Ocean Acidification and Alaska Fisheries:

Views and Voices of Alaska's Fishermen, Marine Industries and Coastal Residents

Rachel Donkersloot, PhD
Fisheries Program Director

Coastal Voices on Ocean Acidification Project
Alaska Marine Conservation Council
PO Box 101145
Anchorage, AK 99510
www.akmarine.org

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Executive Summary

In winter 2011-2012 the Alaska Marine Conservation Council (AMCC) sponsored community roundtable discussions on ocean acidification and Alaska fisheries in the fisheries-dependent communities of Homer, Kodiak and Dillingham in southern Alaska.

The roundtables were designed to engage coastal Alaskans and members of the Alaska seafood industry whose lives and local economies will be affected by changes linked to ocean acidification (OA). Specifically, the roundtables were intended to accomplish three inter-related goals: 1) bring together the efforts and expertise of scientists, subsistence harvesters, commercial fishermen, natural resources managers and coastal residents to better assess and address the impacts of OA on local fisheries and livelihoods; 2) develop ideas and advance dialogue concerning the needs and potential contributions of fishermen and fishing communities in responding to the threat posed by OA; and 3) provide insight into how the fishing industry might engage in policy action related to OA in the future.

Each roundtable discussion was set into motion with a presentation given by a leading scientist in the field. In Homer and Dillingham, the presentation was given by Dr. Jeremy Mathis, a chemical oceanographer and director of the Ocean Acidification Research Center (OARC) at the University of Alaska Fairbanks. In Kodiak, roundtable participants listened to a presentation by Dr. Robert Foy, director of NOAA's Alaska Fisheries Science Center Kodiak Laboratory. The discussion which flowed from scientific presentations included key topics: research priorities; economic and ecological concerns and constraints; rural energy (in)efficiencies and upgrades; local-level engagement and OA adaptive strategies; and contributions to OA science and policy from the coast and fishing industry. In total, 55 people participated in the community roundtables. Key findings are listed below and elaborated on more fully in the following pages. These findings reflect the views, vulnerabilities and interests of the fishermen, marine industry stakeholders and community members who attended the roundtables.

Key Findings

- The science about ocean acidification is a clear reason for concern for the health and productivity of the oceans coastal Alaskans depend on.
- The economic value of Alaska's commercial fisheries approaches $4 billion (first wholesale value), but it is not known how ocean acidification will affect specific fisheries and what the cost will be to the seafood industry and fishery-dependent communities.
- Fishermen and shellfish farmers want to participate in scientific monitoring of ocean pH. Fishermen aboard vessels can collect water samples and shellfish growers are skilled observers of local conditions.

- In addition to quantifiable economic impact, coastal Alaskans are concerned about damaging traditional uses of marine resources and harm that will come to the ecosystem that supports those resources.
- Because of uncertainty about what the exact impacts of ocean acidification on fisheries will be, concerns about the future tend to be eclipsed by more immediate and tangible issues facing fishermen and fishing communities. One exception was the shellfish growers who are already experiencing the loss of oyster spat due to corrosive waters in the Pacific Northwest.
- Despite acknowledgement that ocean acidification is inevitable and the exact consequences are unknown at this time, doom and gloom attitudes did not permeate the discussion. Roundtable participants explored ways to address the root cause of ocean acidification in order to mitigate its effect, including reducing carbon emissions as individuals, industries, communities and nationally. They recognized the economic benefits of clean energy, especially in rural Alaska where the cost of living soars with fuel prices.

Cultures and Economies

From the average citizen to commercial fishermen to political leaders and policy makers everyone wants to know: What is OA going to cost Alaska? The short answer is: We don't know. There are estimates and economic models but there are not definitive answers for Alaska fisheries. That said, the economic importance of commercial fishing to a state that has more coastline than the entire continental United States combined is impressive. The seafood industry is the largest private sector employer in the state. The value of Alaska's commercial fisheries was $3.8 billion in 2010 (first wholesale value). . With all that in mind, the threat of OA extends beyond the context of the commercial economy.

For example, during our time in Dillingham we expected to talk plenty about what OA means for Bristol Bay's iconic sockeye salmon. And we did. For many, it is impossible to "imagine this community without salmon, a day when we didn't have salmon." But community concern was not limited to salmon. There was keen local interest in the fate of razor clams and cockles in a nearby bay. The clams and cockles in Kalukuk Bay are not commercially harvested but after the third person mentioned them in conversation we followed up to find out more about them. This is what we were told:

> There used to be a village there. We have one elder who is 88 years old here in Dillingham who grew up in Kalukuk. She lives for the spring time, when she gets clams from her grandson who goes over there.
>
> It takes a lot of effort and work to get those Kalukuk clams. You go over there with a snow machine, and you take a ladder. You have to take a ladder because we still have winter [conditions this time of year], so they take a ladder to use to get down onto the beach from the ice edge. But for an elder here in our

> community who loves those clams, she gets a twinkle in her eye she is so happy when she gets them. So to me, I don't know what value you give to it and I don't think you can quantify it but it's something that we do here in rural Alaska. And that, to me, would be such a tragic loss, to lose those clams.

This story captures nicely the somewhat hidden ways in which OA will potentially harm families and communities in Alaska coastal communities. It further works to remind us of how understanding the impacts of OA in purely economic terms is at best a partial understanding, and one which can obscure a very real loss in people's lives and localities.

Priorities Amidst Uncertainties

Roundtable participants identified increasing and investing more in OA monitoring in Alaska waters as a priority. "We need basic research, stressed a Kachemak Bay shellfish farmer, because right now I don't think anybody has a clue about what's going on here in the bay." This research priority shines critical light on the need for the continuation and expansion of OA monitoring and research in Alaska waters. "You can't manage what you don't monitor," explained another roundtable participant. As well, the sentiments expressed here by a Kodiak fisherman are emblematic of a broader outlook encountered in communities: "I think the threat is real, but I just don't know enough about it in terms of how it's truly going to affect fishing. I want to know more. But it has me concerned."

Because there remains uncertainty surrounding the impacts of OA, and because the threat of OA remains largely unrecognized in the daily lives and livelihoods of Alaska's fishermen and communities, there exists a tendency for the threat of OA to be eclipsed by more tangible threats to local waters and ways of life. The exception here is shellfish growers in Kachemak Bay near Homer who rely on hatcheries in the Pacific Northwest to supply their oyster larvae and are therefore directly impacted by the recent upwelling of acidic waters along Washington and Oregon coastline. "[Shellfish farmers here] are probably the best informed [on ocean acidification] because it affects us directly. I think everybody in the state got hit by that spat shortage. I know I did. Severely. I know [ocean acidification is] right on the tip of everybody's tongue right now, as far as what's happening." More broadly however, the perceived threat of ocean acidification is ancillary to other more tangible threats which frequently found their way in and out of conversations attuned to local-level concerns for Alaska waters and ways of life. Three dominant examples include 1) bycatch; 2) the potential development of Pebble Mine in the Bristol Bay region; and 3) access rights to fisheries; notably the move toward catch share programs in the Gulf of Alaska. We highlight them here because even as Dr. Mathis stresses point blankly to roundtable participants that "we are past the tipping point for carbon dioxide in our oceans," these are the issues that tend to demand center stage. Their impacts on fisheries and the communities that depend on them are perceived as both more tangible and more immediate, and community members invest their limited resources (e.g. time, energy, capital) accordingly.

All of this works to inadvertently push the issue of OA further down the line in the local hierarchy of worry and resistance. It is a push that may be exacerbated by a sense of inevitability as captured in the following comments. "I get the sense that we can't do

anything about [OA]." "Is there an alternative [to OA]? Not that we're going to let [the ocean] go, but what can we do?"

This is not to say that doom, gloom and "oh well" attitudes permeated community roundtable discussions. In fact, it was through collectively reckoning with the inevitability and unknown consequences of ocean acidification that participants moved forward on the front of how to address ocean acidification, and reduce carbon emissions, as individuals, industries, communities and countries.

Carbon, Costs and Community Concerns

This high cost of living in coastal Alaska, and in Dillingham especially, was discussed as a critical threat to the viability and vitality of Alaska's coastal communities. Soaring energy costs in recent years have spurred community-level action and state energy programs dedicated to reducing energy costs and improving efficiency both within the fishing industry and wider community. Programs include investing in renewable energy projects, retrofitting fishing vessels and energy efficient upgrades for housing. Although these programs weren't implemented with ocean acidification in mind, the benefits of renewable energy in Alaska, and particularly in Alaska's coastal communities, are wide-ranging and inclusive of both economic and environmental concerns. Referencing both environmental and economic thresholds, one participant imagined his community serving as a beacon to others. Explaining how coastal Alaska will be changed by climate change and ocean acidification first and more intensely than many other places on the planet, he went onto to stress the importance of facilitating the transition to an "environmentally-based economy" for his children and grand children.

> We're at a place now where a shift is necessary. And our generation can either be the clutch or that shift is going to happen without a clutch. It's our job to find ways to enhance that transition. I don't know if you drive a vehicle with a standard transmission but if you try to make a shift without a clutch you're going to have some problems.

Inspiring? Yes. But even the optimism of this participant was tempered by the size and scale of the problem. He continued, "It seems to me that the [carbon] pollution happens in such a magnitude coming from all over the globe that it's just a lot easier to point to China or some place else and say, 'Well that's where the problem is.' Somebody that's got a wind farm in Alaska is not even a drop in the bucket I guess. I get stuck there in trying to understand what the stimulus is [for global solutions]."

This is the fundamental question which arose at each roundtable. What can *we* do? A wind farm in Alaska isn't going to have an impact on the greater global picture. At the same time, Alaska is going to have to deal with the consequences of what is a global problem. Roundtable participants grappled with the tension between knowing that "we have to lead from the bottom" in efforts to address OA, and the reality that grassroots-level efforts and "volunteering to reduce emissions is not going to get us where we need to be." The way forward, stressed a Kodiak participant, has to include "a coordinated

effort between individuals, industry, government and community to make it work. Individuals can't make it work in the long run if you want to make it cost effective."

Contributions from the Coast

In each roundtable, participants emphasized the importance of operating on a dual track system; that is, working at both the personal level and the political level. Members of the fishing industry were identified as well-situated for contributing to OA science and informing policy. Several participants proposed establishing partnerships between industry and science as a means to monitor ocean conditions and mitigate the impacts of OA. Sectors of the industry could quite literally provide the vessels of opportunity to aid in collecting water samples on their way to and from fishing grounds. Although technical challenges remain, including managing samples and chain of custody, these protocols were perceived to be hurdles rather than stalemates in such efforts.

Speaking with shellfish growers reveals a different set of strengths in the Alaska seafood industry's contribution to OA science. Whereas fishing vessels provide snapshots of their working environment at certain times of year, the nature of mariculture entails everyday observations of the surrounding environment. Shellfish growers are uniquely positioned to observe changes in the local marine environment. Monitoring is, in a sense, built into the art of raising oysters. The shellfish growers spoke of observing such things as a clear spot in the water where there shouldn't be, more plankton than usual and smaller jellyfish. In short, it's not just oysters that shellfish growers pay attention to; it's the color of water, the size of kelp and the number of barnacles. Shellfish growers take into account what is thriving and what is dying in their working environment on a daily basis. In this way, they serve as powerful witnesses to change. The role of Alaska's seafood industry in collecting data and informing OA science can better tell us how to manage, mitigate and adapt to a changing environment.

Much of the dialogue during roundtable discussions revolved around two key points: 1) the consequences of ocean acidification are largely unknown; and 2) uncertainty does not validate inaction. What we do know, stressed a participant, is that "ocean acidification is changing habitat, and that is problematic for a place like Alaska. We have a pristine environment and ocean acidification is changing that." So while we can't definitively say what the impact will be of increasing levels of anthropogenic CO_2 on king crab in the Bering Sea, we have an unsettling indication of what changing ocean chemistry means for the tiny copepod. A Homer participant put it aptly: "So when you have these little animals that we can barely see with the naked eye that the fish need to eat, to survive… that's when I got really concerned about this. Because man, if it hits those small guys, [and the] food chain. We can't see it, but it's there… [I]t's like a helicopter that you can see the fuselage, you can see the rotor, but it's the little tiny cotter pins that are holding that all together. If you take that cotter pin, if some of them shake loose, it will shake the whole thing apart. And I think that's what OA is doing…. and I don't think we need that."

Table of Contents

List of Acronyms

ADF&G	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
AMCC	Alaska Marine Conservation Council
BTU	British thermal unit
CO_2	Carbon dioxide
EPA	Environmental Protection Agency
IPCC	Intergovernmental Panel on Climate Change
KBC	Kachemak Bay Campus
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OA	Ocean Acidification
OARC	Ocean Acidification Research Center
ppm	parts per million
UAF	University of Alaska Fairbanks
US	United States

Introduction

In winter 2011-2012 the Alaska Marine Conservation Council (AMCC) sponsored community roundtable discussions on ocean acidification and Alaska fisheries. These roundtables – which were held in the fisheries-dependent communities of Homer, Kodiak and Dillingham in southern Alaska – were part of a larger project spearheaded by AMCC. The larger project, *Coastal Voices on Ocean Acidification*, aims to promote a better understanding of the current and potential impacts of ocean acidification (OA) on Alaska fisheries and livelihoods. Further to this, the project helps to identify (if not raise) the level of awareness and sense of importance coastal Alaskans and members of the Alaska fishing industry attach to the issue of OA.

The community roundtables were designed to engage coastal Alaskans whose lives and local economies will be affected by changes linked to ocean acidification. Specifically, the roundtables were intended to accomplish three inter-related goals: 1) bring together the efforts and expertise of scientists, subsistence harvesters, commercial fishermen, natural resources managers and coastal residents to better assess and address the impacts of OA on local fisheries and livelihoods; 2) develop ideas and advance dialogue concerning the needs and potential contributions of fishermen and fishing communities in responding to the threat posed by OA; and 3) provide insight into how the fishing industry might engage in policy action related to OA in the future.

This report identifies and discusses the key questions, concerns and conversations that arose during the community roundtables. Findings presented here reflect the views, vulnerabilities and interests of the fishermen, marine industry stakeholders and community members who attended the roundtables. Findings are organized around key themes including: research priorities; economic and ecological concerns and constraints; rural energy (in)efficiencies and upgrades; local-level engagement and adaptive strategies; and contributions from the coast and fishing industry.

Our intention in turning the contents of the community roundtables into a written, tangible case study is to not only move the discussion on OA forward, but to ensure that the perspectives, experiences and everyday realities of Alaska fishing families, industries and communities are understood and accounted for in public policy related to OA. More broadly, we offer up this case study to share with others, especially fishing communities and organizations across Alaska and the United States, the learning process and findings which transpired from this work.

Methods and Materials

During December 2011 and January 2012, AMCC worked with Alaska Sea Grant's Marine Advisory Program to host roundtable discussions on OA and Alaska fisheries in the communities of Homer, Kodiak and Dillingham. These three communities were

selected as fitting locations due in part to the difference and diversity of fisheries dependence found within and between them. The waters surrounding Homer for example are home to roughly a dozen shellfish farms, in addition to vital commercial and sport fishing industries. In northern Bristol Bay, the small town of Dillingham is sustained by a seasonal commercial salmon fishing industry and a local culture and life-way linked inextricably to the harvesting of subsistence resources, most notably salmon. Finally, moored in the western waters of the Gulf of Alaska, Kodiak Island serves as the state's largest fishing port and is home to almost every possible gear group (e.g. trawl, longline, jig, pot, seine, gillnet), and a year-round resident seafood processing sector. These communities and economies will be described in greater detail below. For now, it is worth noting that despite the variable size of these towns, species targeted, and industry sectors represented, the common thread connecting these communities is a local economy dominated by the commercial fishing industry.

Structure and Organization of Roundtables

In organizing roundtable events we targeted both leaders and less prominent members of the seafood industry to ensure a diversity of views. Event flyers were posted publicly around town and online to reach interested participants. Roundtables were also advertized publicly through radio announcements and community calendars to welcome the whole community. Community leaders and key industry players were invited to participate through regular fishery media outlets and direct communication with fishery organizations.

Roundtables lasted roughly two to three hours in length. Each community meeting began with everyone in attendance introducing themselves (and their affiliation if applicable). Roundtable participants were also asked to complete a short survey at the start of each meeting. The survey listed 11 categories and was intended to better identify roundtable participants in the specific context of if and how they were involved in fisheries. The survey asked participants to check all boxes which applied to them with survey responses including categories such as: commercial fishing permit holder; crew; outreach/education; processor owner or employee; subsistence harvester; resource management; and/or concerned citizen. A copy of the survey can be found in Appendix A. The survey also provided space for participants to write in their own responses if they felt the categories did not adequately reflect their involvement in fisheries. Some participants noted that their grandchildren fished. Others explained that fish was an important part of their family's diet. A few participants also made note of seemingly non-fisheries related employment or volunteer work that they were engaged in as evidence of their involvement in the community which depends on healthy fisheries.

Each roundtable discussion was set into motion with a presentation given by a leading scientist in the field. In Homer and Dillingham, the presentation was given by Dr. Jeremy Mathis, a chemical oceanographer and director of the Ocean Acidification Research Center (OARC) at the University of Alaska Fairbanks. His research focuses on marine chemistry and ecosystem dynamics and includes OA monitoring in the Arctic Ocean, Bering Sea and Gulf of Alaska. In Kodiak, roundtable participants listened to a

presentation by Dr. Robert Foy, director of NOAA's Alaska Fisheries Science Center Kodiak Laboratory. Dr. Foy's current research program focuses on the ways in which crab species found in Alaska waters (including red, blue and golden king crab) are affected by changing pH levels. His research sheds light on how shallow water species such as red king crab and deep water species such as golden king crab might be physiologically affected by changing pH levels due to an increase in CO_2. Both Mathis and Foy structured the scientific presentation to include: 1) a general introduction to OA; 2) the current and potential impacts of OA in Alaska waters, including what OA means for Alaska fisheries and economies; and 3) an overview of their respective research projects on OA. Scientific presentations lasted roughly one hour in length and participants were encouraged to ask questions throughout the presentation.

Figure 1.0 Dr. Mathis discusses his research with roundtable participants in Dillingham. *Photo by Alan Parks*

In each case, the discussion which flowed from the scientific presentation was facilitated by a moderator whose primary task was to engage roundtable participants through key discussion topics and informed questions. Discussion topics included: 1) research priorities; 2) current and next generation ecological concerns; 3) business concerns; 4) economic options to fishing: 5) energy efficiency and ways to reduce energy costs and emissions within the seafood sector and locality; 6) market concerns/opportunities associated with OA; and 7) the role of industry and community in OA science and policy. More fundamentally, questions included: What do you know about OA? What do you want to know? What, if anything, about the scientific presentation surprises you, concerns you, scares you?

Although each roundtable followed this similar form and content, each community discussion also took on its own direction due in part to the particularities of place and the most significant issues currently weighing on life and work, if not the future of fishing, in the locality. Such hot button issues include but are not limited to the potential development of Pebble Mine in the Bristol Bay region and fisheries management policies, notably the implementation of catch shares programs in federal fisheries in the Bering Sea and Gulf of Alaska. For some participants the threat of OA to Alaska fisheries and communities was couched in if not eclipsed by these immediately pressing

issues. We will return to this later on in the findings section. We mention it here because it speaks to the significance of place in understanding the sense of urgency with which individuals, industries and communities work to address OA and its impacts on life along Alaska's coastline.

One final methodological note: As mentioned earlier, the roundtables were part of a larger project entitled, *Coastal Voices on Ocean Acidification*. As part of this larger project, AMCC worked with WWF to capture – through audio, still photography and film footage – members of the Alaska fishing industry talking about their lives and livelihoods with particular attention given to the issue of OA. This material will be used primarily for electronic media and to create a hub for OA communications to the seafood industry, members of the media, elected officials and other opinion leaders. In all but a few instances (due to time constraints), those individuals who agreed to be interviewed on camera for this component of the project also attended the roundtable. This allowed for the roundtable discussion to serve as fodder for individual interviews. Although much of the materials drawn on below come directly from community roundtable discussions, some of the stories and concerns shared during the on-camera interviews have also found themselves onto the following pages.

People and Place

Homer

Located on the shores of Kachemak Bay in the southwestern corner of the Kenai Peninsula is the small city of Homer (pop. 5,003) (US Census Bureau 2010). Although commercial and sport fishing industries have served as leaders in the local economy for at least the last five decades, the town is more broadly comprised of government offices, non-profit organizations, small businesses and artists. (Members from each group attended the Homer roundtable.). The population of Homer is predominantly White (89.3 percent to be exact) and the town has a reputation within the state for being socially progressive. A recent manifestation of Homer's progressive nature is found in the Homer Climate Action Plan (http://www.cakex.org/virtual-library/730). Developed in 2007, the Plan embodies the efforts of local government and community in reducing the threat of global climate change.

The main commercial fisheries in Homer are halibut, salmon and groundfish. In 2000, 539 Homer residents held a total of 1,150 commercial fishing permits (Sepez et al. 2005). The sport fishing sector annually lures in thousands of non-resident visitors (from the Lower 48 of the US, Canada and beyond) to fish for halibut and salmon in the waters and rivers near Homer. Homer boasts the title of 'Halibut Capital of the World.' More recently, Homer has become home to a growing mariculture industry. Since the 1990s, roughly a dozen shellfish farms have been established in the waters of Kachemak Bay. These farms form the Kachemak Shellfish Mariculture Association and are a part of the Kachemak Shellfish Growers Coop which opened an oyster handling facility on the Homer Spit in 2009. The Coop also owns an at-sea nursery for Pacific oysters across Kachemak Bay in Halibut Cove. Shellfish growers in Kachemak Bay were directly

harmed by the recent oyster crash in the Pacific Northwest resulting from corrosive marine waters (see for example Skigliano 2011). Oysters are not indigenous to Alaska and shellfish growers here rely on hatcheries in the Pacific Northwest and elsewhere to supply their larval oyster, also called the hatchery's 'spat' or 'seed.' Shellfish growers in Homer are attempting to hatch larvae locally next year to avoid spat shortages stemming from recent volatility in hatcheries in the Pacific Northwest (referred to as the Willapa Bay Seed Crisis) (see for example Welch 2009).

Figure 2.0 Homer Spit. *Photo by Matthew Sill*

The community profile described above is reflected in the turnout for the Homer roundtable. The roundtable was held in a classroom at the Kachemak Bay Campus (KBC) in Homer. Dave Aplin, Senior Program Officer at the World Wildlife Fund Homer Field Office, acted as moderator. Dr. Jeremy Mathis joined the group from Fairbanks via the college's video conference system. Twenty-seven community members (14 men and 13 women) attended the Homer roundtable. Another four people from the Soldotna area joined the discussion via the video conference connection. Comprising the group were commercial fishermen, oyster farmers, scientists, local staff from the EPA, ADF&G, and the US Fish and Wildlife Service, KBC instructors, members of the conservation community, local non-profits, as well as a high school student and local author, both of whom planned on writing about OA in upcoming projects. Summarizing some of the ways in which Homer participants identified themselves through the survey (see Appendix A): 11 people marked the education/outreach category; eight marked research/science; and four marked resource management. Four participants also identified as involved in commercial fishing, one identified as a shellfish grower. Half of the participants (14 out of 27) also identified as involved in subsistence and/or personal use fishing. Two participants identified their involvement in fisheries in relation to diet: "I love to eat oysters, mussels, clams…" and "I eat fish, it's an important part of my family's diet."

Dillingham

Along the rich waters of Bristol Bay, Dillingham sits on the north shore of Nushagak Bay. The town of 2,329 residents marks the meeting of the Wood River with the Nushagak River. More than half of the local population (roughly 56 percent) is Alaska Native (US Census Bureau 2010). Just over 30 percent of the population is White, and another 7.9 percent identify as both Alaska Native and White (US Census Bureau 2010).

Salmon serves as the economic and social lifeblood of the community and region. Every year all five species of salmon return home to the rivers and streams of Nushagak Bay. Their return ignites a seasonal economy which causes the town's population to double for nearly six weeks every summer with seasonal workers including commercial fishermen, crew and cannery workers. In 2000, 457 commercial fishing permits were issued to residents of Dillingham (Sepez et al. 2005). Of these, 245 were issued for salmon (others permits include halibut and herring). In 2000, there were a total of 481 licensed crew members resident in Dillingham (Sepez et al. 2005). World-class sport fishing opportunities further shore up the local economy through guiding/fly-in services and sport lodges but the sector runs ancillary to the community's main economic engine of commercial fishing.

The harvesting of subsistence resources is an integral aspect of local diets, identities and social relationships in the community. Nearly every single household uses subsistence resources, notably salmon but also herring roe, smelt, halibut and marine mammals (Sepez et al. 2005). According to the ADF&G's Division of Subsistence report, the per capita harvest for all subsistence resources by community members in Dillingham was 242.23 pounds (cited in Sepez et al. 2005:408). This is in contrast to Homer, which has an average annual per capita harvest of subsistence foods of 93.8 pounds, and Kodiak which has a per capita harvest of 151.05 pounds (cited in Sepez et al. 2005).

Despite white-out blizzard conditions, 14 community members (five men and nine women) made the trek into town for the community roundtable on an evening in early January 2012. Only 10 of the 14 participants turned in the survey. There were three commercial fishermen (i.e. permit holders) in attendance. (Other participants identified themselves as connected to the fishing economy through close family members who are commercial fishermen). Only one participant identified themselves as involved in the processing sector. Others in attendance were involved in education/out-reach through involvement in an Alaska Native natural resource non-profit organization and the local college; and community/economic development through a regional Alaska Native corporation and a local state legislator's office (House District 37). A few high school students also attended the roundtable. Nine out of the 10 participants to turn in the survey identified themselves as involved in subsistence fishing. One participant described her reason for attending as rooted in the inter-relationship of social and ecological health in her community: "I'm here because, I know it sounds strange, but I see that we treat the oceans and the lands the same way we treat women and girls, and people we view as having less power. And I think that what we are doing to Mother

Earth is a reflection of what we are doing wrong elsewhere and I'd like to do something about it."

Kodiak

The City of Kodiak (population 6,130) sits on the northeastern edge of Kodiak Island in the Gulf of Alaska (US Census Bureau 2011). The population is diverse in that 40 percent of the local population is White, roughly 10 percent is Alaska Native and 37.4 percent is Asian (predominantly Filipino).

Kodiak is among the state's largest fishing ports. There were 1,569 commercial fishing permits and 1,263 crew licenses issued to Kodiak residents in 2000 (Sepez et al. 2005:202). Unlike the singular significance of salmon in Dillingham, the commercial fishing industry in Kodiak is diverse. Kodiak is home to nearly every possible gear group and these gear groups target a variety of species including crab, halibut, herring, groundfish, black cod, scallops and salmon. Kodiak is also a major seafood processing center with more than a dozen processors in the community operating year-round.

Like Homer and Dillingham, Kodiak is recognized for its first-class sport fishing opportunities. In 2000, there were 11,331 sport fishing licenses sold in Kodiak (5,000 of these were sold to Alaska residents) (Sepez et al. 2005:203). This is in contrast to Dillingham where 2,210 sport fishing licenses were sold in 2000 and Homer where 20,550 sport fishing licenses were sold (14,664 of these were sold to non-residents) (Sepez et al. 2005:231).

Figure 3.0 Saint Paul Harbor, Kodiak. *Photo by Alan Parks*

A total of 18 people attended the Kodiak roundtable, including five women and 13 men. Eight of the participants were involved in commercial fisheries as permit holders and/or quota share holders. One person identified as crew in commercial fisheries and another wrote in the margins on the survey to identify themselves as a former salmon seine boat skipper put out of business by the *ExxonValdez* oil spill. Yet another wrote in the survey margins to redefine or expand upon the category of involvement in commercial fisheries: "Kodiak is a fishing dependent community. Everyone here is involved in fisheries in one way or another." Twelve participants are involved in subsistence fishing and 15 identified themselves as involved in recreational

fishing. Ten people identified themselves as involved in research/science and/or education/outreach. Kodiak participants included the harbor master, a local diver, staff from the local utility, educators, several self-identified concerned citizens, and one self-identified "grunt" worker.

Ocean Acidification: A Brief Overview

Over the past 150 years human emissions of carbon dioxide (CO_2) from processes and technologies developed during the industrial revolution has increased CO_2 concentrations in the atmosphere from 280 to 385 parts per million (ppm).

Oceans play an essential role in regulating the earth's climate by absorbing carbon dioxide (CO_2) from the atmosphere. Since the start of the industrial revolution, the oceans have absorbed about 525 billion tons of carbon dioxide (CO_2), including about one-third of all human generated, or anthropogenic CO_2 (CNRS 2008). Anthropogenic CO_2 is caused by human activity such as fossil fuel burning and changes in land use practices (e.g. deforestation, urbanization). Scientists estimate that roughly 46 percent of anthropogenic CO_2 stays in the atmosphere, another 29 percent is absorbed by land (e.g. plants), and 26 percent is absorbed by our oceans.

As CO_2 dissolves in seawater, it fundamentally alters ocean chemistry by lowering the pH level of surface waters, causing them to become more acidic and inhospitable to calcium carbonate shells and skeletons (Cooley and Doney 2009:1). Ocean acidification has been called the "other carbon problem" or the "evil twin" to climate change because it is caused by the same CO_2 emissions as climate change. The impacts of OA are additional to, and may exacerbate, the effects of climate change.

How does ocean acidification work?

Seawater pH is a critical variable in marine systems. The pH scale ranges from 1-14 and measures the acidity of water, with 1 being the most acidic. The pH scale is like the Richter scale for earthquakes in reverse, each decrease of a pH unit indicates a ten-fold increase in acidity. Today's surface ocean water is slightly alkaline, with a pH ranging from 7.5 to 8.5. As CO_2 reacts with water, it forms carbonic acid, which releases hydrogen ions. These hydrogen ions lower the pH of the water. The average surface pH of the global oceans has dropped from 8.2 to 8.1 since the industrial revolution. On the pH scale, this seemingly small change of 0.1 indicates an increase in acidity of 30 percent. If global CO_2 emissions continue on current trends, our oceans will see a pH drop of 0.4 – a 150 percent increase in acidity – by the end of the century.

Due to increased acidity, less calcium carbonate is available for marine organisms to use in making calcified shells. Said differently, carbonate concentrations, notably the shell building minerals of calcite and aragonite, decrease with increasing acidity. This means that if the pH of the oceans drops by 0.4 by the end of the century, as currently predicted, the amount of calcium carbonate minerals available would decrease by 50 percent (ESF

2008). This shift would create a more acidic ocean environment than the world has had in the past 20 million years.

Research has shown that lowered ocean pH affects the processes by which animals such as corals, mollusks and crustaceans make their support structures.

Figure 4.0 Dr. Foy shows off a red king crab at the AFSC Kodiak Laboratory. *Photo by Alan Parks*

Shelled pteropods are tiny planktonic snails, also known as the sea butterfly, that are near the bottom of the food chain. Pteropods have been described as the "ground zero" of ocean acidification. They will be one of the first casualties of increasing acidity in Alaska's marine waters. In recent experiments exposing live pteropods to the conditions predicted by "business-as-usual" carbon emission scenarios, the pteropod shells showed evidence of dissolution and damage within 48 hours. Pteropods are a key food source for salmon and other species. They comprise 50 percent of the juvenile pink salmon diet. A 10 percent decrease in the population of pteropods could mean a 20 percent decrease in an adult salmon's body weight (Mathis 2009). A recent study by Armstrong et al. (2005) shows a striking 45 percent decrease in pteropods in juvenile pink salmon diet in the northern Gulf of Alaska between 1999 and 2001. Researchers are now grappling with the critical questions of why there was such a dramatic change in the diet of pink salmon in these years and what it ultimately means. In addition to pteropods, marine organisms at risk from increasing acidification include the corals and coralline algae commonly found in reef communities. Coldwater coral communities, for example along the Aleutian Islands, form important fish habitat. Foraminifera and coccolithophores, planktonic organisms that are abundant in most surface waters, are also at risk.

There is a dearth of economic impact assessments related to ocean acidification, but the high threat to marine ecosystems posed by acidification indicates that fisheries and the coastal economies that depend on them may be severely harmed (see Cooley and Doney 2009). Acidification alters the chemical balance of the oceans, and in doing so undermines the foundation of the food-web. Some commercial species like clams and crabs will be directly affected by reductions in calcium carbonate. For others, like most fish populations, impacts will be indirect as acidification affects their key prey species. A recent study by Cooley and Doney (2009) found that 75 percent of the $4 billion fishing industry in the United States is somehow connected to an organism that is potentially

impacted by ocean acidification. (These figures were based on 2007 US domestic ex-vessel revenue).

Ocean acidification is likely to alter the biodiversity of the world's marine ecosystems and may affect the total productivity of the oceans. Previously it was thought that these changes would take centuries, but new findings indicate that an increasingly acidic ocean environment could cause problems in high-latitude marine ecosystems within just a few decades. Estimates of future atmospheric and oceanic CO_2 concentrations, based on the Intergovernmental Panel on Climate Change (IPCC) CO_2 emission scenarios, suggest that by the year 2050 atmospheric CO_2 levels could reach more than 500 ppm, and near the end of the century they could be over 800 ppm. This would result in an additional decrease in surface water pH of approximately 0.3 pH units by 2100 (http://www.sfos.uaf.edu/oarc/).

Alaska Waters on the Frontline

> "The same things that make Alaska's marine waters among the most productive in the world may also make them the most vulnerable to ocean acidification" (Mathis 2009).

Although ocean acidification has been referred to as a "worldwide crisis in ocean chemistry" (Scigliano 2011), its impacts will not be felt uniformly across the global ocean. Currently, the oceans' surface water layers have sufficient amounts of calcium carbonate for organisms to use (known as saturated states or points). Saturation state refers to whether or not there is enough carbonate minerals in the water column to build shells. This calcium carbonate rich layer is deeper in warmer regions and closer to the surface in colder regions. Alaska has low saturation states, meaning that the saturation states (i.e. depths of water) are much shallower in Alaska waters than elsewhere, including the North Atlantic. Because calcium carbonate is less stable in colder waters, marine life in the polar oceans will be affected by calcium carbonate loss first. A study published in *Nature* by 27 U.S. and international scientists stated, "Some polar and sub-polar waters will become under-saturated, probably within the next 50 years" (Orr et al. 2005). More acutely, Dr. Mathis's current OA monitoring research project in the southeast Bering Sea Shelf shows that for nearly half of the year (July through October) sections of the Bering Sea are undersaturated in aragonite with CO_2 levels above 700ppm (350ppm is a healthy ocean pH level).

The changes in ocean chemistry described above will reduce the ocean's ability to absorb CO_2 (acting as a carbon "sink") from the atmosphere. Researchers at the University of East Anglia have shown that the North Atlantic is currently slowing its uptake of CO_2, reducing the sink by greater than 50 percent since 1995. Though variation in the Northern Atlantic Oscillation is attributed as the primary cause, the problem is exacerbated by the high inorganic carbon levels in the ocean (Schuster et al. 2007). Although the ocean is an important natural carbon sink, it is not an infinite one. When the oceans can no longer take one-third of anthropogenic CO_2 out of the atmosphere, more greenhouse gases will remain in the atmosphere, accelerating the warming trend.

The critical research question now is "to what extent will ocean acidification alter marine ecosystems and biodiversity?" Predictions for the consequences of ocean acidification are based on the Intergovernmental Panel on Climate Change's (IPCC) scenarios for future carbon dioxide emissions. Under the "business-as-usual" scenario (a scenario in which we continue to add carbon to the atmosphere without regulation; also known as the continually increasing scenario), by 2050 organisms in the polar oceans will be facing a pH low enough to cause calcium carbonate shortages. Under the "stabilization" scenario (where future carbon emissions are reduced), the polar and sub-polar oceans may continue to have calcium carbonate present, but at a much lower concentration and in a much thinner surface layer.

The effects of increasing acidity on the oceans will last for thousands of years since the oceans cycle very slowly. It takes 1,000 to 2,000 years for the ocean to mix itself one time. According to researchers from the Royal Society (the British equivalent of the U.S. National Academy of Sciences), "Reducing CO_2 emissions to the atmosphere appears to be the only practical way to minimize the risks of large-scale and long term changes to the oceans" (Raven et. al. 2005). During the discussion in Dillingham, Dr. Mathis further contended, "CO_2 mitigation is the #1 priority that we should be working on." Mathis concluded, "The oceans will always be productive. The question is, what will they be productive with? "

Key Themes and Findings

Priorities: From Research to Resistance

"You can't manage what you don't monitor."

If the roundtables revealed one basic fact it is that there remains a lot of unanswered questions regarding the impacts of ocean acidification on Alaska fisheries. The second might be, to paraphrase a roundtable moderator: People don't really care about chemistry, people care about fish.

Is there a connection between ocean acidification and the recent decline in king salmon returning to the Nushagak? Could OA help to explain the smaller size of sockeye returning to Bristol Bay in recent years? "There is considerable discussion on why the size of the sockeye is decreasing, and all the speculation so far is that it's because we're taking the larger fish out of the gene pool, but seeing this I wonder… is [OA] a factor?" What is the correlation between OA and the decline in seabirds around Homer? Why hasn't the Kachemak Bay shrimp fishery rebounded after a 25 year shutdown? Could ocean acidification play a role in the shrinking halibut biomass in the Gulf of Alaska? How is OA changing halibut habitat in the Gulf of Alaska? Are halibut in competition for food with arrowtooth flounder?

These are just some of the questions posed by participants during the community roundtables. The answer to each was largely the same – We don't know… yet. As Dr.

Foy put it to the Kodiak crowd, "The expertise has not caught up with the issue." Each of the above questions might be considered a research priority in its own right. That is, these are the issues and aspects of OA that roundtable participants want to know more about. More broadly however, a key research priority identified by participants across the community roundtables was to increase and invest more in OA monitoring in Alaska waters. "Is it real for the Gulf of Alaska?" asked a Kodiak participant. Another added, referring to Dr. Foy's experimentation at the AFSC Kodiak Laboratory, "What I'd like to see is an investment in monitoring around Kodiak Island. The research is being done in the lab, yet no monitoring." A shellfish grower in Kachemak Bay contended, ""We need basic research, because right now I don't think anybody has a clue about what's going on here in the bay." He reiterated the need for more research by elaborating on recent changes he's witnessed.

> We'll see episodes, like three years ago we drove out [to the farm] and the water was super clear, like it is in the winter, which means there's no food in the water. It was July. It was odd. You never see the bottom in July, it's usually pea soup colored. That didn't happen last year… This year there wasn't any jellyfish… but two years ago, there were tons of them… [and] butter clams have taken a hit too. There used to be tons of butter clams right by my farm, now there's none. Literally.

This priority is in part being met by Dr. Mathis's ongoing research in the northern Gulf of Alaska and Bering Sea. For the last five years, Mathis and his research team have collected water samples from sampling stations in the northern Gulf of Alaska twice a year, once in May and again in September. In March 2011 they deployed their first mooring in the Gulf of Alaska (named GAK1). This mooring measures CO_2, pH and O_2 levels, as well as temperature and salinity at both the surface level and at a depth of 250 meters. Mathis has recently received funding to continue these observations for another five years. Efforts to understand ocean conditions along the southeast Bering Sea shelf have also ramped up in recent years. In the last three years (2008-2010), Mathis has spent 450 days at sea. His work shows that in both the Gulf of Alaska and Bering Sea, the intrusion of anthropogenic CO_2 is causing undersaturation in the shell-building mineral aragonite. For the first time, Mathis found calcite undersaturation (in addition to aragonite undersaturation). It prompted Mathis to install a second mooring in the Bering Sea in May 2011.

It may seem superfluous that roundtable participants are identifying monitoring as a research priority at a time when OA research activity seems to be increasing in Alaska waters. In fact, some participants felt that it was time to move beyond monitoring given the information available to date: "To me it's like okay, we know. What can we be doing now? But I understand what he's doing with monitoring, yeah, we need more of this data to show the trends." This sentiment touches on an important distinction. Monitoring tells us something about ocean conditions and how they are changing. It does not however tell us something definitive about the consequences of those changing conditions. Although Dr. Foy's current research program provides compelling evidence for what the impacts of OA might be for crab species and other benthic calcifiers, the actual consequences of changing ocean conditions remain largely unknown in the natural environment. This is

particularly so in the context of Alaska fisheries and livelihoods. This will be discussed further below. This is problematic from the point of view of many participants who reckon with awareness that we can't afford to wait to feel the impacts of OA to act on it while at the same time knowing how difficult it is to proactively address an issue that has yet to be realized.

> When does [OA] become more than a threat? When do people become involved? When it hits the pocketbook.

> I don't know a lot about [OA]… Perhaps that's because you don't really see any discussion until it's well advanced and then it's hard to reverse it.

Finally, this call from roundtable participants to increase OA monitoring in Alaska waters comes on the heels of the Governor's office removing funding for an Ocean Acidification Research Initiative from the University of Alaska's 2013 capital budget request. The request for $2.7 million in funding aimed to accomplish three things: 1) Install monitoring buoys to measure OA over time; 2) develop an economic model to assess the potential impact of OA to Alaska's fisheries; and 3) set up a system to collect water samples from commercial and recreational vessels across Alaska to look at broad acidification levels around the state. At the time of writing, concerned citizens, industry and university players and other entities attuned to the issue of OA are eagerly waiting to see if the Alaska Legislature successfully adds this funding for OA research back into the 2013 budget. (Funding for the OA Research Initiative was also removed from the University of Alaska's 2012 capital budget request at the level of the Governor. The Legislature was unsuccessful in adding it back into the 2012 budget).

This basic research priority shines critical light on the need for the continuation and expansion of OA monitoring and research in Alaska waters. This is problematic not only because "you can't manage what you don't monitor" – to quote a Kodiak roundtable participant – but because this priority underpins and engenders another key finding of this case study. That is, because there remains uncertainty surrounding the impacts of OA, and because the threat of OA remains largely unrecognized in the daily lives and livelihoods of Alaska's fishermen and communities, there exists a tendency for the threat of OA to be eclipsed by more tangible threats to local waters and ways of life. Below we provide a few excerpts from roundtable discussions which illustrate a lack of certainty in locating OA as the definitive culprit for some of the potential and current changes occurring in Alaska waters and fisheries. The sentiments expressed below further help to set the stage for the following section which situates people's perceptions of OA within a broader suite of perceived threats currently shaping life and work along Alaska's coastline.

> I run into people all the time who haven't heard of ocean acidification. Both in the fishing industry and around town in support services.

> There's an awful lot of uncertainty surrounding ocean acidification. And industry and the public lose confidence if changes are implemented in management and

> then it doesn't happen. Credibility of management is as important as anything else.
>
> I'm struck by how little we actually know [about the impacts of OA].
>
> I don't know much about [OA]. I don't know what fisheries it's impacting on the west coast. I mean it's hard to tell with fisheries because they all seem to be screwed all the time. It's hard to tell which ones are getting hit or not. I don't know where the impacts are…

Formidable Threats, Inevitable Oceans

"I get the sense that we can't do anything about it."

"I can't imagine such a huge global shift that we lose something.
It's hard for me to grasp and I think it's hard for a lot of local people to grasp."

The sense of uncertainty surrounding what ocean acidification actually means for Alaska fisheries and livelihoods needs to be considered in the local context. What is worth reiterating here is that the threat of OA, though looming, remains largely unrecognized in most people's everyday lives. The exception here is shellfish growers in Kachemak Bay who rely on hatcheries in the Pacific Northwest to supply their oyster larvae and are therefore directly affected by the recent upwelling of acidic waters along Washington and Oregon coastline. One shellfish grower explained, "We're probably the best informed [about ocean acidification] because it affects us directly. I think everybody in the state got hit by the [recent] spat shortage. I know I did. Severely. I know [ocean acidification] is right on the tip of everybody's tongue right now, as far as what's happening, because the hatcheries can't produce [the spat]."

More broadly however, the relative invisibility of ocean acidification stands in stark contrast to other more tangible threats which frequently found their way in and out of conversations attuned to local-level concerns for Alaska waters and ways of life. Three dominant examples include 1) bycatch; 2) the potential development of Pebble Mine in the Bristol Bay region; and 3) access rights to fisheries; notably the move toward catch share programs in the Gulf of Alaska. These three issues in particular infiltrated discussions on ocean acidification. One project participant identified bycatch as the "number one threat" to his livelihood. Another identified absentee ownership (the migration of fishing privileges away from working fishermen), a common component of catch share programs, as the "biggest problem" facing local fisheries. Yet another compared concern (including his own) for ocean acidification versus Pebble Mine in the following way: "Pebble Mine is easy to latch on to because it's a big hole in the ground that they're proposing. It's such an in your face deal."

We highlight these issues here because even as Dr. Mathis stresses point blankly to audience members that "we are past the tipping point for carbon dioxide in our oceans,"

these are the issues that tend to demand center stage. Their impacts on fisheries and the communities that depend on them are perceived as both more tangible and more immediate, and community members invest their limited resources (e.g. time, energy, capital, etc.) accordingly. One participant described in detail the necessary cost of participating in fisheries politics: "It takes thousands of dollars. If I fly from here to Anchorage and put myself up in a hotel room for eight days to be at the [North Pacific Fishery Management] Council meeting. I mean, I get to speak three minutes. But it might cost me $2,500 for those three minutes. But you have to be on alert through the entire Council process." The same participant described ocean acidification as follows: "I think the threat is real… But I just don't know enough about it in terms of how it's truly going to affect fishing. I want to know more. But it has me concerned." Another participant described recent changes she'd witnessed on the water (changes she did not directly link to OA) as follows: "I know it's here, I just don't know what it is… What is really going to happen to Bristol Bay? That is just a huge unknown to me."

All of this works to inadvertently push the issue of OA further down the line in the local hierarchy of worry and resistance. It is a push that may be exacerbated by a sense of inevitability; a sense that there is no alternative.

> I get the sense that we can't do anything about [OA].
>
> Is there an alternative [to OA]? Not that we're going to let [the ocean] go, but what can we do?
>
> We're talking about mitigation of a problem that could be labeled as inevitable.

Another participant explained, "I keep coming back to how knowing more about acidification will help us? Because the problem is ongoing, and we're not in control. We're not the one's putting the majority of the carbon into the ocean. We can't stop it."

This is not to say that doom, gloom and "oh well" attitudes permeated community roundtable discussions. In fact, it was through collectively reckoning with the inevitability and unknown consequences of ocean acidification that participants moved forward on how to address ocean acidification, and reduce carbon emissions, as individuals, industries, communities and countries. Prior to outlining potential avenues for community action and industry involvement in reducing the threat of OA, the next sections discuss the threat of OA in relation to two fundamental facts of life in rural regions of coastal Alaska: 1) the importance of subsistence resources, practices and economies; 2) the high cost and consumption of energy in coastal Alaska.

Razor Clams, Cockles and Kings: Subsistence Foods and Social Relationships

"To me, the king salmon are the really prized fish. You get your king salmon strips and your gumchuk... Whatever excess is on the backbone I just take the meat off and can it, and that becomes what we use in the winter time when we make fish bread ."

From the average citizen to commercial fishermen to political leaders and policy makers everyone wants to know: What is OA going to cost us? The short answer is: We don't know. We have estimates and economic models but we don't (yet) have definitive answers for Alaska fisheries. The economic importance of commercial fishing to a state that has more coastline than the entire continental United States combined is impressive. The seafood industry is the largest private sector employer in the state. The value of Alaska's commercial fisheries in 2010 was $3.8 billion. In short, Alaska fisheries are not only wild, they are worth a lot. With all that in mind, in this section we aim to discuss the threat of OA beyond the context of a commercial economy.

Earlier we cited ADF&G reports which present data on the per capita harvest for all subsistence resources by community members in the respective communities. Despite calculating per capita harvests down to a tenth of pound (in Dillingham the per capita harvest was 242.23 pounds (Sepez et al. 2005:408)); this measurement is in fact quite crude when one considers the broader significance of subsistence practices to families and communities in coastal Alaska. Below a participant works to explain how subsistence practices embody social values, roles and relationships in the community.

> Our two youngest one's, they keep the smokehouse running and see that the fish are hung. But the subsistence lifestyle… means more to our children than just learning how to cut fish or taking the tongue out of a moose. It binds our family together, it helps you learn who you can count on to do certain kinds of things and who you have to make allowances for. It teaches you how to work together, and get things done. It encompasses a feeling of sharing and community… There's a sense of closeness, of intergenerational closeness that a subsistence lifestyle provides.

We spent three days in Dillingham during the week of the roundtable. We expected over the course of those few days to talk plenty about what OA meant for the region's iconic sockeye salmon. And we did. For many, it is impossible to "imagine this community without salmon, a day when we didn't have salmon." Freezers are filled with it. "And it's not just fresh frozen fillets. There's fish that's smoked for a day that's put away. There's fish that's smoked for three days then put away. There's heads that are in my freezer. Fish heads. Some of them are smoked, some of them are fresh frozen. How can you imagine not having it or going without?"

Figure 5.0 Salmon gillnetters in Dillingham.

But concern was not limited to salmon. There was keen local interest in the fate of razor clams and cockles in a nearby bay. The clams and cockles in Kalukuk Bay are not commercially harvested but after the third person mentioned them in conversation we followed up to find out more about them. This is what we were told:

> There used to be a village there. We have one elder who is 88 years old here in Dillingham who grew up in Kalukuk. She lives for the spring time, when she gets clams from her grandson who goes over there.
>
> It takes a lot of effort and work to get those Kalukuk clams. You go over there with a snow machine, and you take a ladder. You have to take a ladder because we still have winter [conditions this time of year], so they take a ladder to use to get down onto the beach from the ice edge. But for an elder here in our community who loves those clams, she gets a twinkle in her eye she is so happy when she gets them. So to me, I don't know what value you give to it and I don't think you can quantify it but it's something that we do here in rural Alaska. And that, to me, would be such a tragic loss, to lose those clams.

We include these stories here to illustrate the somewhat hidden ways in which OA will potentially harm families and communities in Alaska coastal communities. It is important to remember that understanding the impacts of OA in purely economic terms is at best a partial understanding, and one which can obscure a very real loss in people's lives and localities.

Still, a recurring theme throughout the roundtables was the difficulty of legitimizing action, particularly action related to reducing carbon emissions, without the heavy weight of economic impact to power it forward. Political policy pressure points respond primarily to dollar values. Over half of the funding requested for the Ocean Acidification Research Initiative in the University of Alaska's 2013 Capital Budget Request goes toward hiring staff to develop a robust economic quantification of what ocean acidification is going to cost the state of Alaska. Professor Mathis explained, "That seems to be what all of our representatives, on both sides, what to know. They agree that [OA] is a problem, but getting them to spend money on it is hard because they don't see that there is an economic driving force behind it yet."

The reality of life in rural Alaska is that there <u>is</u> an economic driver underlying efforts to reduce CO_2 emissions. The impetus here is not necessarily environmental concern or changing ocean chemistry. Regardless, the economic incentives dovetail seamlessly with environmental interest creating an opportunity for action which benefits both our bank accounts and ocean environment.

Beacons, BTUs and Sustainable Transitions

The State of Alaska ranks number one in the country for per capita energy costs (US Dept of Energy 2009). In 2009, Alaska spent $7,684.06 on energy per person, a difference of $4,223.33 from the US average of $3,460. Until recent months, Alaska also ranked number one in the country for total energy consumption per person. We are now ranked

number two, just behind Wyoming. In 2009, Alaska consumed 907 million BTUs per person, well above the US average of 308 million (US Dept of Energy 2009b).

This high cost of living (in Dillingham especially) was discussed as a critical threat to the viability and vitality of Alaska's coastal communities. Soaring energy costs in recent years have spurred community-level action and state energy programs dedicated to reducing energy costs and improving efficiency both within the fishing industry and wider community. One participant contended, "The legislature can and has done things that will allow us to live our lives in a way that will have an impact." Programs include investing in renewable energy projects, retrofitting fishing vessels and energy efficient upgrades for housing. Statewide energy policies encompass goals which aim for 50 percent of the state's electricity to come from renewable sources by 2025. The state has also created an Emerging Energy Technology Fund which includes a $250 million low interest revolving loan fund to fund energy efficiency improvements in public buildings. These programs weren't implemented with ocean acidification in mind, but the benefits of renewable energy in Alaska, and particularly in Alaska's coastal communities, are wide-ranging and inclusive of both economic and environmental concerns.

When energy prices doubled in Kokhanok in 2009, the village of 170 people on Lake Iliamna started looking for ways to stabilize costs. They now have three wind machines. Kodiak Electric Association has invested in advanced wind power capacity. In fact, more than 90 percent of the electrical energy consumed in the town of Kodiak comes from wind and hydro energy. Dillingham residents have also installed wind machines and three outdoor wood furnaces. Add to this picture more than a dozen electric cars driving down the streets of Petersburg and an organic farm in Bethel which provides local produce to the folks of the Yukon-Kuskokwim Delta who typically have to import their fruits and vegetables and you begin to get a sense of the direction we're heading. These efforts reduce today's living costs, but they were also made with the next generation in mind. They are local-level attempts to ensure that the next generation can afford to live in their home community.

It is in the interest of our oceans and economies that we work to reduce energy costs and consumption. Referencing both environmental and economic thresholds, one participant imagined his community serving as a beacon to others. Explaining how our Alaska home will be changed by climate change and ocean acidification first and more intensely than many other places on the planet, he went onto to stress the importance of facilitating the transition to an environmentally-based economy for his children and grand children.

> We're at a place now where a shift is necessary. And our generation can either be the clutch or that shift is going to happen without a clutch. It's our job to find ways to enhance that transition. I don't know if you drive a vehicle with a standard transmission but if you try to make a shift without a clutch you're going to have some problems.

Inspiring? Yes. But even the optimism of this participant was tempered by the size and scale of the problem.

> It seems to me that the [carbon] pollution happens in such a magnitude coming from all over the globe that it's just a lot easier to point to China or some place else and say, 'Well that's where the problem is.' Somebody that's got a wind farm in Alaska is not even a drop in the bucket I guess. I get stuck there in trying to understand what the stimulus is [for global solutions].

Other participants also questioned how meaningful local efforts actually were in the grand scheme of things. "I think the real issue is how do you get the China's and the India's and the other countries that are coming along that are using such a large amount of our fossil fuels and contributing to the overall demise, or carbon emissions. I mean we have to lead by example but that's the big issue for me in the long run." That is the question. What can we do? A wind farm in Alaska isn't going to have an impact on the greater global picture. At the same time, Alaska is going to have to deal with the consequences of what is a global problem. In the final section of this case study, we trace the contours of what we as members of Alaska's coastal communities and the seafood industry can do to reduce carbon emissions and deal with the threat of ocean acidification.

Two Tracks, Adaptive Strategies and Partnerships

"We can't curb China's CO_2 emissions but we can think about how we manage our fisheries, and how we sustain our fisheries here in the state. That's something that we can do."

Roundtable participants grappled with the tension between knowing that "we have to lead from the bottom" in efforts to address OA, and the reality that grassroots-level efforts and "volunteering to reduce emissions is not going to get us where we need to be." The way forward, stressed a Kodiak participant, has to include "a coordinated effort between individuals, industry, government and community to make it work. Individuals can't make it work in the long run if you want to make it cost effective."

In each roundtable, participants emphasized the importance of operating on a dual track system. That is, working at both the personal level and the political level. "We are the problem, we are carbon," claimed a Homer participant. She continued: "There are 64 light bulbs burning in this room right now." (When she mentioned the number of light bulbs a second time, another participant got up and turned off half of the lights in the room). At the same time, participants are acutely aware that "we need to find new ways of dealing with the politics to address these issues." "Who is going to the carry the water?" "Who is going to send the message to policy-makers?" These types of questions suggest that while shutting off your car in line at the coffee kiosk, composting and turning down the lights are worthy individual acts, such efforts have to occur in tandem with larger coordinated strategies aimed at policy. Addressing ocean acidification through existing community networks and regional organizations already invested in the health (defined broadly here) of our communities and fisheries was one such strategy proposed by roundtable participants as a potential starting point.

Members of the fishing industry were identified as well-situated for contributing to OA science and informing policy. Several participants proposed establishing partnerships between industry and science as a means to monitor ocean conditions and mitigate the impacts of OA. Sectors of the industry could quite literally provide the vessels of opportunity to aid in collecting water samples on their way to and from fishing grounds. Although technical challenges remain, including managing samples and chain of custody concerns, these protocols were perceived to be hurdles rather than stalemates in such efforts.

Speaking with shellfish growers reveals a different set of strengths in the seafood industry's contribution to OA science. Whereas fishing vessels provide snapshots of their working environment at certain times of year, the nature of mariculture entails everyday observations of the surrounding environment.

> [This is] the perfect place to monitor [ocean acidification]. It all comes up [here], the kelp, all the things that settle, the little fish, the barnacles set, the jelly fish go through. You get to see everything… when you're farming shellfish, you see it everyday… [So] if you want to study ocean acidification, this would be the place to do it, right here on the farm… My product is four or five years old [before it goes to market] so you're watching the whole progression. You see the history of your whole operation in every oyster you sell. There is history in every shell.

Shellfish growers are uniquely positioned to observe changes in the local marine environment. Monitoring is, in a sense, built into the art of raising oysters. The shellfish growers we met with spoke of observing such things as a clear spot in the water where there shouldn't be, more plankton than usual and smaller jellyfish. In short, it's not just oysters that shellfish growers pay attention to. It's the color of water, the size of kelp and the number of barnacles. Shellfish growers take into account what is thriving and what is dying in their working environment on a daily basis. In this way, they serve as powerful witnesses to change. The role of Alaska's seafood industry in collecting data and informing OA science can better tell us how to manage, mitigate and adapt to a changing environment. As Dr. Mathis noted, "Data can tell us to fish at a different time, like a month earlier or a month later, or to catch less in any year. [It can tell us how] to keep the fishery sustainable. That's the data that we don't have."

Summary of Key Findings

- The science about ocean acidification is a clear reason for for concern for the health and productivity of the oceans coastal Alaskans depend on.
- The economic value of Alaska's commercial fisheries approaches $4 billion (first whole sale value), but it is not known how ocean acidification will affect specific fisheries and what the cost will be to the seafood industry and fishery-dependent communities.

- Fishermen and shellfish growers want to participate in scientific monitoring of ocean pH. Fishermen aboard vessels can collect water samples and shellfish growers are skilled observers of local conditions.
- In addition to quantifiable economic impact, coastal Alaskans are concerned about damaging traditional uses of marine resources and harm that will come to the ecosystem that supports those resources.
- Because of uncertainty about what the exact impacts of ocean acidification on fisheries will be, concerns about the future tend to be eclipsed by more immediate and tangible issues facing fishermen and fishing communities. One exception was the shellfish growers who are already experiencing the loss of oyster spat due to corrosive waters in the Pacific Northwest.
- Despite acknowledgement that ocean acidification is inevitable and the exact consequences are unknown at this time, doom and gloom attitudes did not permeate the discussion. Roundtable participants explored ways to address the root cause of ocean acidification in order to mitigate its effect, including reducing carbon emissions as individuals, industries, communities and nationally. They recognized the economic benefits of clean energy, especially in rural Alaska where the cost of living soars with fuel prices.

Concluding Remarks: Cotter Pins and Copepods

"Time is everything and it doesn't sound like we have a lot of time."

In the above pages we have identified some of the key themes which arose during community roundtable discussions. These include the priorities, concerns, obstacles and incentives (both direct and indirect) shaping people's awareness of and ability to address and reduce the impacts of ocean acidification.

Much like the roundtables, this case study will serve as a point of departure rather than an end product. We consider the roundtables a success not by what was said in the space of two hours, but by what comes after. The ultimate purpose of the community roundtables was not to capture conversations, but to move them forward, to facilitate creative dialogue between citizens, seafood industry, coastal communities, scientists and policy makers.

Although much of what we reported on above hinges on how much we don't yet know regarding the consequences of ocean acidification, uncertainty does not validate inaction. What we do know, summed up by a Kodiak participant here, is that "ocean acidification is changing habitat, and that is problematic for a place like Alaska. We have a pristine environment and ocean acidification is changing that." So while we can't definitively say what the impact will be of increasing levels of anthropogenic CO_2 on king crab in the

Bering Sea, we have an unsettling indication of what changing ocean chemistry means for the tiny copepod.

> So when you have these little animals that we can barely see with the naked eye that the fish need to eat, to survive… that's when I got really concerned about this. Because man, if it hits those small guys. I mean, they have this little food chain going on. We can't see it, but it's there. …[I]t's like a helicopter that you can see the fuselage, you can see the rotor, but it's the little tiny cotter pins that are holding that all together. If you take that cotter pin, if some of them shake loose, it will shake the whole thing apart. And I think that's what OA is doing…. and I don't think we need that.

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Appendix A: Roundtable Participant Survey

Ocean Acidification and Alaska Fisheries Roundtable

Monday, January 9, 2012
Dillingham Senior Center, Dillingham

Name (Optional): _____

*****Please Circle Best Response…**

Age Range 20s 30s 40s 50s 60s 70s 80s

Gender Male Female

*****Please check all that apply…**

I am involved in…

1) Commercial Fishing… ☐

As a… Permit Holder… ☐ For… Salmon… ☐
Quota Holder… ☐ Groundfish… ☐
Crew… ☐ Halibut… ☐
Other…_____ Shellfish… ☐

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2) Subsistence Fishing… ☐

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3) Shellfish Farming/Mariculture… ☐

As a… Owner/Operator… ☐
Employee… ☐
Other… _____

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4) Recreational Fishing… ☐

For… Salmon… ☐
Rockfish/Lingcod… ☐
Halibut… ☐
Crab… ☐

5) Charter Operations… ☐

As a… Owner/Operator… ☐ For… Salmon… ☐

Employee… ☐ Rockfish/Lingcod… ☐

Other… _____ Halibut…. ☐

6) Seafood Processing… ☐

As a… Owner/Operator… ☐

Employee… ☐

Other… ☐

7) Research/Science… ☐

8) Resource Management… ☐

9) Education/Outreach… ☐

10) Community/Economic Development… ☐

11) General Public/Concerned Citizen… ☐

12) I am involved in fisheries in other ways…
Please explain: