October 2022

Olympic Coast Ocean Acidification Sentinel Site 2022 Symposium Summary Report

The Olympic Coast Ocean Acidification Sentinel Site (OASeS) held its first symposium in Ocean Shores, Washington on May 10-12, 2022. This hybrid meeting brought together the OASeS Steering Committee, federal and state agencies, tribal governments and community members, resource managers, scientists, and interested public focused on changing ocean conditions on the Olympic Coast. Nearly 100 people attended, either in person or remotely - reaching broad audiences from Washington, Oregon, California, Connecticut, Washington D.C., and Slovenia! The purpose of the meeting was to share information and emergent research, generate solutions, and address work plan actions related to policy, management, science, education, and outreach needs of the region regarding changing ocean conditions. We heard directly from tribal members regarding their concerns and observations related to ocean acidification (OA) and changing ocean conditions, policy priorities from the national and state perspectives, emergent research results, and education and outreach efforts related to OA. There was true value in bringing the diversity of voices together to share, listen, and learn from one another. The Steering Committee met on the final day of the symposium to reflect on lessons learned for future symposia, suggested changes to our membership and work plan, and how to better collaborate with other OA-related entities.

Figure 1: During the OASeS “Weaving Indigenous Knowledge” session with tribal members, participants from Quinault, Queets, Hoh, and Quileute shared their experiences and observations on ocean change. Photo: Katie Wrubel

The Office of National Marine Sanctuaries formally designated Olympic Coast National Marine Sanctuary (OCNMS) as an Ocean Acidification Sentinel Site in November of 2019. The four Coastal Treaty Tribes who are sustained by these waters - the Hoh, Makah, and Quileute Tribes, and the Quinault Indian Nation - together with the state of Washington, support this designation for OCNMS and the Washington outer coast as a whole. A Sanctuary Advisory Council (SAC) working group was set up as a roundtable-style steering committee composed of 18 entities that guide Sentinel Site activities and ensure broad representation of coastal resource manager and stakeholder interests.

Figure 2: The OASeS logo was designed by a Sequim, WA, 7th grader following a competition with local schools (open to Clallam, Jefferson, and Grays Harbor counties). The winner received a $500 scholarship award.

The meeting was made possible through the generous support of Washington Sea Grant, Washington State Department of Ecology, Washington Ocean Acidification Center, National Marine Sanctuary Foundation, and The Nature Conservancy. We greatly appreciate their support in making this symposium a success.

See Appendix A for the full meeting agenda.

Day 1

The OASeS Symposium was opened by a welcome from members of the Quinault Indian Nation as the meeting was held on their traditional lands. The first day of the Symposium was focused on providing an introduction to the sentinel site and grounding attendees on the importance of the Olympic Coast, as well as focusing on policy and management needs.

Ocean Acidification Sentinel Site Overview - Our first session was aimed at orienting attendees to the issue of OA and the concept and purpose of the sentinel site. Jan Newton, Senior Principal Oceanographer with the Applied Physics Laboratory at University of Washington, provided a high-level overview of OA. Kevin Grant, Superintendent of OCNMS, provided a history of efforts to establish a sentinel site in the region, summarizing over a decade of work by the sanctuary, SAC, Intergovernmental Policy Council (IPC), and many other partners. Micah Horwith, Coastal Scientist with Washington's Department of Ecology and co-chair of OASeS, provided an overview of the Sentinel Site, recent accomplishments, as well as plans for future work under OASeS. Recent OASeS accomplishments included selecting the co-chairs, prioritizing a work plan, developing a 2-pager for outreach, presentations to Marine Resource Committees, and strengthening partnerships across members. Future work for OASeS includes integrating Symposium takeaways into the work plan, creating an OASeS website, and committing to biennial symposia on the outer coast.

Culture and Values - The second session was moderated by Melissa Poe, Social Scientist at Washington Sea Grant, and focused on recent discussions on the culture and values held by Olympic Coast communities. The goal of this session was to ground attendees on what is at risk with OA as learned through tribal members and recent reports on the ecosystem services of the outer coast. The session opened with an introduction by Melissa Poe of the interconnections between the ocean and people, including a unique sense of place, cultural heritage, sense of identity, spiritual values, and unique governance. The diverse values also include community fishing, such as subsistence for traditional and ceremonial foods; all of which are practices that ensure the continuation of intergenerational knowledge transfer. These practices strengthen social and community cohesion while bringing many other values and benefits, including but not limited to, supporting local livelihoods, economic vitality, and seafood access through commercial fishing, commercial clam digs, and tourism.

After the opening comments, Katie Wrubel, Resource Protection Specialist at OCNMS, provided an overview of the status and trends of key ecosystem services of the region as assessed in the sanctuary's Condition Report. From a western perspective, ecosystem services are benefits humans receive from the ecosystem and include services such as, subsistence harvest, commercial harvest, sense of place, heritage, consumptive and non-consumptive recreation, science, and education. OCNMS recognizes that many indigenous communities have a reciprocal relationship with the ecosystem and have difficulty placing services in discrete "bins." The Office of National Marine Sanctuaries follows a consistent national framework for assessing the condition of sanctuaries, with a rating and trend scheme. For ecosystem services, these ratings are based on the site's capacity to provide the ecosystem service, with "good" indicating the capacity to provide the service is unaffected, "fair" is the capacity to provide the service is

compromised and enhanced management would enable acceptable performance, and “poor” is the capacity to provide the service is compromised and it is doubtful that new or enhanced management would restore it. Overall, ecosystem services were viewed as being in “good” or “fair” condition within the sanctuary region, with growing concerns about how climate change and OA will affect these services in the future.

Liz Schotman from the Surfrider Foundation provided an overview of the recreational uses and associated economic value they bring to the coast through two surveys conducted in 2014. Recreational uses were aggregated in specific locations on the outer coast due to access points, but overall in 2014 Washington state residents took 4.1 million trips to the coast and contributed an estimated $481 million to coastal economies. The most popular recreational activities include beach going, site seeing, wildlife viewing, photography, and biking/hiking.

We then shifted to two tribal members of the Quinault Indian Nation - Andy Mail and Jennifer Scott. Andy Mail highlighted the decline of razor clams and concerns over their shell thickness, as well as warming waters and lack of kelp along this stretch of coast. Razor clams are an important cultural and economic resource for the Quinault Indian Nation. Jennifer Scott shared that she started digging razor clams at 6 years old and has continued into her 60’s resulting in a deep connection to place, understanding when and where to harvest and to not take more than you need. Previous Federal Indian policies, like assimilation, have resulted in intergenerational trauma and many cultural practices need to be relearned. Quinault historically had an abundance of resources, allowing time to develop specialized arts and craftsmanship. Quinault have a deep understanding and connection to the environment and an intrinsic understanding of changing ocean conditions. Intergenerational harvests of razor clams continue today, where children are not only learning about harvesting, but a greater transfer of knowledge about the environment and culture. Jennifer closed her session with a poem by Clarence Pickernell, a Quinault tribal school teacher (Figure 3).

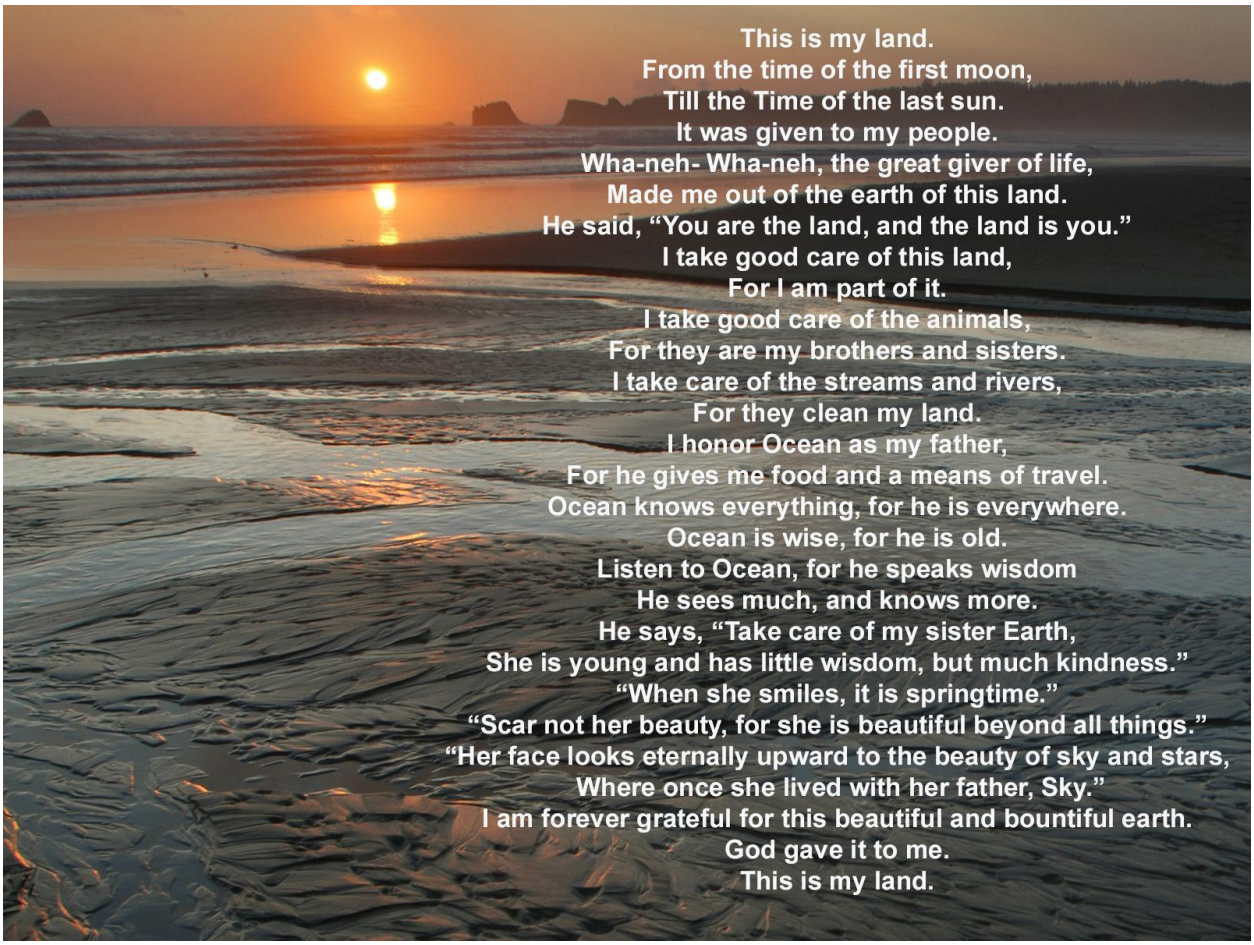

Figure 3: A slide from Jennifer Scott's presentation with Clarence Pickernell's poem.

During the session and throughout the symposium, participants were invited to participate in an activity where they wrote their relationship to the Olympic Coast on a poster (in person and virtual) (Figure 4).

Figure 4: Word cloud from participants on what the Olympic Coast means to them.

Policy Priorities and Solutions - The third session was moderated by Russell Callender, Director of WA Sea Grant and OASeS co-chair, and focused on policy efforts at the federal and state levels. Libby Jewett, Director of NOAA's Ocean Acidification Program, provided an overview of federal programs and policies to support OA research and partnerships, including the Human Dimensions of OA Research Plan and NOAA's OA Research Plan.

Jennifer Hennessey from the Office of Governor Jay Inslee shared information on Washington state's climate policies, including their targets for carbon emission reductions under the Climate Commitment Act. Understanding that ~45% of the state's emissions come from transportation, ~25% from building/construction, and ~16% from electricity helps policies to target each sector to reduce greenhouse gas emissions. Washington is also working to address nutrient pollution from wastewater treatment plants and improve adaptation and remediation efforts across the state. She noted that carbon emission reduction is the most important and cost effective course of action for the state's response to climate change .

Lastly, we heard from Caren Braby from the Oregon Department of Fish and Wildlife. Oregon's Ocean Acidification and Hypoxia Council has released an Ocean Acidification and Hypoxia (OAH) Action Plan for Oregon. Oregon is also a member of the OA Alliance, and many state agency work plans include OA. Efforts to develop an OAH communications plan aim to raise public awareness and empower Oregonians to address OA. The panel received several questions, including one on partnerships across federal, state, tribal, and local levels. Panelists emphasized the importance of learning and data connectivity and sharing resources. Panelists also suggested the possible establishment of a regulatory framework and promoted the increased use of traditional knowledge to inform decisions. Additionally, panelists noted the

difficulty of using federal funds to support tribal engagement, especially when items like food for community events cannot be financially supported.

Tools for Prediction and Response - The fourth session was moderated by Tommy Moore, Oceanographer at the Northwest Indian Fisheries Commission and OASeS co-chair. The first presentation, from Parker MacCready of the University of Washington School of Oceanography, provided an introduction to the LiveOcean model and Northwest Association of Networked Ocean Observing Systems (NANOOS). LiveOcean makes daily 3-day marine water property forecasts for the Pacific Northwest (outer coast and coastal estuaries) and Salish Sea. Utilizing the Regional Ocean Model System (ROMS), with realistic forcing through tides, 45 rivers, open ocean conditions, and wind and solar heating in addition to biogeochemistry parameters. Applications of the LiveOcean model were shared, including forecasts of corrosive water due to OA that harms shellfish aquaculture in Willapa Bay and short-term forecast of harmful algal blooms (Pseudo-nitzschia) hotspots via particle tracking maps, as well as shore-based testing, which informs shellfish harvest decisions. In addressing the needs for improving tools, models, or monitoring, recommendations include automated alerts on conditions for shellfish growers, high-resolution nested sub-models to improve forecasts in places like Willapa Bay, easier access to the model output by science users, and more real-time bottom dissolved oxygen and pH moorings shared through NANOOS and that can be compared to LiveOCean through the NANOOS Visualization System (NVS) Comparator. Next, Samatha Siedlecki from the University of Connecticut introduced the J-SCOPE (JISAO's Season Coastal Ocean Prediction of the Ecosystem) model during a pre-recorded presentation. Forecasts are needed for fishery management, with temporal and spatial scales relevant for different management decision points, but they need to be tailored to stakeholder and fishery manager needs. Utilizing the Climate Forecast System (CFS), they dynamically downscale a Regional Ocean Model (1.5 km resolution of physics and biogeochemistry on the outer coast), and take those ocean conditions and derive upper trophic level habitat models and indices of key fish species (sardine, hake, and juvenile and adult crab), they build a forecast system on their website. J-SCOPE produces 6-9 month seasonal forecasts of physical conditions, Chl-α, O_2, pH, plankton, and Ω in addition to sardine, hake, and crab habitat which are delivered to the Pacific Fisheries Management Council each spring. Performance testing occurs utilizing observations in the region from moorings, regional cruises, groundfish surveys, and others. Owen Liu from NOAA's Northwest Fisheries Science Center provided a presentation on climate relevant information for fisheries management, focusing on how climate variability (temperature and oxygen primarily) may affect the availability of certain groundfish species to west coast fisheries by the end of the century. We then heard from Andy Suhrbier from the Pacific Shellfish Institute (PSI) on targeted water quality monitoring for oysters, clams, geoduck, and others. PSI has long-term monitoring stations at hatcheries, nurseries, farms, and floating upwelling stations where they record various water quality measurements, including carbon chemistry. Hatcheries and nurseries have found a way to adapt by constantly monitoring water quality parameters. A wide variety of grow-out adaptations aimed at reducing risk, such as selecting cooler areas, height adjustments, multiple seed sources, reducing overcrowding, and reducing stress, may also exist.

Management and Adaptation Needs - The last session of the day was moderated by Micah Horwith and focused on management and adaptation needs of resource managers and other decision makers. Paul McElhany presented on the state of biological thresholds, highlighting that thresholds are used in a variety of ways, including regulatory applications and to help identify possible biological thresholds. However, we don't know the thresholds for many species. Recommendations for thresholds should be explicit about their intended application, use the Paris Agreement goals as a reference (i.e., RCP 2.6 models ∆ pH ~ .17), develop local, species-specific and habitat-type thresholds, and compare thresholds to observed species distributions. Next we heard from Katie Keil from 48 North Solutions about the results of interviews and surveys with natural resource managers about needs related to changing ocean conditions. In 2018, managers identified better information about plankton, downscaled models, and additional riverine and marine monitoring stations as top priorities. They also wanted to know more about the biological responses of species to changing ocean conditions, the current abundance of shellfish and fish species, and local impacts of large-scale oceanographic factors (i.e., El Niño-Southern Oscillation). In 2020, Dungeness crab, harmful algal blooms, and salmon were identified as priority information needs. Communication materials, increased monitoring, and a web-based clearinghouse of geo-referenced data would also help address challenges. In conclusion, determining species thresholds, separating climate change from natural variation, and improving collaboration and communication were the primary needs identified through this multi-year process.

Dan Ayres, Coastal Shellfish Manager from Washington Department of Fish and Wildlife (WDFW), presented on the razor clam and Dungeness crab fisheries management needs. WDFW collaboratively monitors and manages these fisheries with the four Coastal Treaty Tribes. The 2021-2022 razor clam season is estimated to have generated >$60 million in tourist-related spending on the coast. Domoic acid is the biggest factor affecting closures of razor clam harvest. Dan noted that OA research on razor clams is needed at Kalaloch Beach, and flagged that Olympic National Park plans to start characterizing in-sediment OA parameters where adult razor clams live this summer. Moreover, Dungeness crab is Washington's most valuable fishery, with a 2019 ex-vessel value of ~$44 million, and >$85 million of sales in the first four months of 2022 alone. Dungeness crab management measures include size, sex, and season. Changing ocean conditions are affecting the crab fishery, including the massive harmful algal bloom that ended the fishery early in 2015, as well as marine heatwaves bringing whales closer to shore and increasing entanglement risks.

The last talk of the day was by Haley Kennard, Natural Resource Policy Analyst for the Makah Tribe on the development of the Tribe's Ocean Acidification Action Plan. The ocean is vitally important to the Makah Tribe, with fisheries accounting for 50-70% of the Neah Bay economy, not to mention the cultural, spiritual, and subsistence importance of the ocean. The Makah Tribe has developed a Makah Ocean Policy which emphasizes the importance of the ocean as well as consultation protocols for state and federal agencies. The Tribe has been working on climate change planning for some time, with direction from the Makah Tribal Council and community outreach and input every step of the way. The community has expressed concern over climate change and OA, especially impacts to fisheries and fresh water supply. The Makah OA Action

Plan is grounded in community priorities and previous climate work, using the best available science and indigenous knowledge to identify culturally-relevant adaptation strategies. Some of the overarching themes of the OA Action Plan include: research and monitoring; implementing mitigation and adaptation actions; engagement beyond the reservation boundary; and fostering OA literacy and engagement among the Makah community. COVID-19 has hindered the Tribe's progress on the OA Action Plan; however, progress is still being made, including through OA Alliance webinars, web stories on climate impacts, as well as research and monitoring. One takeaway is the need to invest in tribes' research and monitoring efforts and priorities, in addition to agency investments.

Day 2

The second day of the symposium was focused on science, research, and education and outreach efforts.

Ocean Acidification Regional Vulnerability Assessment for the Olympic Coast - This session was moderated by Meg Chadsey, OA Specialist with WA Sea Grant. Jan Newton opened the session with an overview of this place-based assessment of coupled socio-ecological interactions. Jan Newton focused on the physical and biological results of the project, and noted that one of the major challenges faced by the team was insufficient biological data, including thresholds for key species. Ultimately, the assessment focused on four species - razor clams, Dungeness crab, olive snails, and Pacific halibut (full results will be available soon). Next, Halle Berger presented on Dungeness crab modeling work she conducted while at the University of Connecticut. This work looked at modeled current and future conditions and anticipated effects on various life stages of crab, and found that the Dungeness population was most vulnerable to low oxygen conditions overall, and that stressors acting on larval life stages may present a critical future bottleneck.

Melissa Poe led the next presentation, which focused on community well-being. Her team conducted interviews with tribal representatives and hosted community workshops to gather input. Next, Melissa Watkinson-Schutten with the Puget Sound Partnership discussed socioeconomic dimensions to address inequities. She looked at county and zip code level demographic data, and found that education was a predictor of economic security and that there were large disparities across regions, among other socioeconomic conditions that indicate differences in adaptive capacity from community to community.

This session was closed out by John Reamer and Haley Kennard of the Makah Tribe, who discussed the Tribe's food sovereignty program, ʔuxawaɬ qwaqik ʔusubaqey (Use What You May Need). This program is a part of the Makah Tribe's climate resilience planning, and is rooted in the knowledge of the Makah community. The Makah food sovereignty program has been able to generate community engagement through food sharing, and noted the need and desire for generational knowledge transfer across the tribe as a climate resilience and food sovereignty strategy. Key takeaways from this session include: 1) continuing to prioritize community engagement as it is essential for developing culturally relevant resilience strategies and supporting information exchange, understanding, and application of findings; 2) investing in

community engagement as part of research efforts; expanding climate resilience and OA planning to recognize socio-economic as well as environmental vulnerabilities, including engaging appropriate departments (e.g. Department of Health, Social Services, etc.); and 3) continuing to monitor changing community priorities and perspectives on an iterative basis to inform program development.

OA Indicators and How to Sample - This session was moderated by Tommy Moore and focused on identifying considerations and best practices for pairing biological and chemical monitoring efforts along with human dimension indicators. Jan Newton started the session with an overview of the OA Indicator Dashboard NANOOS is developing for the West Coast Ocean Alliance Data Portal. The indicators are focusing on anomalies from reference conditions and species-specific thresholds. This was followed by Micah Horwith, who presented on the WA Department of Ecology's Indicator Report. He is focused on developing a broad indicator that will be applicable to the general public, and focused on when marine conditions at a given site had aragonite saturation states greater than 1. He noted that for Puget Sound Dungeness crab, larvae are generally found during the time periods when conditions are good, and that future climate projections suggest a reduction in the duration of favorable conditions.

Moving away from indicator development, Tim Wootton of the University of Chicago presented on alkalinity dynamics near Tatoosh Island. Tim Wootton found that alkalinity varies with water mass and at different timescales ranging from decadal to seasonal to diel changes.

Karma Norman of NOAA's Northwest Fisheries Science Center discussed human dimension indicators along the west coast. NOAA has developed Community Social Vulnerability Indexes (CSVI), which are reported annually as part of the California Current Integrated Ecosystem Assessment; however, Karma Norman noted that the CSVI are broad in scope and do not capture the nuances of the Olympic Coast well. Jenny Waddell of OCNMS closed out the session with a discussion on summer field season plans for the sanctuary, noting changes and improvements that have been made. Discussion included 1) selecting indicators that the intended audience can understand (e.g., chemistry may not be the best suited for a non-scientific audience), 2) encouraging the Washington Department of Ecology to expand their monitoring efforts to the outer coast (beyond estuaries), and 3) using euphausiids (krill) as a biological indicator, in addition to more sedentary species that live close to shore (oysters, mussels, etc.). Panelists also noted the need for redeployment and continuous maintenance of the National Data Buoy Center data buoys at Cape Elizabeth and Juan de Fuca for real-time monitoring and more reliable forecasting of ocean conditions. Several noted the desire to integrate local and indigenous knowledge which tend to be more qualitative and narrative-based information about ocean change (knowledge pluralism), and develop a more quantitative approach toward capturing the deeply established cultural-social connection of coastal people to oceans and climate change for community vulnerability indicators.

Emergent ocean change research in a multi-stressor context relevant to Olympic Coast - Oceanic - This session was moderated by Jan Newton and focused on multi-stressors in the oceanic environment. Richard Feely, of NOAA's Pacific Marine Environmental Laboratory

(PMEL), gave an overview of OA and hypoxia along the west coast of the US. He noted that respiration processes (seasonal change) and anthropogenic CO_2 (decadal change) are the dominant causes of decreased pH in subsurface waters. OA observations suggest that the quantity of suitable habitat for sensitive species is thus shrinking due to OAH, with corrosive waters shoaling year after year. Biological impacts of OA are already being observed on Dungeness crab. Next, Simone Alin, PMEL, discussed past, present, and future estimates of OAH conditions along the Olympic Coast. She noted the timing of when hypoxia sets in at OCNMS mooring sites along the Olympic Coast and that all sites can experience bottom-water pCO_2 concentrations >1000 µatm by mid-June and showed estimates of near-future conditions at northern vs. southern Olympic Coast sites for 2030 and 2040. Vera Trainer discussed Harmful Algal Blooms (HABs) and OA. She noted that toxic HABs will likely be "winners" in more acidified waters, and that there are few studies looking at HABs under multiple stressors. Following this, Halle Berger discussed multi-stressor impacts to Dungeness crabs. She noted that global ocean models may not accurately reflect what is happening in coastal regions, and demonstrated the importance of downscaling regional models to more discrete areas of interest. Lastly, Nina Bednarsek, from Oregon State University and the National Institute of Biology in Slovenia, presented on multiple stressors across temporal and spatial scales. She notes that predictions suggest greater nearshore OA variability in the future. She went on to discuss impacts on pteropods, Dungeness crab, and oysters, and noted that nearshore temporal variability needs to be better integrated into biological observations.

Emergent ocean change research in a multi-stressor context relevant to Olympic Coast - Nearshore - This session was hosted by OCNMS research coordinator Jenny Waddell, and focused on multi-stressor impacts in the nearshore environment. Steve Fradkin, from Olympic National Park, discussed some of the intertidal monitoring work conducted by his team on the Olympic Coast since 2008. Steve Fradkin estimates that 80% of all taxa in this habitat are vulnerable to OA although, at present, there is no clear evidence of OA impacts on rocky intertidal assemblages. Next, Alex Stote, Washington Sea Grant's Crab Team Coastal Specialist, discussed the invasive European Green Crab (EGC) as an additional stressor to changing ocean conditions. EGC are a highly invasive species that can tolerate a wide range of conditions and are typically found in salt marshes and estuaries. She noted that EGC are more tolerant of OA than Dungeness crab and in the future, EGC might be able to outcompete Dungeness crab.

Lastly, Laura Nelson, University of Washington, discussed understanding perceptions of climate vulnerability to inform more effective adaptation in coastal communities. She noted that perceptions of risk and vulnerability drive behavior, and that vulnerability assessments often don't capture the full range of what is at risk for a community. Based on random surveys of commercial fishers along the West Coast, she found that many had observed declines in target species but did not attribute these changes to climate change.

A key discussion topic raised during these sessions was the need to engage with local students to train the next generation (especially tribal students) in STEM/STEAM, whether through development of a summer camp for tribal students in collaboration with UW's Olympic Natural

Resources Center (ONRC) and OCNMS, or through sharing funding opportunities. This topic was also discussed in greater detail during the steering committee meeting and will be explored further by the Education and Outreach Subcommittee. Additional points of discussion included: gaps in nearshore biological observations, differing aragonite saturation thresholds for different species, and the need for monitoring of ocean chemistry parameters for adult or settled razor clams.

Weaving Indigenous knowledge into education, ocean change, and resilience planning - This session was moderated by Melissa Poe and focused on how indigenous knowledge can support community adaptation efforts. The session was opened with a blessing by David Howeshata Hudson, a hereditary chief of the Quileute Tribe. Dave spoke of the changes at the mouth of the Hoh River during his lifetime as a result of erosion. Now most homes have been relocated away from the traditional village location. Lia Frenchman (Quinault Indian Nation), Harold "Fudd" Charles Jr (Queets), and Ann Penn-Charles (Quileute Tribe) also shared their experiences related to environmental and cultural changes and how their tribes are working to build resilience to climate change. Indigenous knowledge comes from generations of environmental stewardship. They noted that they have already observed changes in riverine and nearshore fisheries, and that some species found in middens from 100^{+} years ago cannot be found anymore. Other observations included that kelp forests, which are used for medicine and safety stops during canoe journeys, are not as prevalent, especially along the southern coastline. They are working to teach tribal youth traditional techniques and practices that are still viable, such as techniques like dip-netting for smelt, but risk being lost due to a lack of fish. The pain that tribal youth feel missing out on what elders talk about and cultural practices that are at risk due to changing conditions. The panel shared that certain canoe routes are already affected as the traditional launch and landing sites are too dangerous to safely access with changing conditions. They also highlighted the need for many of us to unlearn harmful western understandings/practices/assumptions to better include Indigenous knowledge to heal the ecosystem and communities.

Changing Ocean Conditions In the Classroom - This session was moderated by Lee Whitford, OCNMS SAC Chair, and focused on teaching OA and climate change in K-12 schools and colleges. Jacqueline Laverdure with OCNMS started the session with a discussion of the work the sanctuary is involved in to increase ocean and climate literacy in the classroom. OCNMS uses place-based and STEM-focused activities to engage teachers and students, including OA monitoring activities. Additionally, OCNMS provides OA educational tools and resources, such as a NOAA OA Resource Collection, and manages NOAA Pacific Northwest B-WET and Ocean Guardian School grant programs that support regional OA initiatives. Second, Jerry Walther, Taholah Education Center, discussed their work using cooperatives that bring together elders, universities and colleges, natural resource managers, federal experts, tribal fishers, etc. to share experiences and expertise. Next, David Long, Flathead Valley Community College, discussed how to engage people in OA monitoring. Lastly, Alice Ryan, a teacher at Quileute Tribal School and several of her students gave a presentation on their work on OA and biological sampling. They implemented programs that allowed students to help collect chemical and biological samples, thereby helping students develop basic lab skills and spark interest in

STEM. The discussion included asking teachers what they need most from scientists (willingness to help), the need for effective communication of changing ocean conditions, and ways to track the impact science education is having on the coast.

Citizen science for OA on the Olympic Coast - This session was moderated by Chris Butler-Minor, from OCNMS, and focused on how citizen science approaches can be used in OA monitoring. Wiley Evans, from Hakai Institute, shared his experiences with community-based monitoring of OA conditions in British Columbia, Canada, and Alaska. He noted the importance of these measurements in refining regional chemical and biological relationships, and that this work has served as an opportunity for engagement. Next, Cynthia Catton, WA Department of Natural Resources, presented on their Acidification Nearshore Monitoring Network (ANeMoNe) program in Puget Sound. This is a community monitoring program collecting data inside and outside of eelgrass meadows. A number of lessons learned were shared, including listening to volunteers on the ground, spending time adequately explaining the field protocols, hands-on training in invaluable, and understanding the needs of the community. There was interest from attendees on how to expand ANeMoNe sites to include the outer coast. Discussion at the end of this session focused on how to maintain community scientists, noting that they aren't free and that continued investment and engagement is needed. Some examples were discussed, including the coastal guardians' program in British Columbia, Olympic Region Harmful Algal Bloom, Coastal Observation and Seabird Survey Team, and involving students in monitoring.

Day 3

The OASeS Steering Committee met on the last day to discuss the Symposium, the OASeS work plan, and other business.

Overview/Recap of Symposium - Overall, there were positive responses by attendees on the symposium. A combination of being able to meet in person and the diversity of voices heard during the meeting were highlighted by many participants. Several improvements for future symposia were noted, including technological improvements needed for effective hybrid meetings, fewer talks (or stricter moderation) to allow for more time for discussion and synthesis, a desire for more networking opportunities (breaks, lunches, morning sessions, etc.), a poster session to better engage college students, more integration of panels across science, management, policy, and education themes, and fewer data-heavy presentations for mixed audiences. An additional recommendation was made to have pre-recorded talks that attendees can watch in advance of the symposium to allow for more interaction and discussions during the symposium (flipped classroom approach). It was also recommended that we rotate themes, and that the next symposium should feature education and outreach activities more prominently.

OASeS Steering Committee Business - We discussed the status of co-chairs' terms, which run through the end of 2022; as there are currently no term limits. We agreed to continue quarterly virtual meetings with a goal to meet in person or hybrid once a year. We discussed adding additional member seats to OASeS, including 1-2 community-at-large seats, 1 Marine Resources Advisory Council (MRAC) seat, and possibly 1 OA Alliance seat. The co-chairs will draft suggested changes to the Charter and present the proposed changes at our next meeting.

Work Plan Progress - We went through the high-priority tasks within the work plan and did not make many changes in our initial review. However, it was recommended that the subcommittees meet to further develop each goal, and the group highlighted the need for the education and outreach subcommittee to identify ways OASeS can better engage tribal communities now that COVID-19 restrictions are being eased. Several ideas were raised, including understanding what information each community is most interested in, hosting community seminars, and striving to enhance representation (and reduce barriers) in fellowships and scholarships. There was a lot of brainstorming on how the OASeS Steering Committee can support tribal communities in the ways they want to be supported, so we plan to dig into this further during future subcommittee meetings. There was also interest in the topic of marine carbon dioxide removal and options that may be available and appropriate to our region, and members suggested exploring the topic further during the next steering committee meeting.

MRAC Joint Discussion - We were able to have the MRAC coordinators join the steering committee meeting to discuss ways in which we can enhance coordination and collaboration between our groups. It was agreed that we will have regular updates during each other's meetings. MRAC is planning to develop a series of one-pagers that OASeS members can help produce. MRAC asked if OASeS members intend to submit a budgetary request, noting that any request would need to be submitted by the end of summer. The OASeS Co-chairs did submit a budget request with MRAC on behalf of OASeS for a nominal amount of money to support continued biennial symposia on the outer coast, development of the OASeS website, and development of outreach materials. A decision will be made by the state legislature in 2023.

Conclusion and Feedback

We have learned a great deal about hybrid meetings and plan to hold biennial OASeS Symposia, targeting even-numbered years moving forward. While we experienced some technological glitches in switching between formats (i.e., in-person, remote, and pre-recorded talks), the hybrid meeting format worked well overall and allowed us to accommodate various speakers and reach a broader audience.

Many of the steering committee's thoughts were mirrored in responses to a questionnaire. We had 19 participants respond to the questionnaire, 68% attended in person and 32% attended remotely. Overall, there was strong support for the diversity of voices we had during the symposium, and the breadth of topics covered. Respondents also enjoyed being able to see each other, expressing appreciation for the hybrid options and the evening receptions to allow everyone to catch up and network. Folks also enjoyed the venue itself and being on the Washington coast.

Overall, 63% of respondents felt the hybrid meeting format worked well (albeit with some technical issues to improve upon), 32% weren’t sure (attended in person), and 5% (1 person) did not feel like the hybrid meeting format worked well. Areas that could be improved for future symposia include improvements to the hybrid format to reduce technical delays (e.g., sound system challenges, use Zoom over GoToMeeting, have a dedicated tech person for

troubleshooting), fewer and shorter talks to allow more time for discussion (e.g., pre-record talks by remote speakers), consideration of breakout sessions or topic hubs, more networking opportunities (e.g., field trips), increased use of the Jamboard (e.g., state agencies could not use so explore other platforms, like Mural, that might be more effective), longer breaks, and more interactive panels focused on what is needed to advance the work. Suggestions for improving engagement with remote participants included use of different platforms for remote participants (Discord, Slack, etc.), small group breakouts for remote participants for virtual networking opportunities, an introductory tutorial on how to use Jamboard, panel conversations and more dedicated time for remote questions and discussions. Many also noted the need to better enforce agenda timing, which was especially important for remote participants who only joined for certain sessions.

For the timing of future symposia, 42.1% of respondents prefer spring (March - May), 21.1% each prefer either summer (June - August), fall (September - November), or winter (December - February (Figure 5)). However, there were specific requests to avoid negative tides (due to conflicts with intertidal research and harvesting), crossing the government fiscal year, and the fall mushroom season. Overall, timing and format should be driven by a particular audience - for congressional representatives targeting recesses, breaks, and field visits would be best, for fishermen targeting the off season (spring or fall), for students avoiding breaks.

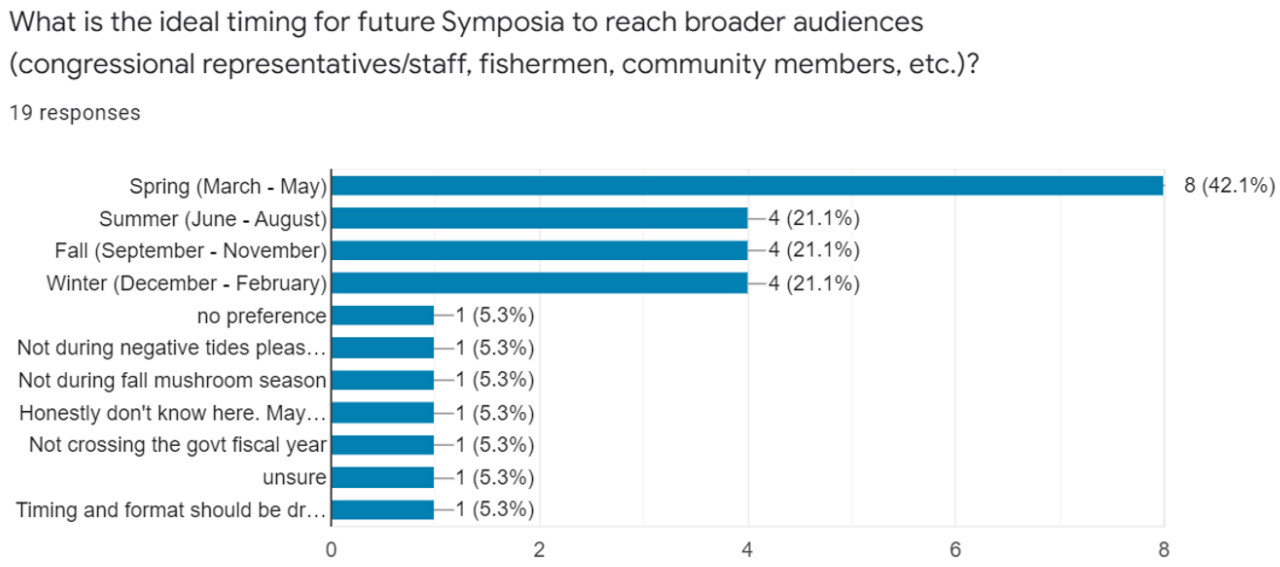

Figure 5: Summary results of preferred timing for future OASeS Symposia.

Regarding future symposium topics, respondents would like to see:

- more educational focus/school group talks,
- student presentations,
- roundtables on community needs (co-production focus),
- what other sanctuaries are doing with regard to OA,
- more traditional knowledge sessions,
- restoration that has supported local refugia (adaptation to OA),

- adaptation efforts,
- a panel on important information gaps that need filling and a session on solutions,
- more data and science,
- planning sessions to gather input on specific priorities or needs (e.g., communication, education, outreach),
- success stories from the Olympic Coast and other regions,
- discussions on why we are having a symposium and what we are trying to accomplish (with reminders throughout),
- speed-dating for collaboration,
- more OASeS swag,
- more community science, and
- discussions and exercises with policy-management-science-community representatives on how to address a given goal or challenge.

Additional requests include a list of recent OA publications from the symposium (including from the presentations) as well as better online presence of the symposium. The symposium was not widely promoted due to the COVID-19 pandemic and the lack of an OASeS website, however, future symposia will be better promoted.

Overall, respondents were very positive and appreciative of the symposium, and attendees especially enjoyed the diversity of voices heard, COVID-19 safety protocols, evening receptions, and being able to see everyone again (Figure 6). We will utilize all of the provided feedback to organize our next symposium in 2024.

Figure 6: Several former Sea Grant Fellows (Knauss and Hershman) with WA Sea Grant Director and OASeS co-chair, Russell Callender. From left to right: Halle Berger, Julie Ann Koehlinger, Kevin Grant, Laura Nelson, Haley Kennard, Russell Callender, Katie Wrubel, Kara Cardinal, Laura Letson. Photo: Chris Butler-Minor.

Appendix A: Symposium Agenda

OASeS Symposium - Agenda
May 10-12, 2022
Ocean Shores Convention Center
120 W Chance a La Mer NW, Ocean Shores, WA 98569

Join meeting from your computer, tablet, or smartphone:
https://global.gotomeeting.com/join/934726957
or:+1 (872) 240-3412 Access Code: 934-726-957

Day 1: Focus on Management and Policy, with an overview of OASeS

- 9:30 - 10:00am **Registration, open networking**

- 10:00 -10:20am: **Welcome and Opening**
  - Quinault Indian Nation

- 10:25 - 11:15am: **Olympic Coast Ocean Acidification Sentinel Site Overview**
  - Moderator: Katie Wrubel, Olympic Coast National Marine Sanctuary
  - Jan Newton, University of Washington - Ocean Acidification 101
  - Kevin Grant, Superintendent, Olympic Coast National Marine Sanctuary
  - Micah Horwith, Department of Ecology and OASeS Co-chair – OASeS/Olympic Coast perspective

- 11:20 - 12:20pm: **Culture and Values**
  - Moderator: Melissa Poe, Washington Sea Grant
  - Katie Wrubel, OCNMS - Ecosystem Services of the Olympic Coast
  - Liz Schotman, Surfrider Foundation - Recreational Use on the Olympic Coast
  - Andy Mail, Quinault Indian Nation
  - Jennifer Scott, Quinault Indian Nation
  - Sabrina Kramer, Quinault Indian Nation

- 12:20 - 1:20pm: **Lunch Break***
  - *Boxed lunches provided for 80 people

- 1:20 - 2:40pm: **Policy priorities and solutions**
    - Moderator: Russell Callender, Washington Sea Grant
    - Libby Jewett, NOAA Ocean Acidification Program (remote)
    - Jennifer Hennessey, Office of Governor Jay Inslee, – State policy priorities for OA and changing ocean conditions
    - Caren Braby, Oregon Department of Fish and Wildlife (remote)
    - Discussion:
        - How can policy address changing ocean conditions, what are our potential solutions at national, regional, and local levels?
        - What can the general public do?

- 2:40 - 2:50pm: **Break**

- 2:50 - 4:00pm: **Tools for Prediction and Response**
    - Moderator: Tommy Moore, Northwest Indian Fisheries Commission
    - Parker MacCready, University of Washington - LiveOcean Model (pre-record)
    - Sam Siedlecki, University of Connecticut - J-SCOPE (pre-record)
    - Owen Lui, NOAA Northwest Fisheries Science Center - Climate relevant information for Fisheries management (groundfish spatial distribution modeling with climate and IEA reports to PFMC) (remote)
    - Andy Suhrbier, Pacific Shellfish Institute - Targeted water quality monitoring for oysters, clams, geoduck and beyond.
    - Discussion:
        - Use of model outputs and translation to outputs and response?
        - What are the needs for improving tools, models, or monitoring?
        - Are there empirical data needs for model improvements?

- 4:05 - 5:25pm: **Management and Adaptation Needs**
    - Moderator: Micah Horwith, Washington State Department of Ecology
    - Paul McElhany, NOAA Northwest Fisheries Science Center - State of research on biological thresholds (remote)
    - Katie Keil, 48 North Solutions - Understanding and Advancing Natural Resource Management in the Context of Changing Ocean Conditions (remote)
    - Dan Ayres, Washington Department of Fish and Wildlife - Razor clam and Dungeness crab fisheries management needs

    - Haley Kennard, Makah Tribe, Makah Tribe's OA Action Plan
    - Discussion:
        - What impacts have you experienced to date? How did you respond to them?
        - How have resource managers adapted to changing ocean conditions to date and where can we go in the future? Thought exercise - in 20 years if OA conditions worsen, how might you respond with management actions?
        - What information do resource managers and end users need? Fishermen - what programs or websites do you check before going out? How would you like to receive information?
        - What social science/human dimension information needs are there?

- 5:25 - 5:30pm **Wrap up for the day**

- 5:30 - 6:30: **Evening Reception**
    - Evening Reception outside at Convention Center with hot appetizers provided and drinks for purchase

Throughout the meeting - please capture your thoughts on sticky notes (or Jamboard slide #12/20) related to research needs that may be relevant for internship or fellowship projects:

- Topics: Information gaps/data gaps/project ideas
- Outcome: Generation of scholar/intern ideas for OA? Hollings, Nancy Foster, tribal internships, etc. (running list of project ideas); tangible projects that are approachable for summer to a year to multi-year projects (species, oceanographic, human dimensions/social science, archeology, etc.) - sticky notes on posters for ideas
- What do we need and how to move forward? OASeS research needs and priorities, and how do we secure ongoing funding and other support?

Day 2: Focus on Science/Research and Education/Outreach

- 8:00am: **Open networking**

- 8:10 - 9:30am: **Ocean Acidification Regional Vulnerability Assessment**
    - Moderator: Meg Chadsey, Washington Sea Grant
    - Jan Newton, University of Washington/NANOOS/WOAC - Project overview and physical/biological results
    - Halle Berger, University of Connecticut - Seasonality and Life History Complexity Determine Vulnerability of Dungeness crab to Multiple Climate Stressors
    - Melissa Poe, Washington Sea Grant - Community well-being in relationship to a healthy ocean
    - Mel Watkinson-Schutten, Puget Sound Partnership - Socio-economic change and equity dimension
    - John Reamer and Haley Kennard, Makah Tribe - Food sovereignty program (remote)
    - Discussion:
        - What are some of the key lessons learned from this project?
        - What are some key information gaps (species vulnerability, social science, community engagement, etc.)?

- 9:35 - 10:40am: **OA indicators and how to sample** – Identify some considerations and best practices on pairing biological and chemical monitoring efforts as well as human dimension indicators
    - Moderator: Tommy Moore, Northwest Indian Fisheries Commission
    - Jan Newton, University of Washington/NANOOS - Indicator dashboard
    - Micah Horwith, Department of Ecology - Ecology Indicator Report
    - Tim Wootton and Cathy Pfister, University of Chicago - Alkalinity Dynamics in an Area of Rapidly Declining Ocean pH (remote)
    - Karma Norman, NOAA Northwest Fisheries Science Center - Approaches to human dimensions indicators for West Coast communities (remote)
    - Jenny Waddell, Olympic Coast National Marine Sanctuary - Upcoming field season plans for OCNMS
    - Discussion:
        - What biological indicators should we be focusing on?
        - Who is and where are we sampling?
        - Are there additional oceanographic parameters we should be monitoring? Where? How will this improve model forecasting?

        - How are end users using this information?
        - How (and how often) are we monitoring human dimension indicators for OA/changing ocean conditions?
        - Where are samples needed most and at what frequency?

- 10:40 - 10:50am: **Break**

- 10:50 - 12:05pm: **Emergent ocean change research in a multi-stressor context relevant to Olympic Coast - Oceanic**
    - Moderator: Jan Newton, University of Washington
    - Dick Feely, NOAA Pacific Marine Environmental Lab - Impacts of Ocean Acidification and Hypoxia on pH and Aragonite Saturation State Along the US West Coast
    - Simone Alin, NOAA Pacific Marine Environmental Lab - Past, present, and future OAH along the Olympic Coast
    - Vera Trainer, NOAA Northwest Fisheries Science Center - Harmful Algal Blooms and Ocean Acidification
    - Halle Berger, University of Connecticut - Regional attribution of coastal processes to aragonite, pH, and carbon variability in Washington and Oregon waters: A modeling study
    - Nina Bednarsek, Oregon State University and the National Institute of Biology, Slovenia - Multi-stressors risks across temporal and spatial scales (pre-recorded)
    - Discussion: 10 min clarifying Qs; Discussion combined with next session

- 12:05 -1:10pm: **Emergent ocean change research in a multi-stressor context relevant to Olympic Coast - Nearshore**
    - Moderator: Jenny Waddell, Olympic Coast National Marine Sanctuary
    - Steve Fradkin, Olympic National Park - Intertidal monitoring and vulnerability (remote)
    - Alex Stote, Washington Sea Grant - European green crab as an additional stressor under changing ocean conditions
    - Laura Nelson, University of Washington - Understanding perceptions of climate vulnerability to inform more effective adaptation in coastal communities
    - Discussion (combined with previous session):
        - How do we better connect nearshore and offshore efforts?
        - Where do nearshore and offshore dynamics differ?
        - Where are the gaps and vulnerabilities? Where are investments needed?

        - How are they engaging with local communities to ensure their work is relevant?

- 1:10 - 1:55pm: **Lunch****
    - **Boxed lunches provided for 80 people

- 2:10 - 3:10pm: **Weaving Indigenous knowledge into education, ocean change, and resilience planning**
    - Moderator: Melissa Poe, Washington Sea Grant
    - Lia Frenchman - Quinault Indian Nation
    - Dave Howeshata Hudson - Hoh Tribe
    - Ann Penn-Charles - Quileute Tribe

- 3:10 - 4:10pm: **Changing Ocean Conditions In the Classroom**
    - Moderator: Lee Whitford, Sanctuary Advisory Council Chair
    - Jacqueline Laverdure, Olympic Coast National Marine Sanctuary
    - Jerry Walther, Taholah Education Center - Cooperatives: The Importance To Our Learning and Way of Life
    - David Long, Flathead Valley Community College - Getting to their Hearts: Motivating People to do Something about OA (remote)
    - Alice Ryan and Students, Quileute Tribal School - Get Dirty! (remote)
    - Discussion:
        - What are the formal and informal education needs not currently being met, how can we help connect educators and students with information re: changing ocean conditions on the Olympic Coast?

- 4:15 - 5:20pm: **Community science for OA on the Olympic Coast**
    - Moderator: Chris Butler-Minor, Olympic Coast National Marine Sanctuary
    - Wiley Evans, Hakai Institute - Examples of community monitoring from a Hakai Institute perspective (remote)
    - Cynthia Catton, Department of Natural Resources - Acidification Nearshore Monitoring Network (ANeMoNe) in Puget Sound (remote/pre-record)
    - Discussion:
        - Any community science or related programs we can establish on the Olympic Coast? What could a community science project look like?

- 5:20 - 5:30pm: **Wrap up and What's next for OASeS?** Russell Callender, Washington Sea Grant

- 6:00-8:00pm: **Evening Reception** - Ocean Pours Taproom - Beer Garden space outside. Outside food is allowed, can purchase hot dogs, hot pretzels, and other food at Ocean Pours. 759 Ocean Shores Blvd NW, Ocean Shores, WA

Day 3: OASeS Steering Committee Meeting

- 8:00 - 8:45am: Overview/Recap of Symposium
- 8:45 - 10:15am: Work Plan Progress: Review of Work Plan, determine if results of symposium panels address existing tasks, if new tasks need to be added, etc.
- 10:15 - 10:45 am: MRAC joint discussion (what we are doing, synergistic projects, how can we collaborate better? Alignment with WOAC, GOA-ON, etc.?)
- 10:45 - 11:00am: Steering committee business (co-chairs, meeting schedule, membership, etc.)
- 11:00 - 11:15am: Wrap up and next steps

October 2022

Thank you to our sponsors for making this event possible

Sea Grant Washington

DEPARTMENT OF ECOLOGY
State of Washington

National Marine Sanctuary Foundation

WOAC
WASHINGTON OCEAN ACIDIFICATION CENTER

The Nature Conservancy
Protecting nature. Preserving life.

OCEAN ACIDIFICATION SENTINEL SITE
OASeS