John Eric (March 2007:52) of Chefornak reflected this high regard: "As someone who has lived along the ocean, I have always viewed it as the most important element of our environment. We cannot live without the ocean. Our ancestors mainly sustained themselves from the ocean. Also, all species of fish enter the rivers from the ocean…It's no wonder that the ocean has the name *imarpik* [from imaq, "contents"] because it holds everything."

Dozens of *qanruyutet* (instructions) embodied time-tested rules for interacting with the ocean. John Phillip (October 2003:239) of Kongiganak noted, "They say that we cannot depend on the ocean or all the bodies of water." Many contend that a person can never fully learn all the potential hazardous situations out on the ocean. According to John Jimmie (March 2007:75) of Chefornak: "I'd hear the cautionary lessons of the ocean when I'd go to

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the *qasgi* [men's house]. They would mention that a person won't learn the ocean. They said there's nothing on the ocean that one can lean on for support, and there's nothing stronger than the ocean." Nelson Island elder Paul John (December 2007:69) explained: "They said that when we are on land, we can lean on something with our hands to avoid danger. But they said there is nothing on the ocean that one can lean on for support when encountering danger." Paul Tunuchuk (March 2007:257) recalled: "They said if someone says, 'I have learned the ocean,' they will be lying. They said a person won't learn to predict conditions on the ocean." John Eric (March 2007:264) added: "The ocean indeed cannot be learned. One person said that before he learned to predict ocean conditions, he stopped going there."

Elders repeatedly shared the observation that unlike the land, the ocean was always changing. In this observation, they touch upon a defining characteristic of the Bering Sea coast relative to both Bering Strait and the Arctic coast of North Alaska. Tidal variation on the Arctic coast of Alaska is modest (at Barrow less than 15 cm) and the landfast ice typically much thicker during most of the season, making it less likely to break and deform. On the Bering Sea coast, however, tides can vary as much as one meter. Moreover, the Bering Sea coastline's low elevation can translate into extensive mudflats during low tides, and fall storm surges can push water and ice inland up to 50 km. Finally, Nelson Island and lower Kuskokwim coastal hunters can rely on neither thick, multiyear ice nor a well-defined separation between freeze-up, winter, spring, and breakup regimes that, through the 1990s, helped impart more predictable conditions in most High Arctic regions.[3]

While sea ice scientists have sometimes assumed that Bering Strait hunters on Diomede, St. Lawrence, and King Islands hunt in the most diverse and demanding ice conditions in Alaska, conditions on the lower Bering Sea coast are equally, if not more, challenging due to the complex interplay among tides, currents, and wind. An added element of complexity is the important role played by deformation in the thinner (less than one meter), weaker, and hence more dynamic ice of the Bering Sea coast (Hajo Eicken, University of Alaska Fairbanks, *pers. comm*., August 2009). The result is a remarkably rough ice environment, where there is really no safe place, as all types of ice have some propensity to break up or deform or behave in potentially dangerous ways. Off Barrow, the rule of thumb is that older, first-year ice and multiyear ice thicker than one meter are usually safe from deformation and thus may provide safe havens even in dynamic ice environments (Hajo Eicken, University of Alaska Fairbanks, *pers. comm*., August 2009; Druckenmiller et al., 2010). Along the Bering Sea coast, however, the ice rarely reaches that thickness through calm growth; hence, even level ice is likely to deform in some fashion. As a result, hunting in and around the ice requires a wealth of knowledge regarding its formation, its physical characteristics and behavior, and its dangers. John Eric (March 2008:293) noted that although a person could learn the normal seasonal cycle, no year was ever the same: "When an entire year has passed, the [ice formations] cannot be exactly the same as the year before. A person cannot learn it, but we can talk about it based on our observations of what it looked like in the past." (A detailed discussion of Yup'ik understandings of sea ice conditions and formation will be published next year; see Fienup-Riordan and Rearden, in press).

THE OCEAN KNOWS

Qanruyutet are not the only guidelines for dealing with the ocean and its uncertainties. *Eyagyarat* (traditional abstinence practices following birth, death, illness, miscarriage, and first menstruation) that guide behavior during life's transformations must also be taken into account. Many Yup'ik elders believe that because the ocean has a sense of awareness, it will sense a person who is under a circumstance that prohibits them from being down on the ocean; the ocean indeed has always been aware and knowing. As John Eric (March 2007:101) explained: "My father and those before him mentioned those other customs which we followed—our *eyagyarat* having to do with the ocean. He said that if someone died during winter, their son or his siblings have to wait until someone brought a seal pup up to the village before going down to the ocean. They also said that the occurrence of a miscarriage is something that the ocean doesn't like. Someone who experienced it said that when that occurs [in a family] they have to wait for the appearance of a grebe [typically in late March] before a person can go down to the ocean."

[3] In our discussion of Yup'ik sea ice, we stand on the shoulders of classic studies, especially Nelson (1969), and extensive recent sea ice research in other parts of the Arctic, including Aporta (2002, 2010); Oozeva et al. (2004); Gearheard et al. (2006); Eicken et al. (2009); Druckenmiller et al. (2010); Eicken (2010); Krupnik et al. (2010); and Laidler et al. (2010).

People's safety during transformative events was believed to rest on their invisibility in a sentient universe. For example, Frank Andrew (September 2000:32) of Kwigillingok noted the admonishment that one going through first menstruation should climb a hill and to throw moss or dirt at *ella* to blind it." The ocean also had eyes that must be closed. This requirement to stay out of view explained the reasoning behind restrictions regarding ocean hunting. Frank continued: "They said that men practicing *eyagyarat* should not go down to the ocean until the grebes and ringed seals arrived in spring. Grebes come first to the ocean and move on to land. When grebes started to defecate and when the blood of the ringed seals soaked the ocean down there, they said the *makuat* [ocean's eyes] close and become blind. Nothing would happen to hunters when they went down to the ocean, and they would no longer risk developing physical ailments."

Frank Andrew (October 2001:106) also noted the consequences when those restricted from hunting or traveling on the ocean disobeyed *eyagyarat*: "The ocean knows when a child dies. If those who have a duty to abide by *eyagyarat* go down to the ocean before the family's time of abstaining is over, large waves break the ice apart. But if they had not gone down, large waves would not develop until after the sea mammals down there have their offspring. That is the *piciryaraq* [way] of the ocean. The grebes blind the ocean's eyes that it uses to look around. After the grebes arrive the ocean won't react if they go down. The ice cannot be broken and the weather is calm as in the past. The ocean down there *nallutaituq* [knows everything that is going on]." Walter Tirchik (April 2001:150) of Chefornak recalled that his uncle told him the same thing—when the grebes arrive and defecate in the ocean, the ocean's eyesight dims, and hunters practicing *eyagyarat* can safely approach the sea at that time." To ignore this admonition was to invite disaster. Walter continued: "Avegyaq's mother told her son, 'They have not spoken of grebes, don't go down.' He replied, 'Those things are not true.' After he went down, large waves as high as this ceiling developed, and he returned home. After that I think he started believing it."

Ocean Conditions and Safety: Ocean Swells

Large waves and windy weather were visible and immediate penalties for failure to follow *eyagyarat*. Frank Andrew (August 2003:75) described his understanding of ocean swells known as *qairvaak* (literally, "two large waves"), the long, high-amplitude waves generated by storms in the open Bering Sea and North Pacific:

During winter, the ocean is quiet and very calm, and the qairvaak *are not there. And when sea mammals begin to have their pups, the* qairvaak *begin to appear. They call the smaller of the two swells the wife,* ulcuar *[small swell], and her husband is the larger one,* ulerpak *[large swell]. They only exist down in the ocean and don't get to the Kuskokwim River.*

Those who talked about them said that they are a married couple, a female and a male. Then in spring when the waves begin to get stronger in our area, they constantly make "engg, emmm" noises like a person in pain. When the wave lifts the shore ice, something makes noise like that, "Eeeeee-mmmm." It seems to be the ice. They say it's those two, the noise of the persons of the water. The female is higher pitched.

Sometimes, however, the *qairvaak* appear before their usual time. Frank (October 2003:75) continued: "They say those two [ocean swells] have awareness, and they don't like it when a person breaks a law. Even though we don't see them as human, they become upset when a person who must follow abstinence practices offends them and will appear before their usual time, breaking up the shore ice."

The occurrence of ocean swells marks the transition from relatively stable winter hunting conditions along shorefast ice to the myriad sea ice forms of spring. These high-amplitude waves originating far from shore can break the ice pack hundreds of miles away from the open ocean. Swells travel relatively fast and present a direct link to processes far away (Hajo Eicken, University of Alaska Fairbanks, *pers. comm*., August 2009). John Eric (December 2009:235, 2007:113) explained:

Since there are many sandbars along our shore, qairvaat *that reach shallow areas are constantly breaking. They don't break in deep areas. Only* qairvaat *that reach shallow areas are dangerous…*

When qairvaat *first arrive, conditions are bad, as they are powerful [when they hit]. When that starts to occur, the sun starts to heat the near shore ice. Once in a great while the* qairvaat *break the ice and take it out to sea. [The shore ice] gradually recedes, and eventually it gets closer to shore and reaches land. That's how the ocean down below my village is during spring.*

Swells are present in summer and fall but usually not in spring. Paul John (March 2008:572) explained: "There are no *qairvaak* during spring because the

BOX 1 | *Imarpik* (The Ocean)

Since 2006, the Calista Elders Council (the primary heritage organization in southwest Alaska), with support from the National Science Foundation, has worked with Yup'ik-speaking elders in Bering Sea coastal communities to document every aspect of the world around them—weather, land, lakes and rivers, snow, survival, sea ice, environmental change, and, of course, the ocean. The results of our work together will soon be available in a book, *Ellavut/Our Yup'ik World and Weather: Continuity and Change on the Bering Sea Coast*, by Ann Fienup-Riordan and Alice Rearden (University of Washington Press).

Yup'ik elders share knowledge through recounting hundreds of *qanruyutet* (admonishments or instructions) concerning all aspects of their world. These short, memorable phrases are set off by the enclitic *-gguq* (they say, it is said), implying ancestral voice. Elders often share *qanruyutet*, followed by longer explanations. These *qanruyutet* continue to guide Yup'ik interactions with *ella*—translated variously as weather, world, universe, and awareness. Below are a few examples pertaining to the ocean that sustains them.

They say the ocean cannot be learned. Before we have learned [to predict its conditions] we have reached this age.

—Simeon Agnus, Nightmute

They say the ocean down there, when feeling displeasure, doesn't feel pity for people.

—Paul Andrew, Tuntutuliak

They told us that sometimes if we were very scared on the ocean, we should eat until we were full.

—John Phillip, Kongiganak

While some travel it gets windy. When that happens, they were instructed not to give up. They used the small pieces of wood that floats as examples. They told us to compare ourselves to them, pretending to be pieces of wood. If we can get through it, we would get out of it like the wood, but we can drive our boat the wrong way or tip over if we panic. If we act like floating wood it can help us stay alive.

—Paul John, Toksook Bay

There is also an instruction that a person should make an effort not to panic down on the ocean although he encounters peril. They say if he doesn't suddenly panic, he will recall the things that those who were constantly speaking had talked about. "Oh yes, this is what they said we should do." They say that person will find a way to save himself.

—Paul John, Toksook Bay

They said a person cannot learn a lesson without encountering danger from time to time. That's why sometimes when I hear that someone has encountered danger but hasn't died, I say, "It's okay. When he encounters that again, he will recall that. He will learn from it."

—Roland Phillip, Kwigillingok

They say that the ocean doesn't delay things for a later time. It won't say, "Wait," because it does things at that moment. Since ice detaches and breaks when the tide goes out, although you say, "Wait a minute," it won't listen to you. The conditions will change right away.

—John Eric, Chefornak

In the past they also mentioned that a person doesn't go somewhere by just pointing his index finger. They do not travel without ever encountering peril. They encounter danger once in a while. Sometimes, death is close. That's why they mentioned in the past that a person doesn't point his index finger and travel to a place. That's an example they used.

—Roland Phillip, Kwigillingok

ice holds them back; the *qairvaak* will obviously be a great distance from shore in an area that doesn't freeze and has no ice." Frank Andrew (October 2003:66) noted that normally *qairvaak* arrived when the walrus started to be seen in late April and early May.

While swells are not dangerous to travel on in deep, ice-free water, Paul Tunuchuk (March 2008:307) noted the admonishment not to stay in the ice in spring if swells arrive: "They are dangerous when they collide with one another. And when there is a lot of ice, the swells obviously advance toward shore." Ocean swells are a force to be reckoned with. John Eric (March 2008:296) emphasized their power: "*Qairvaat* are large, and a sheet of ice that is a distance away disappears from sight when [the swell rises]. They say they come up toward land from the ocean and can rise over three feet. Because they are large, no matter how thick an ice sheet is, [*qairvaat*] can break it…They also said that [*qairvaat*] are large when they first arrive, but the next day or day after, they are calmer."

Michael John (June 2008:209) of Newtok contrasted waves formed by the wind and ocean swells, which make one feel dizzy: "These pieces of ice make an *eng* sound [when *qairvaat* are advancing toward land], and one will start to feel strange." John Eric (December 2007:75) noted that ocean swells come from far out to sea and can be hard to distinguish: "When these *qairvaat* are present down on the ocean, they go down slowly, and then they peak slowly…[*Qairvaat*] aren't apparent. They say that *qairvaat* come to shore from somewhere in Japan. [laughter] *Qairvaat* are astonishing."

Simeon Agnus (December 2007:105) of Nightmute commented on the arrival of ocean swells: "They appear during spring when the shore ice starts to disappear. *Qairvaat* start to be around when fledglings are first seen down on the ocean." Paul John (December 2007:106) noted that ocean swells start to reach shore when the ice that held them back begins to recede. John Eric (March 2008:176) associated the arrival of *qairvaat* with the birth of seal pups: "We also heard that when baby spotted seals and baby bearded seals are born, the ocean swells arrive at that time. They say the motion of the swells puts them to sleep. They are like a babysitter."

To this day, many residents of lower Kuskokwim communities attribute the arrival of ocean swells before their usual time to failure of hunters to follow traditional abstinence practices aimed at making them invisible and thus enabling them to approach the ocean without negative consequences. A person ignoring *eyagyarat* could cause the shore ice to crack and detach along their tracks. Ocean swells are, in fact, a greater hazard in the Canineq (lower Kuskokwim coastal) area than around Nelson Island, which is protected by nearby Nunivak Island. Paul John (December 2007:106) explained: "Although the weather is calm sometimes, [the waves] are deep in shallow areas. Akuluraq [Etolin Strait] has small [waves] like that since Nunivak Island blocks the *qairvaat* that head toward shore from the ocean. That's why there aren't large *qairvaat* around Nelson Island." Simeon Agnus (July 2007:264) shared his experience: "I am afraid of Canineq, the way that the [shore] ice breaks to pieces when there are large ocean swells. In spring camps [on Nelson Island] our means of transportation aren't cause for much worry. Since [shore ice] here isn't extensive, it doesn't detach and float away. But when the wind is blowing directly against the shore, when the ice gets thin, the area where they go down to the ocean collapses."

John Eric (December 2007:111) detailed the dramatic effects of qairvaat south of Nelson Island:

Around 1969, seven snowmobiles sank as the qairvaaq *broke the ice where they were situated. The two of us brought a number of boats to shore at that time. Since there were many [hunters], they'd quickly lift a boat and place it inside the sled. Then we placed [the boats] back toward shore and returned home. People were downcast, as they had no snowmobiles.*

The qairvaaq *broke the shore ice almost one mile back toward shore into fairly large pieces. Since it's hard to tell [when ocean swells arrive], at the time, we were at Qalvinraaq when the tide came in. Angutekayak said to me, "I think there are* qairvaat *around here."*

When I put my head down alongside the boat and looked toward shore, I saw that there were qairvaat*, and our snowmobiles were over there. As he traveled [back] along the [ice] edge, he never decreased his speed. We saw that people in our hunting party had already arrived down below the snowmobiles. Water would splash in the air when two pieces of ice collided. It was like that all the way toward shore.*

John Eric (December 2009:235) noted that ocean swells did not arrive randomly and were strongest when they first arrived: "The ocean swell evidently first arrives during the incoming tide, and it's powerful at that time. Although ice sheets are thick, they collide when

the water suddenly rises, since water is so strong. After that it is much calmer, although swells still arrive." John Phillip (December 2009:262) added the warning in the Canineq area:

When the incoming tide is about to end, the current is strong. Before the end of the incoming tide, they tell us to go to [our snowmobiles], since the ocean swells suddenly become deep at the end of the incoming tide. And when the tide is starting to come in, the ocean swells suddenly get large also.

[Ocean swells] aren't obvious inside the channel, in a deep area. But when they get to a shallow area, they become obvious. Even though the weather is calm and windless when those ocean swells arrive, they break our shore ice to pieces.

Indeed, a conceptual model of ocean waves and swells generated in open water and encountering sea ice (Figure 3) shows our understanding of the physical processes involved. Swells are long-wavelength surface waves that have propagated into a given area of observation after being generated by winds in other areas, often hundreds or thousands of kilometers from their origin. Swells initially travel as deepwater waves at a speed determined by their length, but begin transition to shallow-water waves where speed is determined by water depth when water depth shoals to less than half the wave length (Pond and Pickard, 1978; and see Figure 3 for equations expressing wave speed). Through this transition, wave orbits change from circular to elliptical and then to near horizontal, and waves steepen markedly. If, under climate forcing, the extent of sea ice continues to retreat and thin in spring, and more open water is exposed to offshore wind forcing, the passage of swells under the ice will become a more widespread occurrence, as illustrated in a case study by Matthew Asplin, University of Manitoba and colleagues (Asplin *pers. comm.*, 2011), and described as *qairvaat*.

The Ocean and Ice Are Changing

The sea ice bordering Nelson Island and the lower Kuskokwim coast during winter and spring comprise the southern edge of an enormous ring of ice surrounding the North Pole. Because of the ability of this ice to modify the world around it, some view the changes in sea ice that are now occurring as perhaps the most far-reaching physical change of the earth in our lifetimes (Rozell, 2009:xi). Under these circumstances, the experiences and knowledge of Bering Sea hunters traveling in ice near its southernmost limit may be quite valuable in helping those living farther north adapt to changing conditions (Hajo Eicken, University of Alaska Fairbanks, *pers. comm.*, August 2009). Certain qualities of the sea ice cover and its seasonality exhibit strong gradients with latitude, and there is some indication that these different zones are now shifting north as ice conditions get milder in the Arctic itself. Thus, the types of deformation mechanisms and ice features that Bering Sea hunters know well may have special relevance for northern hunters (and sea ice scientists) in the future.

As temperatures warm, Yup'ik elders have observed corresponding changes in sea ice and, as a result, access to the sea mammals that call the ice home. John Phillip (October 2005:116) noted that recently south of Nelson Island shorefast ice is both thinner and less extensive: "The *tuaq* [shorefast ice] used to be very thick, and it froze as much as six miles [9.6 km] from shore. Nowadays our ocean doesn't freeze far from shore, and our *tuaq* and rivers become unsuitable

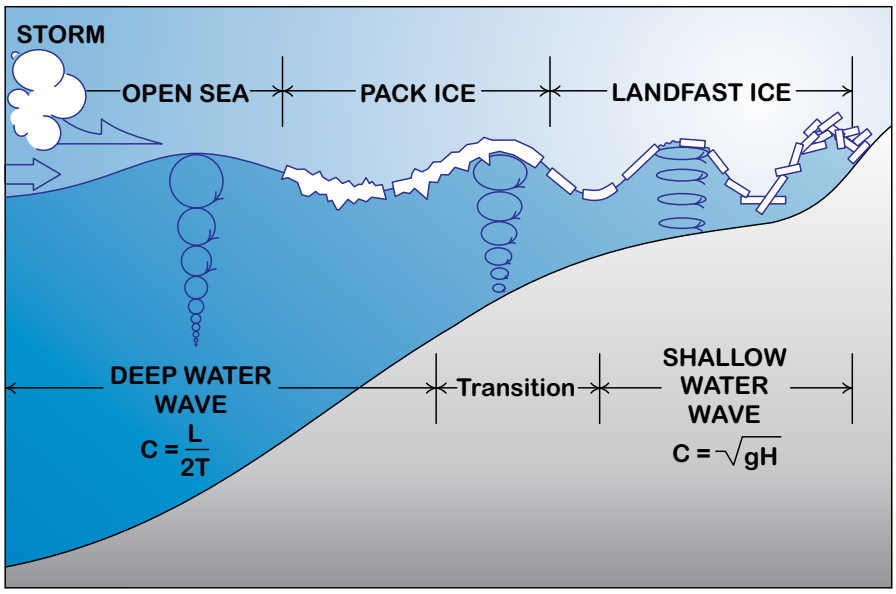

Figure 3. Conceptual model showing the propagation of ocean waves and swell originating in areas of open water under sea ice. C = wave propagation speed. g = gravity. L = wave length. H = depth. T = wave period. The circles and ellipses with decreasing size downwards are meant to represent wave orbital motions. The transition from deep water to shallow water behavior for incoming waves begins when orbital motions "feel" the bottom, approximately where H = 1/2 L.

Figure 4. A Kwigillingok hunter pulling his kayak over the shorefast ice along the Bering Sea coast, late 1940s. In the past, ice could extend up to three miles from shore, while today ice rarely extends past sandbars in shallow water. *Photo credit: Warren Petersen*

Figure 5. A hunter atop *evunret* (piled ice), using the pressure ridge as a lookout at the mouth of the Kuskokwim River. These huge ice piles formed along sandbars in predictable locations in the past. Today, they form less frequently and at different locations. *Leuman W. Waugh, 1935, National Museum of the American Indian L2236*

for hunting because they are too thin and dangerous. And last year, we really couldn't go out seal hunting in the area below [Kongiganak and Kwigillingok] because the shorefast ice was too thin." John Eric (December 2007:334) compared past and present: "The changes in the weather and the ocean have occurred in my presence. Back when the weather was [severely] cold, the ocean down below our village froze a great distance away from shore. And the shore ice would be dry; there were no wet spots on the snow. There were also many birds and seals. That no longer occurs." Paul John (January 2007:9) added: "When shore ice formed a good distance out toward the ocean, they caught many sea mammals and knew that they wouldn't be scarce. Nowadays, the shore ice no longer extends far out because the weather isn't as cold as it was in the past."

North of Nelson Island at the mouths of the Ningliq and Aprun Rivers, however, water is getting shallow and the current is decreasing, allowing an increase in ice buildup along the shore. Peter John (April 2009:78) of Newtok explained:

Since the current is getting weaker, ice tends to easily stick [onto the shore ice] down below [Newtok] when the wind is blowing from the west. Although it isn't extremely cold out, the shore ice becomes extensive. In the past, the shore ice hardly ever extended a great distance out from shore, back when the current was strong.

Aprun used to be dangerous when the tide was coming in. Back when I used to sit [in a kayak] and hunt, I could feel a jolt [as the ice hit and passed by]. Today it no longer does that.

Many note that fewer *evunret* (ice piles) form. As some bays and river mouths become increasingly shallow, ice is also piling in new places. Simeon Agnus (January 2007:127) observed: "*Evunret* are starting to grow in places where they never formed before. Although no *evunret* grew in front of Toksook Bay before, *evunret* are starting to grow there nowadays. When the current moves large ice floes and they pile into a shallow area, they quickly rise and grow." Stanley Anthony (January 2007:128) of Nightmute noted the same is true of *etgalqitat* (ice beached in shallow areas): "These days, Toksook Bay and the areas below Umkumiut and Qurrlurta that once had no *etgalqitat* now have *etgalqitat* because the ocean is getting shallower. Since the ocean is changing, sandbars that were never visible are starting to appear."

Warming temperatures also translate into later freeze-up and earlier breakup in coastal communities. Peter John (March 2007:1196) explained the trend he observed: "In the past when it started to get cold, the ice froze and wouldn't stop freezing. It used to get cold in October and November. These days sometimes it doesn't get cold for a long time. And although it does get cold, it doesn't reach the cold temperatures that it reached when we traveled by dog team [through the 1960s]."

Many observe that shorefast ice does not stay as long as in years past. Stanley Anthony (January 2007:129) said: "Toksook Bay no longer has genuine shorefast ice on it. In the past, birds would arrive while ice was still there, and the ice was safe for a long time." Mark John (March 2007:1197) of Toksook Bay commented on earlier breakup in spring: "When we came home from St. Marys [boarding school] in 1968, we landed in Tununak and they brought us [to Toksook Bay] with a boat. I think it was May 28. Toksook Bay still had shore ice at the time. These days, the shore ice sometimes melts completely by early May."

Finally, with the decrease in both the presence and thickness of shorefast ice, elders observe changes in the impact of ocean swells, which break up sea ice earlier in spring. As a result, hunters often lack a safe platform for butchering seals. Stanley Anthony continued: "These days, when catching an animal, one has to search for a place to butcher it. Back when I first started hunting, a suitable

place was nearby, and one could just quickly climb onto the ice and butcher it." John Eric (March 2007:262) noted that seals also lack ice: "Those adult bearded seals and even walrus could lay on top of large, moving ice floes when they were far from shore. Even though there were ocean swells, the water would only reach their top edges. Those large floes were good because they were thick and not dangerous. But ice floes have gotten thinner, and some break to pieces when we go on top of them. They are mostly snow."

The World is Changing, Following Its People

Yup'ik elders offer their own interpretations of the causes underlying these changes. Paul John (December 2007:376) spoke at length on the impact one change in attitude has had on the abundance of animals. Animals, Paul said, remain plentiful where people share resources but no longer appear where squabbling occurs. As his and other discussions make clear, the Yup'ik conception of *ella* is inclusive of both natural and social phenomena. How we treat our fellow humans directly affects our relations with the world around us. Thus, contemporary elders are as concerned with changes observed in human relations as with changes in the so-called natural world. They recall with feeling how people treated each other in the past compared to the present day.

Throughout our discussions with Yup'ik elders, many repeated the well-known adage, "The world is changing, following its people." Paul Tunuchuk (March 2007:110): "During my lifetime, *ella* is worsening since we are no longer treating it with care and respect." John Phillip (December 2005:120) stated: "I hear the saying that our land and weather will worsen and change along with the people. What our ancestors said stays in my mind. The environment isn't like it was in the past because it is no longer treated with respect and care."

Sophie Agimuk (January 2007:431) of Toksook Bay also spoke of *ella* changing with its people, relating these changes directly to people's failure to follow traditional *qanruyutet* and *eyagyarat*. John Phillip (October 2005:117) testified to the continued awareness of *ella* and its reaction to those who do not respect its rules: "Our young people no longer follow admonishments down on the ocean, even if his spouse just had a child or a miscarriage. *Ella* is changing because it is not treated with care. Our water must be treated with care also. It is said that the ocean has good eyesight and will be aware of ones in that circumstance." John Phillip is not alone. David Jimmie (January 2007:137) of Chefornak attributed the early arrival of ocean swells and subsequent breakup of shore ice and loss of many snowmobiles off the coast of Chefornak to the fact that a man whose son had died traveled to the ocean to hunt: "The ocean is aware and knowing…The customs which our ancestors followed won't be lost."

Elders to the south of Nelson Island emphasize the negative impact of failure to follow *eyagyarat* and the world's awareness of human transgressions. Nelson Islanders focus on changes in interpersonal relations rather than relations between humans and their environment as the primary causes of change. Simeon Agnus (July 2007:581) stated: "Our way of life is not like the way of life our parents experienced. Our parents mentioned that *ella* is getting worse, following its people. Since its people are becoming bad, the weather is replicating their behavior."

Given their view of personal responsibility, the connection elders make between human impacts on the environment, including the effects of commercial fishing and overhunting, and the "natural" effects of climate change should come as no surprise. Throughout our discussions, they continually referred to the role played by human action in the world when describing changes in the environment or species availability. Their insistence that "the world is changing, following its people" is the logical conclusion of their view of the world as responsive to human thought and deed. *Ella* has always been understood as intensely social. The Western separation between natural and social phenomena sharply contrasts with our Yup'ik conversations, which eloquently focus on their connection (Cruikshank, 2005:9).

The adage, "The world is changing, following its people," captures the Yup'ik view that environmental change is directly related not just to human action—overfishing, burning fossil fuels—but to human *interaction*. As Paul Tunuchuk (March 2007:216) said, "We are in this situation today because of not

Figure 6. The edge of the shorefast ice as seen from the north shore of Toksook Bay, February 2008. *Photo credit: Nick Therchik Jr.*

being dutiful to each other. It's as though we are sleepwalking." To solve the problems of global warming, elders maintain that we need to do more than change our actions—reduce bycatch and carbon emissions. We need to correct our fellow humans. They encourage young people to pay attention to traditional rules for living, believing that if their values improve, correct actions will follow.

The way Yup'ik elders work to correct their youth is to speak to them—as they did during village gatherings—sharing knowledge with kindness and compassion. As they say, "We talk to you because we love you." Stanley Anthony vehemently maintained the need to instruct the young, because, as he said, "The instructions aren't mine," implying they are not made up and should not be cast aside.

Finally, elders do not dissociate themselves from observed changes in their homeland but accept personal responsibility. They relate the negative impacts of change they observe today to their failure to instruct their younger generation in proper behavior. Now, they say, is the time to reverse this trend. Observing uninstructed young men and women, John Eric (January 2007:26) remarked, "We must talk to them, to delay them from becoming like dogs." Elders warmly embraced our work together, which they view as much more than passive documentation of change but as part of an active solution.

Understanding Natural Processes: An Example From the Canadian Beaufort

Sea ice conditions in relation to safe travel are central to pan-Arctic peoples. Jimmy Jacobson, Tuktoyaktuk, NWT, gave the example of thin and dangerous ice conditions in the narrow and shallow channel separating two basins within the Eskimo Lakes estuary in the coastal region of the Canadian Beaufort Sea (Carmack and Macdonald, 2008). According to Jimmy, "The water there stays open no matter how cold it gets." Jimmy went on to explain how caribou would come to this spot to use it as a salt lick and how the open water area was used by "greedy" beluga who had lingered too long within the estuary prior to freeze-up, and were thus trapped and facing suffocation or starvation. This surface feature (open water) implied the presence of strong tidally driven flows under the ice cover and the subsequent upward mixing of heat.

Sometimes, however, traditional knowledge is "lost" and must be relearned, often at great cost. Jimmy Jacobson gave the example of dangerous marine conditions along the Beaufort coast (Carmack and Macdonald, 2008). The Mackenzie Inuit who originally occupied this region were almost completely killed off by smallpox in the late 1800s, and with them much knowledge specific to the region, so that when the region was reoccupied by Inuit migrating eastward from Alaska, lessons had to be relearned. The danger of ice shoves (surges of ice from the ocean onto the shore) and storm surges is an example: Jimmy recalled that a lot of "the old-timers" died relearning this lesson, when they were caught camping on the ice in specific locations and under specific wind conditions. And while the synoptic-scale meteorological events that caused these events were beyond the scope of local observers, precautionary rules about when and where to camp under certain wind conditions could be found. This example again points to the fact that local knowledge is not static, but is adaptive and based on experience and experiment.

DISCUSSION

Facing Change Together

All forms of knowing fall short when kept static and isolated. Here we show the value of the co-science approach of local experts and Western scientists working together. As Yup'ik and Inuit elders note, respectful human interaction is the key to survival.

In the many warnings elders give of a dangerous and unpredictable ocean, they also identify key research problems that could be addressed by co-science. One example is that of connecting the response of the nearshore ice regime to ocean swell and tides. Yup'ik people have many words describing the appearance and response of ice to waves and tides (Fienup-Riordan and Rearden, in press) but have no tools to understand the large-scale atmospheric and oceanic conditions that control the timing and magnitude of offshore waves. One way forward starts with face-to-face meetings and focused discussions between coastal residents and scientists, followed by research partnerships linking wind waves and ice dynamics.

A second similar but distinct example concerns the question: "What goes on under the ice?" As noted above, an expanding literature has documented changes in sea ice in recent decades and how indigenous peoples interpret and respond to these changes (cf. George et al., 2004). Most of this work is based on observations from space or by observing surface features and dynamics. Indigenous hunters are certainly mindful that currents and waves beneath the ice create thin and unstable ice, but again,

they lack the specific tools to make the kind of under-ice measurements upon which prediction could be based or upon which trends associated with a warming climate could be detected. They do, however, have superior skills for traveling and working safely and efficiently on ice, and thus are the best fit to collect data on under-ice processes. They also have knowledge of place and timing that can only be acquired through lifelong connection with the environment. Again, simple and cost-effective partnerships involving Western scientists bringing specialized instrumentation to local communities may be of value to both.

Meteorologist Uma Bhatt, who used satellite images to demonstrate linkages between diminishing Arctic sea ice and changes in the Arctic terrestrial ecosystems, provides another opportunity for productive collaboration (Bhatt et al., 2010). She and her colleagues found that areas in the High Arctic have experienced the largest changes, with some exceptions over land regions along the eastern Bering Sea. In discussions with Bhatt, Yup'ik elders pointed out both a decline in tundra berry production and the timing of the harvest in recent years, which they associate with decrease in autumn rain and snow cover. Winds during the growing season were another factor. These observations point to the need to look at changes in wind and precipitation as well as sea ice cover to explain changes in coastal regions.

Yup'ik elders also shared valuable observations about sediment-laden ice—a common characteristic of the shallow, muddy coastal environment where clear ice is the exception rather than the rule. Glaciologist Hajo Eicken of the University of Alaska Fairbanks notes that whereas coastal erosion is often attributed to lack of sea ice allowing fall storms to eat away the shoreline, in fact, sea ice is the most effective mover of sediments in waters with seasonal ice cover (Eicken et al., 2005). How the ice interacts with the coast is not well understood and cannot be captured by satellites. Local observers marking places with dirty ice can help with modeling sediment transport by ice.

Finally, rise of sea level and related effects of increased fall storm surges associated with global warming are of particular concern to ocean scientists and to coastal residents (Jorgenson and Ely, 2001). Here, elders' long-term retrospective observations on these changes may be particularly valuable to scientists.

Indigenous Knowledge and Sensemaking

The ability of coastal people to give meaning to experience is a powerful quality that they bring to the study of environmental change. For example, Whiteman and Cooper (in press) define ecological sensemaking as the process used to make sense of material landscape and ecological processes. They argue that the inability to make sense of subtle ecological clues introduces hidden and sometimes dangerous vulnerability. By tapping deep experiential knowledge, the skill of sensemaking allows a hunter or traveler to interpret clues and react quickly when faced with the dangers of swiftly changing ice and ocean conditions and to quickly know when things are not as they were or as they should be. For example, Paul John (March 2008:572) described how Nunivakers used ocean swells to predict coming wind: "When the people of Nunivak Island only paddled [by kayak] from the village, they evidently kept an eye on the small pieces of ice down on the ocean. They say when the ice out there went out of view and appeared again [above the waves] that was a sign of coming wind, and they would turn back. They say the waves hit first. Although the weather was calm, they'd head to safety to escape danger when those small pieces of ice started to go out of view." John Phillip (October 2003:61) used swells to predict coming wind on the lower coast: "When the wind is going to blow from the north, the swells get high and deep." Hunters also use ocean swells as directional indicators, as they originate in deep water and always flow toward land. John Walter (March 2007:1363) of Tununak recalled: "When we became disoriented we would stop and look at the water, and it looked like it was breathing as it flowed toward land." These examples show the importance of sensemaking, based on long and tested experience, in allowing rapid avoidance of threatening situations.

The experiential knowledge of local people allows the detection of abrupt change and could—if enabled through social networks—provide an early warning system of abrupt ecosystem change. One example is a narrative by Peter Kattuk of Sanikiluaq, Nunavut, based on his experiences in winter 2009–2010. Of 71 seals captured, 69 had shrimp in their stomachs, not the usual capelin. Further, the seals were skinny and tended to sink when shot. Shrimp are a less-nutritious prey than capelin. The question is: Did Peter Kattuk simply observe an anomalous year, or has he experienced a regime shift that may require adaptation? A second narrative is from Adamie Thomassie, an elder of Kangirsuk, Nunavik, a region widely recognized for its charr. This winter, the lakes that Adamie has fished since

childhood are nearly devoid of fish, and caribou hunting has also been poor. The snowmobile tracks that Adamie travels are now ice, from freezing rain, rather than snow. And the sea remains unfrozen, even as temperatures drop below –40°C. The changes Adamie reports are not slow changes over his life but instead are abrupt. Are Peter and Adamie both giving early warning of major change?

An example of a regime shift and adaptive action is given by Hamilton et al. (2004), who documented the adaptive responses of two communities in southwestern Greenland to the collapse of cod stocks in the 1960s. In this case, one community, Sisimiut, prospered through the abrupt ecological transition from cod to shrimp, while the other, Paamiut, maintained a traditional fundamentally unsuccessful cod fishing effort, and thus declined. While both communities experienced the same ecological regime shift and had similar capital and human resources, the stronger social capital (social networks and cohesion) of Sisimiut allowed a more successful adaptation to change. Yet, how can we detect such rapid ecosystem transitions over the vast and poorly monitored Arctic?

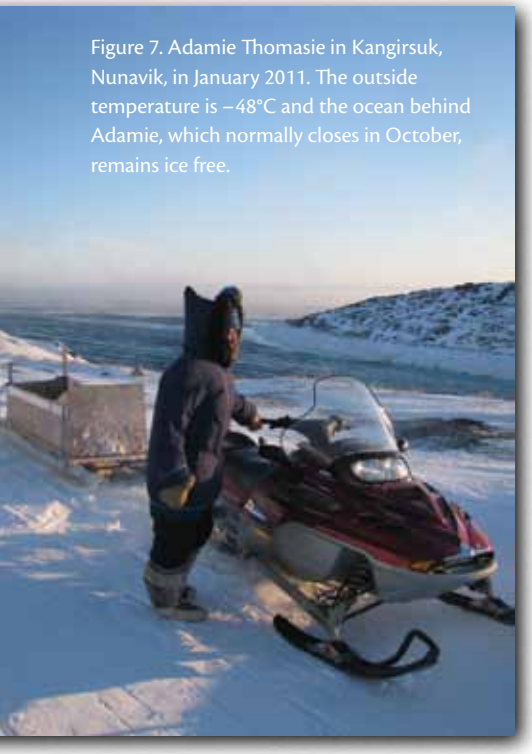

Figure 7. Adamie Thomasie in Kangirsuk, Nunavik, in January 2011. The outside temperature is –48°C and the ocean behind Adamie, which normally closes in October, remains ice free.

Deep Collaboration: Linking Local and Global

Part of the solution to the question posed above may lie in forging truly meaningful partnerships between researchers and Yup'ik and Inuit community members. Our work with Yup'ik community members, for example, has been a major collaborative effort during which we made a serious attempt to coproduce the knowledge we share. Planning meetings went beyond consultation and cooperation, with one group providing ideas and understandings to another, to the co-conceptualization and, more significant, co-commitments (moral and ethical) of true collaboration. True collaboration, as many note, is the joint shaping of representations. These deep collaborations offer powerful alternatives to more conventional research approaches.

In this article, we showed the nuanced understanding of place acquired and passed on by indigenous peoples, both to the needs of their own communities and to Western science in general. At the same time, it is clear that climate change is a global phenomenon and that broader understanding must take into account large-scale connectivity (Carmack and McLaughlin, 2011). Offshore research in the Arctic has revealed huge change in ice cover (Kwok, 2009) and ocean properties (McLaughlin et al., 2011, in this issue), with consequences to the ecosystem (Li et al., 2009; Yamamoto-Kawai et al., 2009). If combined with the training of Western scientists to abstract and apply general laws, and if the pan-Arctic indigenous communities are linked through social networks, then traditional knowledge has the potential to become a foundation of environmental and climate monitoring and to serve as an "early warning system" of change and regime shift. Indeed, the Arctic Ocean is now being monitored. If we add to this monitoring a greater understanding of the seas immediately offshore of Yup'ik and Inuit communities, scales can be bridged and people engaged. How do we move together toward a deeper understanding of the marine system around northern North America to make this potential integration a reality? We can make a start by listening carefully to Yup'ik and Inuit community members, whose understanding of the ocean is not only useful but represents a unique view of the world worth taking into account in its own right. They have long accepted personal responsibility for changes in their homeland. They lead by example.

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