DRAFT

Kachemak Bay Research Reserve

Oyster Population Resiliency

SITUATION ASSESSMENT REPORT

December 2013

For questions contact Stacey Buckelew
stacey.buckelew@alaska.gov

7. Overview

Climate-related changes to the ocean are emerging as a global problem. While the extent of these effects is currently unknown, there could be possible threat to Alaska commercial fisheries which are valued at approximately $4 billion (Alaska Marine Conservation Council 2011). The shellfish mariculture industry in Alaska has been impacted by loss of oyster larvae ('spat') due to more acidic waters in the Pacific Northwest. As ocean conditions continue to change, better information and tools may be needed to develop oyster resiliency and maintain their productivity in Alaska for current and future generations. A workshop is being planned to bring together stakeholders and leverage expertise from west coast National Estuarine Research Reserves, who are working to understand and address the resilience of native oyster populations in the face of rapidly changing ocean conditions.

8. Purpose

The purpose of the Situation Assessment is to clarify issues and identify stakeholder concerns in order to recommend ways to make collaborative dialogue successful at the workshop. Specifically, the Situation Assessment was conducted to:

1. Provide a greater understanding of perspectives, interests and concerns held by various stakeholders;
2. Allow key stakeholders to express their views in the planning phase of the workshop;
3. Identify common interests in workshop content and areas of disagreement;
4. Provide independent recommendations on tools that might be employed during a workshop to ensure effective dialogue among stakeholders;
5. Identify desirable outcomes or information gains from the workshop.

9. Area Description

(Source: SeaGrant Marine Advisory Program, 1992)

Alaska's aquatic farming industry is young. In 1988, the Aquatic Farm Act was signed into law authorizing the Alaska Department of Fish and Game (ADF&G) to issue permits for the construction and operation of aquatic farms and hatcheries that would supply aquatic plant or shellfish seed stocks to aquatic farms.

Pacific oysters grow very well in Alaska where the cold water supplies abundant, high-quality plankton. Although native to warmer waters, Alaskan shellfish can match growth achieved by shellfish raised in the Pacific Northwest because of the dense plankton blooms. In Alaska, because cold water retards maturation, high-quality oysters are available year round. Cold, clean water also reduces bacterial contamination, extending shelf life and assuring safety when eating cultured oysters, especially when eaten raw.

Pacific oysters cannot reproduce in Alaska due to the cold water. In Alaska there is no shellfish hatchery; therefore, all farmed Alaskan oysters are imported as spat (juvenile oysters) from Pacific Coast hatcheries. Resilience of outside sources of oyster spat is an issue due to mortalities associated with more corrosive waters in the Pacific Northwest, and the inability for facilities to meet the market demand in Alaska.

In Alaska, oysters are grown in suspended nets that are anchored in the ocean. Kachemak Bay is an ideal location for rearing oyster given the extreme tidal fluctuations, which average a vertical difference of 15 feet (Fig 1). Located in a relict glacial-fjord estuary, Kachemak Bay is relatively buffered against large storms generated in the Bering Sea and Gulf of Alaska. The Bay's bathymetry is characterized by a submerged glacial moraine at the mouth of the Bay, and trenches and holes reaching 175 m deep. On the south side, the Bay is guarded by jagged snow-covered peaks. The Harding Icefield, one of the last remaining alpine ice sheets left in North America, hosts seven glaciers that flow into Kachemak Bay. In contrast, the northern side is part of an extensive lowland, with a gentle topographic gradient and no active glaciation.

Kachemak Bay is legislatively designated State Critical Habitat area; however, aquatic farms are allowable and limited to suspended aquaculture only. Within Kachemak Bay there are 12 active oyster farms, which are located in protected bays and inlets on the south side of the Bay. The approximate locations of these are shown in Figure 1.

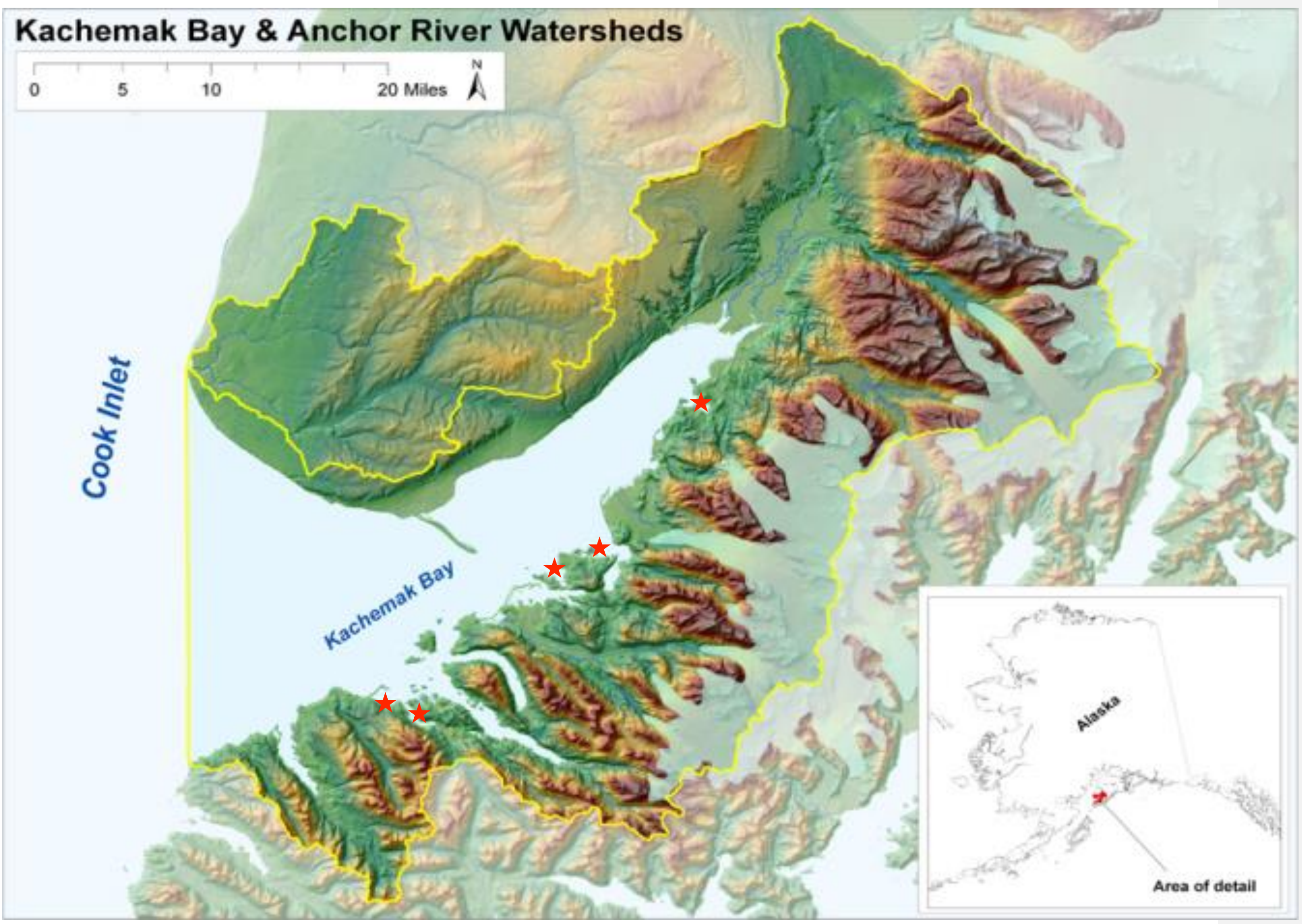

Figure 1. The approximate locations (shown by red stars) of oyster farms on the south side of Kachemak Bay, AK.

10. Methods

The following methods were used to conduct the Situation Assessment:

a. **Identification of Stakeholders:** General categorizes as well as specific organizations and individuals were identified for interview. These stakeholders included:
    - State and Federal Agencies (Alaska Department of Fish and Game (Commercial Fisheries and Aquaculture), Department of Environmental Conservation, Department of Natural Resources, Kachemak Bay Research Reserve, NOAA Kasistna Bay Labs)
    - University Researchers & Affiliates (SeaGrant, University of Alaska Fairbanks)
    - Shellfish Industry (oyster growers, Alaska Shellfish Farms, Kachemak Shellfish Mariculture Association, Jakolof Bay Oyster Co, local co-op managers: Alaska Shellfish Growers Association, Pacific Coast Shellfish Growers Association)
    - Environmental Organizations (local non-profits: Cook Inletkeeper, Alaska Marine Conservation Council, WWF, Alaska Ocean Observing System)

b. **Interview Process**: Individuals identified were invited to participate in the interview process, either in person or by phone. Interviews were conducted one-on-one as informal conversations using a working list of questions to spark discussions and elicit input. Stakeholders interviewed are listed in Table 1.

c. **Interview Questions**: The following questions were used during stakeholder interviews as a starting point for conversation.
    - What is your role in the oyster community?
    - What are some of the challenges or issues that the Kachemak Bay oyster community currently faces or may face in the future?
    - Of these, which issues are priorities to be addressed at the workshop?
    - How well-defined are these issues?
    - Do you have ideas on how these issues can or should be addressed?
    - What should not be discussed?
    - How well-educated are you on these issues, or what additional information might be needed at the workshop?
    - Are there other key individuals or organizations we should be talking to?
    - What would be a desirable outcome from the workshop or what would make this a successful process?

d. **Interview Responses**: Response to these questions were then compiled and analyzed to summarize stakeholder input. Outcomes were be assigned to four categories:
    - **Stakeholder Interests :** the tangible and intangible values which are often behind positions, by group

- **Stakeholder Perspectives:** key thoughts about how the issues can or should be addressed
- **Stakeholder Vision for Outcome:** desired outputs from workshop
- **Key Issues to be Addressed:** the problems, and any potential challenges or conflicts

11. Assessment Results

11.1 Stakeholder Interests

The interview process identified nine primary oyster-related interest groupings. The interests noted below are not exhaustive. Rather, they represent the key interests expressed during the interviews:

1. Agricultural
2. Business and Industry Operator
3. Infrastructure Owner
4. Environmental
5. Federal Government
6. State Government/Management
7. Tribal
8. Research
9. Public Health

5.2 Stakeholder Perspectives

Following is a summary of stakeholder comments organized by these topics, with associated key issues, perspectives and questions.

Marine Ecosystem

Key issues:

- The trends and variability of ocean conditions in Kachemak Bay are not well understood, although monitoring is ongoing.
- A network for ocean acidification monitoring is in its infancy for Kachemak Bay.

Stakeholder views on this topic include:

- Information on phytoplankton blooms is valuable; disseminating information about the timing of phytoplankton blooms is needed for juvenile oyster planting.
- Uncertainty exists on the range of temperature, pH, and salinity in Kachemak Bay. The ability to evaluate trends and predict these variables is needed.

- Ocean pH is being collected for pelagic waters in the Gulf of Alaska, but is just beginning to be collected for Kachemak Bay. Water samples are being collected opportunistically by vessels. Cooperation with oyster growers is needed for more regular and targeted sample collection.

- Tidal fluxes and glacial meltwater result in varying salinity levels in Kachemak Bay. Understanding the acceleration of freshwater to the Bay and potential impacts to oysters is needed.

- Climate stressors (temperature, salinity, pH) and PSP are important concerns for the local mariculture industry. While PSP is a concern it is often associated with warmer water temperatures although there have been documented cases year-round in Alaska.

- Water temperature is the single known variable to influence adult oyster growth and survival. Fluctuations in temperature likely impact the oyster's ability to filtrate.

Oysters Growth and Survival

Key issues:

- Adult oysters experience considerable winter mortalities, although the causal factors are largely unknown.

- The relationship between oyster mortalities and ocean condition variability has not been robustly examined.

Stakeholder views on this topic include:

- Pacific oysters in Alaska are among the slowest growing species in the industry.

- Overwinter survival is the biggest issue with adult oysters in Kachemak Bay.

- There are issues with oyster mortality, although these are typically non-episodic.

- Mortality often happens in the winter at rates up to 30-40%. The reason for mortality is largely unknown and may be related to husbandry practice or ocean conditions.

- Adult oysters rely on energy storage from protein (not fat) to survive Alaska winters. This factor may be associated with the observed winter mortalities.

- Closer documentation about oyster survival by growers and information sharing with researchers is needed to help identify survival trends that could be linked to ocean conditions.

Native Species

Key issues:

- Native bivalve species in Kachemak Bay have undergone abrupt population declines in the past decade. The reason for this demise is largely unknown.

- Restoration and enhancement efforts in Kachemak Bay must be prescriptive to ensure success.

- The regulations within the Kachemak Bay Critical Habitat area may preclude certain restoration activities from happening within its boundaries.

Stakeholder views on this topic include:

- The decline of native bivalve species (scallops, mussels, razor clams etc.) in Kachemak Bay was abrupt and not well understood. Impacts to population are speculative and include: overfishing, ocean acidification, depredation by sea otters, recruitment, and other unknown factors. The rates of decline are alarming and are considerable cause of concern for native bivalve populations, as well as the potential fate of the oyster fishery.

- The decline in native bivalve species needs to be reversed (note: there is a specific distinction between bivalve and shellfish, as the term shellfish also includes crabs which are not the focus of this assessment).

- There is missed market opportunity in Kachemak Bay by not commercially harvesting native bivalve species. Instead many of these species are imported from outside the region or Alaska.

- Research and understanding of larval transport and settlement is needed, particularly for native bivalve species.

- Population densities of native bivalve species may be a limiting factor to spawning success, and may need further explored. “Spawning sanctuaries” have been used in other regions as restorative or precautionary measures.

- Fouling of marine inverterates on fishing gear is an issue. In Kachemak Bay there were previous monitoring efforts on larval barnacle and mussel pre-settlement, which was shared with oyster growers to assist with mitigation. Larval monitoring efforts have fallen by the wayside in recent years.

- Littleneck and razor clams are an important part of the cultural history and identity of native tribes in Kachemak Bay. Restoration proposals have been submitted by native villages in Kachemak Bay, but have yet to be funded. The regulations within the Kachemak Bay Critical Habitat area may preclude certain restoration activities from happening within its boundaries.

- Further research is needed around causal factors for native bivalve population decline in Kachemak Bay. Restoration and enhancement efforts have been preliminarily considered, but actions need to be prescriptive to ensure success.

- Aquaculture for native mussel species is being explored in Kachemak Bay. The techniques have been developed and refined over a period of 10 years. Growers are working to develop a market for this species and one that may displace clams (which are imported from outside AK).

Hatchery

Key issues:

- The shellfish mariculture industry in Alaska relies upon importing oyster larvae ('spat') from the Pacific Northwest, and has been impacted by loss of spat due to more acidic waters there.

- In Alaska, preliminary efforts are underway to set oyster larvae in facilities located within the state. Research is needed to better understand husbandry practice and water quality conditions to ensure success at these facilities.

Stakeholder views on this topic include:

- Oyster hatcheries in the lower 48 have experienced catastrophic larval mortalities attributed to water pH, carbonate availability, and freshwater levels. Whiskey Creek in Oregon is actively treating and managing water acidity to maximize success of larval development. Since 2012-13 in Kachemak Bay, oyster seed has been imported (at >250 um) to the hatchery/seed setting facility for larval development. This facility has demonstrated great success in juvenile oyster development.

- The reasons for juvenile oyster mortality in a hatchery setting are poorly understood, and could be associated with husbandry and water quality.

- More research and information sharing around efforts to improve Pacific oyster spat production in the lower 48 is needed to help safeguard the industry.

- More information is needed on what local facilities in Alaska should be doing now to prepare for ocean acidification.

- Ocean acidification research to water intakes at the Alutiiq Pride hatchery facility in Seward, AK (in partnership with the University of AK, Fairbanks) is underway beginning fall 2013.

- The capacity for algae/phytoplankton production and storage is a current limiting factory for the setting facility in Homer.

- As a potential, long-term strategy to safeguard industry in Alaska an oyster hatchery could be developed. This would buffer against current seed instability for imported spat.

- Energy becomes a cost prohibitive barrier to making production of local spat economically viable.

- The market demand for oyster seed in Alaska exceeds the supply. Only about 50% of the oyster seed needs in Alaska are filled by hatcheries in the lower 48.

- Results from a 10-year study indicate that particular lineages of larval brood stock appear to perform better in different water quality conditions. More research and attention is needed as to whether particular brood lineages demonstrate resiliency to acidic waters. These studies in Alaska are time-prohibitive, as it takes up to three years for oysters to reach maturity.

Governance and Management

Key issues:

- In Alaska, widespread indifference of recreational and subsistence harvesters to PSP warnings causes considerable concern for the Alaska Division of Public Health and the Alaska Department of Environmental Conservation.

- Commercial oyster growers are required to conduct regular tissue testing; however, , the timeliness of these results is an issue and cause of concern for the industry.

Stakeholder views on this topic include:

- Public health knowledge relating to oysters is beneficial to oyster growers to control and protect their industry.

- There is a need to transfer shellfish-related information research to public health sector in order to improve decision-making.

- More awareness and attention to public health issues around bacteria and toxic dinoflagellates is needed by the general public.

- Currently there are separate recreational (voluntary) and non-recreational (industry-required) PSP testing requirements. Opportunities to share information cross-sector may be helpful.

- Health officers don’t always participate in the oyster farming practice. More participation will increase their exposure and understanding of relevant issues.

Issues to Avoid

Ideas were shared by stakeholders on issues that are not best addressed at the proposed workshop.

- Oyster growers carry the financial responsibility for water quality monitoring to fulfill state regulatory requirements despite not contribution to the demise of water quality. Recreational tourism and lodges may be the culprit(s) and should share in the burden for testing.

- Results from PSP tissue testing lags market and consumption demand. Reliable and acceptable on-site tissue tests are needed to expedite reporting.

- Enhancement efforts for wild shellfish stocks; this is a politically sensitive topic.

- Exhaustive discussion on regulatory requirements for water quality monitoring and fiscal responsibilities for conducting monitoring
    - Current regulations are at regional-level and cannot be changed locally.

5.3 Stakeholder Vision for Outcome

From stakeholder interviews the following desired outputs for the workshop were identified:

- Create a nearshore water/pH monitoring program for Kachemak Bay and involve shellfish industry in sampling. These goals are similar to those previously identified by growers in other areas of Alaska (AMCC 2012, Ocean Alaska Priorities 2007).

- Central data portal for Kachemak Bay ocean measurements (e.g. temperature, salinity, pH) used and accessed by researchers and oyster growers. Portal may show results from PSP testing, as well as relevant information links. Alaska Ocean Observing System Cook Inlet portal is a possible option for data hosting and visualization.
    - This information needs appropriately packaged in a manner most useful to the oyster industry.

- Broader geographical database to include ocean condition information and relative success of bivalve species along the Pacific coast. This tool may allow oyster growers to evaluate and forecast the success of different species in Alaska.

- Kachemak Bay workgroup that convenes regular to receive and provide oyster-related information. Specifically the group would focus on :
    - The utility of research information being disseminated to oyster growers;
    - The success and failure of oysters that season;
    - Incidental observation of conditions or growth that could be linked to available data.

- Formative evaluation(s) of data products and their relative usefulness to ensure outcomes meet desired targets.

- Proceedings document from workshop that could be used by organizations to leverage legislature to prioritize funding.

- Research topics for Kachemak Bay identified, and exploration of partners or networks able to meet research need (e.g. PSP testing, species diversification and development, natural growth. This goal was previously identified by oyster growers in Alaska (State Input to Action Plan 2006).
    - Consolidate research around condition index for oysters to better forecast survival.

- Better information sharing between researchers and growers in Alaska. Improved knowledge on the specific work being done by different organizations.

- Sustained funding sources to support research and product development in Kachemak Bay.

- Effective regional partnerships are needed to create cohesive plans and policies for mariculture in Kachemak Bay.

5.4 Key Issues to be Addressed

During stakeholder interviews the following priority issues were categorized that should be addressed during the workshop.

- Review climate-related oyster studies from other areas and restoration planning tools developed to promote population resiliency. Identify lessons learned from these collaborative studies that may be applied to Kachemak Bay.

  Key Questions for Collaborators:
    - Who were the project partners and how were they engaged?
    - What was most useful in the collaborative process and what was not?
    - What was most useful in the research context and what was not?

- Provide synthesis of research on ocean conditions in Kachemak Bay relevant to bivalves, including oceanography in Kachemak Bay and recent water quality analysis (NOAA Kasistna Bay Lab and KBNERR), including:
    - Benthic mapping
    - Larval transport
    - Ocean circulation models
    - Water column and sub-bay stratification
    - Ocean condition time-series analysis
    - SWMP trend summaries
    - Bivalve life history studies

- Identify potential knowledge links between oyster-related NERR studies and Kachemak Bay for climate stressors. Address data gaps that may be important to more closely investigate.
    - Consider key observations of oyster growth and survivorship that could be paired with ocean measurements and anomalies.
    - Identify optimal conditions for juvenile oyster planting.
    - Review of the importance of fresh water as an impediment to oyster survival
        - There is heavy freshwater outflow into Kachemak Bay from glaciers and snowmelt. Layering is variable throughout the Bay and by season. To what degree and how do snow fall and rain influence stratification?

    Key Questions for Collaborators
    - What information was gathered and used to support the restoration efforts?
    - What is temperature range for successful spawning?
    - Were there predation issues? If so, how were these addressed?
    - What oyster sensitivities to ocean conditions were measured?
    - Were these sensitivities overcome? If so, how?
    - How is ocean pH monitored- in what locations and at what intervals?
    - What life stages of oysters are most sensitive to pH?

- Review of current ocean acidification knowledge in Alaska and summary of pH monitoring within Kachemak Bay (using SWMP and offshore water monitoring)
    - Synthesis of water quality monitoring that is underway with University of Alaska, Fairbanks at the Alutiiq Pride hatchery in Seward, Alaska.
    - Critical review of how water quality information in Kachemak Bay is being collected with specific focus on opportunities to improve current methods.

    Key Questions for Collaborators
    - What examples from other regions are there in partnerships to protect water quality in other areas?

- Specify how the information and process from NERR studies can be translated to better understand native bivalve population declines and inform restoration strategies
    - Identify potential knowledge links from the oyster-related NERR studies that could be applied to native bivalve restoration in Kachemak Bay.
    - Address data gaps around variables that may be important to more closely investigate.

    Key Questions for Collaborators
    - What products were developed from the project? Could these be adopted for this region?

- Evaluate current collaborative networks in Kachemak Bay and identify other potential collaborative efforts to strengthen policy, funding, and farming/hatchery strategies.
    - Help identify next steps and what communities in Kachemak Bay can do.
    - Recognize the value of well-coordinated monitoring and record-keeping by researchers and growers.

12. Next Steps

Next steps for the workshop development include:

- **Finalization of the situation assessment report:** Review and comment on the draft assessment report by project collaborators, followed by incorporation of input and finalization.

- **Draft workshop agenda**: The final situation assessment report will inform a draft workshop agenda, including presentation and participant sessions (e.g. break-out groups, round table discussion, etc). The draft agenda will be shared with the project collaborators for input and then finalized.

- **Subject matter experts**: The final workshop agenda will information recommendations about potential additional technical experts who will serve as resources for the workshop.

- **Workshop**: KBNERR and project collaborators will host a public workshop focused on the materials and agenda mentioned above.

Literature Cited

Alaska Marine Conservation Council (2012). Ocean Acidification and Alaska Fishers: Views and Voices of Alaska's Fishermen, Marine Industries, and Coastal Residents.

Oceans Alaska (2007). Tipping the Balance: Research. Development, and Training: A Strategic Plan to Support the Growth of the Shellfish Industry in Alaska. Meeting proceedings October 31, 2007. Anchorage, Alaska.

SeaGrant Marine Advisory Program (1992). Alaska's Marine Resources, Dec 1992 vil. VII No. 4

Shellfish Industry (2006). State Input to Action: Mission, Priorities, and Communication. Planning session proceedings January 9-10, 2006.

Table 1. Stakeholder Interview List

Name	Affiliation	Role
Steve Rykaczewski	Early Tide Seafarms, Kachemak Bay Oyster Cooperative President	Oyster grower, President
Sean Ruddy	Kachemak Shellfish Mariculture Association Manager	Oyster grower, Manager
Margo Reveil	Jakolof Bay Oyster Company	Oyster grower
Weatherly Bates	Alaska Shellfish Farms; Alaska Shellfish Growers Association	Oyster grower
Roger Painter	Alaska Shellfish Growers Association	President
Marie Bader	Moss Island Oyster Farm	Oyster grower
Angela Doroff	Kachemak Bay Research Reserve	Research Coordinator
Ray RaLonde	SeaGrant Alaska Marine Advisory Program	Aquaculture Specialist
Jan Rumble	Alaska Dept of Fish & Game, Commercial Fisheries Division	Groundfish and shellfish management biologist
Cynthia Pring-Ham	Alaska Dept of Fish & Game, Commercial Fisheries Division	Mariculture Program Manager
Bob Shavelson	Cook Inletkeeper	Executive Director
Dave Aplin	World Wildlife Fund	Arctic Program Outreach Director
Kris Holderied	NOAA Kasistna Bay Lab	Director
Jeff Hetrick	Alutiiq Pride Shellfish Hatchery	Director
George Scanlan	Department of Environmental Conservation	Environmental Health Officer
Ellen Tyler	Alaska Ocean Observing System	Project Coordinator
Ginny Litchfield	Alaska Dept of Fish & Game, Habitat Division	Habitat Biologist

APPENDIX 4. PRESENTATION NOTES

Kachemak Bay oyster biological blueprint
Ray RaLonde, SeaGrant

Due to technological difficulties associated with the remote nature of this presentation, no notes are available.

History and perspectives of oyster mariculture in Kachemak Bay
Steve Rikajeski, Kachemak Shellfish Mariculture Association

- There are12 active Pacific oyster farms in Kachemak Bay. While Pacific oysters are not native to Kachemak Bay, farmers there are keen observers of the marine environment.
- The history of oyster farming in Kachemak Bay is as follow:
    - 1890s oysters imported from Japan
    - 1950 1st attempts made in Bay with on bottom culture
    - 1988 Alaska Aquatic Farm Act passes
    - 1990 first aquaculture made
    - 1991 blue mussel permits- 1st aquatic permits issued
    - 1994- Kachemak Shellfish Mariculture Association (KSMA) formed; 7 permits for new farm;
    - 2013 1st mussel farm constructed in Halibut Cove; 1st farm with predator net
- KSMA is a remote Pacific oyster setting facility located on the Homer Spit. Pacific oysters can't reproduce naturally in Kachemak Bay; therefore is seed imported from the lower 48. There is a shortage of stock linked to changing ocean conditions (ph); market demand in Homer cannot be met.
- Oyster-related research needs identified include:
    - Ocean acidification research in Kachemak Bay- it is anticipated that this is a problem that will be faced in the future
    - Shortage of seed supply in Homer
        - 2011 funding for pilot project received for remote setting facility where eyed larvae set & grow (3-5mm) and then are planted as juveniles
        - First larvae were set in 2013
        - lots of work and space needed to grow phytoplankton for oyster food; more efficient algae-culture methods are needed
        - 25% of remote set oyster already on farms; first results should been seen in 2015 when oysters mature
    - Phytoplankton bloom information and timing is needed
    - PSP testing- need a cheap, reliable field test
    - Low Ph tolerance oyster stock is needed
    - AK has untapped potential for mariculture; "great habitat to make great oysters"
        - Partnership of research & mariculture is need to manifest the potential;

Kachemak Bay native bivalves: harvest reduction limits

Carol Kerkvliet, Alaska Dept pf Fish and Game

- In 2012 sport and personal use regulations in Cook Inlet and the North Gulf Coast reduced the combined bag and possession limits of littleneck and butter clams to 80 clams per person. The reductions were made from previous bag limits of 1,000 littleneck and 700 butter clams.
- Department survey data for Jakolof Bay show littleneck clam density declined from 21 clams per square meter in 2001 to three clams per square meter in 2010. Similarly, Jakolof Bay butter clam density declined from three clams per square meter to one clam per square meter over the same time period. Survey data for the upper and lower islands in China Poot Bay show littleneck clam density declined from 44 and 27 clams per square meter in 2000 to three clams and one clam in 2009. Butter clam abundance at China Poot Bay remains stable. A shorter time series of data from other surveyed sites within Kachemak Bay also indicate declines.
- Clam abundance survey methods use transects set from blue mussel line to low tide mark; $1m^2$ grid placed along transect and crews use rake to collect all clams found within; clams are measured to estimate density along transects, and then density is applied to larger area to estimate abundance.
- The cause of these declines in clam abundance is unknown and may be linked to a myriad of factors, which have been little explored.

Littleneck clam life history and growth studies
Angela Doroff, Kachemak Bay NERR

- Littleneck clam life history and growth studies were conducted in Kachemak Bay from 2006-2009.
- Population trends indicating decline at location in Kachemak Bay, as well as other areas in southcentral Alaska, were from Dennis Lee's research.
- Early life history studies were conducted at 8 sites in Kachemak Bay to estimate the timing of spawning, larval recruitment, and to estimate growth rates of juvenile and adult clams.
- For reproductive studies, clams were captured, sexed, and indexed for reproductive conditions. Correlations of spawning conditions to water temperature were made. Results indicate that the egg diameter profile and fatness indexed differed from 2007 to 2008. Reasons for the difference may be related to colder temperatures in 2008, or an artefact of samples that were frozen prior to lab analysis.
- Recruitment studies were conducted by collecting and sorting sediments from sites sampled in 2007-08. These results indicate patchy or sporadic recruitment, and may help to index recruitment timing.
- A mark-recapture approach was used to assess clam growth at three study plots in Kachemak Bay from 2006-2009. Results indicated variable growth patterns ranging from shrinkage to 8 mm growth. 72% of the clams showed no overwinter growth.
- Future directions for this research include completing data analysis and publication of life history studies, integration of these data with ongoing long-term monitoring projects, and linking early life history data with oceanographic information.

California oyster restoration in the face of climate change
Matt Ferner, San Francisco Bay NERR

- Science Collaborative funded project that started as a collaborative effort two years ago in San Francisco and Elkhorn Slough NERR.

- The goal is to inform restoration efforts to increase resilience of Olympia oysters as they experience rapid environment change from natural & anthropogenic sources.
- In California the main climatic stressors to oysters include warming of water & atmosphere, changes in precipitation patterns, more intense storms, and changing salinity. There are additionally non-climate related stressors that may be exasperated by climate change.
- This study focused on the following questions to inform restoration planning int eh future
    - How will climate change affect oysters?
    - What is the influence of these factors relative to other stressors?
    - What is the interaction between climate change and other stressors?
    - Does decreasing stressor enhance oyster resilience to climate stressors?
    - Which sites will support the sustainable oyster restoration projects under future conditions?
- There is a large and complex range of variables that have direct and indirect effects to oyster populations. This study engaged stakeholders in a collaborative process to determine from their perspective which factors are most important for restoration.
- A conceptual model was used to determine how to best proceed with studies, and which questions to ask that would best inform restoration planning.
- The scope of the project was then narrowed to include four stressors as target for the study: warming, salinity, hypoxia, and sedimentation
- The study approach had four main components- stressor selection, field surveys, lab experiments, analysis & synthesis.
    - For stressor selection, stakeholder meetings were held to hone variables and focus on those that are the most important. This was a six month process.
    - Began field surveys at 25 sites to monitor environmental stressors, recruitment, growth, and connectivity studies to connect recruits with a distant source population. Results from this work are ongoing.
    - The lab experiments were designed to complement field studies and determine the threshold response for survivorship. The impact and tolerance to stressors, seasonality, and interactions were evaluated.
    - The analysis and synthesis portion of the study included decision support tools, reports, and publications, which were needed for accountability and defensibility. The primary stakeholder needs were practical interpretations.
- The preliminary outcomes from these studies indicate that low salinity stress is the factor that most limits growth and survival. In low salinity conditions, oysters cease feeding. Additionally hypoxia has negative effects on growth.
- The project took a new approach to science by collaboratively engaging restoration practitioner with scientists, regulatory agencies, and other end users in the development and implementation of research questions

Bringing the “Oly” back to Oregon Estuaries: Recovery and Enhancement of Native Olympia Oysters in Coos Bay and South Slough Estuary
Steve Rumrill,

- This project was based in central Oregon in a region with interesting geologic history. The highest point in the landscape is 300-400 ft above sea level. Freshwater enters the estuary from multiple locations.

- Native Olympia oysters were historically extensive in Oregon estuaries. Local extinction occurred in 1700-1800s due to tsunami burial where there was an influx of sediment the estuary and damage associated with fires. The early 1900's there was substantial harvest pressure to the population. Olympia oysters were reintroduced to the area from outside sources in 1940-50. Olympia oyster can reach high density and cluster on hard substrate
- Pacific oyster were imported from Japan, and cultivated commercially in Coos Bay beginning in 1910 using bottom, stake, and rack culture.
- The northern limit of Olympia oyster range is British Columbia, Canada. It is unclear what the larval source is for oyster larvae recruiting to Oregon estuaries, such as Netarts, Yaquina, and Coos Bay.
- In 2008, restoration work began in Coos Bay. At the onset it was unclear why populations were slow to recover in the South Slough portion of the bay when other areas had recovering populations.
- To determine which factors limit the further recovery of populations here, the hydrologic regions relative to oyster distribution were evaluated. The primary location of populations was associated with the mesohaline shoreline.
- The goal of the Olympia oyster restoration project for Coos Bay and South Slough was to increase the understanding of oyster reproductive and ecological factor to encourage the recovery of self-sustaining populations.
- It was first important to determine where should efforts be concentrated, and what factors might limit recovery.
- A genetic identity study was conducted of broodstock oyster to determine their origin.
    - It was found that there are four distinct oyster populations in the Pacific Northwest, and those in Coos Bay are not distinctly different than the Willapa Bay, WA population.
- A common-garden experiment was conducted to evaluate local adaptation of oysters from different broodstocks. The ecological performance of outplanted oyster bags in South Slough was measured.
    - Results indicated that natural recruits on collector bags grew faster initially than broodstock. But after 5 months the broodstock took off and grew faster, demonstrating adaptation to environmental conditions.
    - The natural recruits that settled into collector bags were transplanted from Coos Bay to three locations in South Slough to provide stratum for larvae produced by locally-adapted adult Olympia oysters. Results are pending, but look promising for natural recruitment.
- In the early stages of the project a conceptual model was developed to prioritize the factors that influence the recovery of Olympia oysters in Coos Bay. Reproduction, larval supplies, estuarine retention time, settlement, and recruitment were identified as factors that potentially limit recovery of self-sustaining populations of Olympia oysters.
- A project was initiated in 2011-2014 to frame the issues, bring together interested stakeholders, and facilitate meeting to explore existing information, and assemble technical findings into objective deliberations to reach an agreement among the stakeholders.
- The project was separated into three modules: oyster reproduction, larval supply and local dispersal, and larval settlement.

- Findings from the oyster reproduction study indicated that gender changing occurred in early life stages. The key ecological question is how important are regional differences in fecundity; this is still an existing data gap.
- The recruitment of oyster larvae was measured in a field experiment at six sites using larval settlement tubes and ceramic settlement plates. Experiments were placed in various locations throughout bay with and without established oyster. Findings indicated a hotspot of larval supply in the middle of the bay. Additionally, information about timing of seasonal settlement was determined.
- Communication of project results with stakeholders was made through regular fact sheets.
- The project is working towards a goal to complete a conservation and recovery strategy for Coos Bay in 2014. Efforts are underway and involve a structured decision-making process.
- Current knowledge to enhance the strategy includes the spatial distribution of oyster along the shoreline, oyster survival is enhanced in mesohaline zones, and oyster are more abundant in sub-tidal zone further from the estuarine gradient. Data gaps include why oysters are missing from the eastern shoreline? The reason may be related to freshwater input in this area.

<u>Lightening Round Presentations</u>

Environmental conditions in Kachemak Bay
Kris Holderied, NOAA Kasitsna Bay Laboratory

- Kachemak Bay waters are affected by seasonal and inter-annual changes in temperature and the bay receives freshwater input from precipitation, snow pack melt and glacier melt.
- The bay also exchanges water with Cook Inlet and experiences periodic upwelling of ocean water from the adjacent Gulf of Alaska shelf.
- Temperature, salinity, water column stratification and circulation are all factors which may influence plankton growth and bivalve growth and survival. These conditions can vary significantly with freshwater input and ocean water upwelling.
- Our ongoing oceanographic monitoring program measures these conditions and their spatial and temporal variability.
- Oceanographic conditions are measured using vertical oceanographic profile station data and water quality monitoring station data from the Kachemak Bay National Estuarine Research Reserve water quality monitoring stations at the Homer and Seldovia harbors.
- Kachemak Bay oceanography is strongly influenced by freshwater input, resulting in a persistently high stratification and vertical stability that can maintain phytoplankton cells near the surface. Significant inter-annual variability includes differences in mean monthly water temperatures of up to 6 degrees C in winter and 5 degrees C in summer, as well as in the timing of spring snow melt and enhanced water stratification in the summer.

Water quality monitoring in Kachemak Bay
Angie Doroff (for Steve Baird), Kachemak Bay NERR

- KBNERR through the National Estuarine Research Reserve's System-wide Monitoring Program (SWMP) has a long-term water quality, meteorological, and emergent salt marsh vegetation mapping monitoring program in Kachemak Bay. The information gather through SWMP enhance other KBNERR ongoing monitoring programs, such as those for marine invasive species and harmful algal blooms.

- The data collected in the SWMP program provides the basic "ingredients" to examine long-term environmental trends in weather, water chemistry, and biology. Stations are located in Bear Cove, Seldovia, Homer Harbor at the end of the Spit and Anchor Point. The Spit and Anchor Point also have meteorological stations.
- Water quality monitoring is conducted at the surface of the ocean and 1 meter below. Additionally, long-term monitoring includes monthly water nutrient and phytoplankton sampling.
- Temperature tidbits are located at monitoring sites, and the data allows us to determine the relationship between average monthly temperature, salinity, and nutrient levels to algal blooms in the bay.
- This data for long-term monitoring lay the groundwork for examining drivers and relationships to productivity in the bay.

Ocean circulation model and application to larval transport
Angie Doroff , Kachemak Bay Research Reserve

- Kachemak Bay is working with UAF and partners to updating the ocean circulation model for Kachemak Bay.
- Understanding circulation patterns is important to inform the physical oceanographic processes and larval transport patterns in Kachemak Bay and surrounding waters. Further, it will help identify convergence zones that concentrate primary productivity and improve harmful algal bloom monitoring.
- Currently, the KBNERR is involved with three major projects that will help update and refine ocean circulation patterns in Kachemak Bay; 1) we are collaborating with University of Alaska, Fairbanks to collect data on tidal and sub-tidal circulation patterns from drifting buoys; 2) we are collaborating with UAF to validate a NOAA regional circulation model based on KBNERR long-term oceanographic data collected since 2001; and 3) we are collaborating with the NOAA Kasitsna Bay Lab to monitor oceanography and plankton trends in lower Cook Inlet and Kachemak Bay. Collectively, these studies at the KBNERR contribute to our understanding of regional circulation patterns.

Ocean acidification research and monitoring – What's happening in Alaska?
Ellen Tyler , Alaska Ocean Observing System

- Integrated Ocean Observing System (IOOS) is a national program with 11 region throughout the country that focus on local ocean observation. Ocean acidification monitoring is a gap that many partner, including Alaska Ocean Observing System, are working to fill.
- Long-term observations are needed to characterize natural variability and long-term trends in the ocean carbon cycle and for identifying physical and biological mechanisms controlling OA.
- In the past 3 years, year-round fixed moorings for monitoring ocean acidification have been deployed across the state, including Sitka, the Gulf of Alaska (Seward Line), Kodiak Island, and the Bering Sea.
- AOOS and partner intend to fill gaps in ocean monitoring by offering web-based tools via models and real-time information (precipitation, salinity, etc.), including ocean acidification forecasting.
- For ocean acidification forecasting, AOOS and partners will be developing a biogeochemical model that inputs different ocean measurements to project water chemistry.

- Additionally, AOOS has been working with partners to monitor real-time water chemistry at the Alutiiq Pride Shellfish hatchery using a Burkelator device.

A tribal initiative to promote collaborative research to restore marine invertebrates
Glenn Seaman, Seaman Consulting

- The abundance of several species of culturally important marine invertebrates – including clams, cockles, chitons and crabs – has substantially declined in the late 1900s in Port Graham Bay.
- Although not fully understood, the initial decline was believed to be related to anthropogenic, natural predation, and ecosystem change, and loss of traditional management of resources.
- In 2003, the Port Graham Tribal Council and Chugach Regional Resources Commission sponsored a Wisdomkeeper Workshop with Western Scientists to share scientific and local and traditional knowledge to better understand the decline and to identify collaborative research and management projects toward restoring these resources. The Workshop resulted in a research strategy, including the identification of multiple projects, potential collaborators and funding sources.
- In 2011 the Port Graham Tribe initiated a collaborative effort with scientists to evaluate the accomplishments since the 2003 Workshop, identify gaps and research needs, and develop a strategy to both improve cross-cultural communications and establish long-term research partnerships to address tribal natural resource issues.
- An of related research efforts revealed that significant progress was made in areas including, documenting traditional knowledge and management practices, understanding historic use, unraveling the cause of the declines, habitat and contamination mapping, and partnership development.
- Many of the research topics related to resource assessments, marine science, and oceanography were not addressed, and remaining needs include: consolidating GIS data; understanding larval transport and sources; conceptual model and adaptive management approaches; understanding clam abundance, distribution, predation, and monitoring of key factors; and taking policy and management approaches.

Natural resource clam project
Tracie Merrill, Seldovia Village Tribe – [remotely]

- Seldovia Village Tribe conducted a natural resource clam project in 2004-05. The objectives of the study were to:
  - Estimate historical use and distribution of hard shell clams and bull kelp in Seldovia Bay's traditional harvest areas;
  - Assess hard shell clam abundance, distribution, and recruitment; and
  - Quantify abundance of bull kelp.
- Survey of resource users indicated that the majority harvested clams in three primary areas, and either target littleneck, butter, or both clam species.
- Clam abundance was measured in quadrats placed along 200m transects at different sub tidal gradients for six sites.
- Clams were measured, weighted, tagged, and then returned to the same location. Sites were measured the subsequent year to determine growth and mortality. Substrate was separated and characterized.

- Results indicate large biomass of butter claims at the Kasitsna Sandbar compared to other sites, and larger littleneck clams near Kasitsna and Jakolof Bay.
- Study conclusions pinpointed locations where different size frequencies of clams were found, and that clam populations in Seldovia Bay are composed of mainly younger age classes.