The Oregon Coordinating Council on Ocean Acidification and Hypoxia

SECOND BIENNIAL REPORT

September 15th 2020

Submitted by the Oregon Coordinating Council on Ocean Acidification and Hypoxia

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OAH Council, Co-Chairs

Letter from Drs. Jack Barth and Caren Braby

Oregon is among the first places in the world to observe the direct impacts of ocean acidification and hypoxia (OAH). Since the early 2000s, OAH has been a challenge for the aquaculture industry's ability to grow larval oysters and has affected our fishing fleet who pull pots full of dead Dungeness crab during hypoxia events, and who suspect that productivity of crab may not be reliable in the future. While we have now implemented closed-tank systems to ensure sufficient water quality for oyster larvae production in many hatcheries and have a better understanding of regional variability of low-oxygen zones, changing OAH conditions are already undermining our ocean ecosystems and the communities that rely on them. Solutions to OAH challenges in Oregon's coastal waters are not as tractable as creating closed-tank systems in onshore aquaculture facilities. Ocean acidification and hypoxia (OAH) events are now annual seasonal events in Oregon ocean habitats, and are being compared to the Pacific Northwest late summer "fire season" by leading scientists. These events will continue and are predicted to intensify over time. Solutions are needed to help Oregon adapt to the changes we are already experiencing, and to be prepared for the projected worsening changes in our future.

The West Coast of North America is a hotspot of OAH change due to the nature of the upwelling system that transports low dissolved oxygen (DO), low pH, and high carbon dioxide (CO2) bottom-waters to our nearshore environments. Upwelling is responsible for the incredible diversity and productivity that fuel our wild fisheries, but at the same time these deep upwelled waters are now lower in dissolved oxygen and pH, especially during the late-summer OAH season. Fortunately, together we can continue to take action to address OAH, and we have a growing number of success stories from Oregon, the West Coast, and around the world to show examples of how this can be done. Through the ongoing dedication of the legislature, the Governor, and the legislatively created Oregon Coordinating Council on OAH (OAH Council), Oregon has been at the forefront of action in implementing change. We are making progress on OAH science, adaptation, and resilience planning – but there is still much more we can and should do together to create a stronger today and tomorrow.

In 2019, Oregon's OAH Action Plan (Action Plan) was finalized at the Governor's request and was submitted to the International Alliance to Combat Ocean Acidification demonstrating our state's ongoing commitment to the region and world. The Action Plan, further explained in this report, is a step-wise 6-year plan based on the Council's 2018 OAH Legislative Report. The Action Plan identifies ways that our state and local governments, marine industries, and individuals throughout Oregon can learn about, adapt to, and mitigate OAH impacts. In creating the steps in the Action Plan, the OAH Council considered the scientific readiness, urgency of need, anticipated value of actions, and appropriate phasing of implementation steps for each action in five thematic areas: supporting science, reducing causes, building resilience, raising awareness, and implementing solutions.

In 2020, we have faced the nearly unthinkable COVID-19 pandemic that has demonstrated the fragility of Oregon's social and economic fabric. Previously undetected vulnerabilities, including in our coastal seafood businesses and markets, underscore the need to build an approach for now and into the future that relies on resilience and adaptation to change. Similarly, climate and ocean change are expected to occur both gradually, as well as in episodic and dramatic bursts. While this year the pandemic is front and center creating unprecedented change, OAH is quietly continuing unabated and promises to cause disruption and instability for decades to come. We must prepare and take action to avoid eroding our communities' abilities to get access to healthy reliable food sources from the sea to feed their families and provide marine-related jobs. As with COVID, there are solutions in the works that will benefit our human communities and the marine ecosystem on which they rely. We must continue to act through partnerships and coordination of resources throughout our State – while building in key pillars of environmental justice and community equity – so that all Oregonians are ready for climate change.

This 2020 OAH Legislative Report, documents the progress the State has made since the last biennium on implementing the recommendations in the 2018 OAH Legislative Report and the Action Plan. However, this process is only part of the many critical steps that need to be done to help our state and coastal communities. The Oregon OAH Council urges a strong coordinated approach moving forward, involving researchers, fishermen, NGOs, coastal communities and others, to implement actions needed to make Oregon more resilient to future economic and environmental change. Additional investments will be needed over time so that Oregon can continue to lead the nation and the world on new science, successful strategies to mitigate ocean change, and to build resilience and adaptation – the time to act is now.

We have much to do, with little time, and the risks are great. Failure and inaction are not options. Together we can prepare Oregon for the changes we are currently experiencing and those that lie ahead.

John (Jack) Barth, PhD

Executive Director, Marine Studies Initiative
Professor, College of Earth, Ocean, and Atmospheric Sciences
Oregon State University

Caren Braby, PhD

Marine Resources Program Manager
Oregon Department of Fish and Wildlife

Executive Summary

2nd Biennial Report to the Legislature and Ocean Policy Advisory Council
Submitted by the Oregon Coordinating Council on Ocean Acidification and Hypoxia

Oregon was one of the first places in the world to feel the impacts of Ocean Acidification and Hypoxia (OAH), which continues to affect our vulnerable Oregon coastline. Working with a dedicated team of OAH Council members and the public, the 2020 OAH Legislative Report shares Oregon's successes over the past two years, as well as plans and benchmarks for actions for the next 1-3 years. ***To protect our ocean, its species, and the communities that depend on them, we can and must act now.***

The actions highlighted below represent a series of strategic first steps in OAH **science**, **mitigation**, **adaptation**, **awareness**, and **policy**.

Highlights of the OAH Council achievements this biennium (2018-2020):

- ***Coordinated ongoing efforts to bolster OAH monitoring in Yaquina Bay - an economic and research hub for Oregon.***
- ***Participated in the Oregon 2020 Climate Adaptation Framework process, to align the OAH Council efforts with other state mitigation processes.***
- ***Advised the West Coast Ocean Data Portal on ocean acidification data synthesis in order to provide information for adaptation and resiliency planning within Oregon communities.***
- ***Created a working group of education and outreach experts from across disciplines to advise on OAH communications products – including document language translations.***
- ***Consulted with the Governor's Office on a new Executive directive that encourages state agencies to consider addressing OAH in their regulatory and management frameworks.***

Highlights of the OAH Council benchmarks for next biennium (2020-2022):

- ***Ensuring the continuation of OAH monitoring in Tillamook Bay – an ongoing effort of the Oregon Ocean Monitoring Group and regional partners.***
- ***Facilitating OAH data acquisition and convening of regional experts for ongoing Oregon water quality assessments.***
- ***Exploring the role of submerged aquatic vegetation in ecosystem resiliency to OAH impacts through academic-resource management partnerships.***
- ***Convening fishermen-scientist roundtable targeting at-risk communities and industries to share updates and next steps on OAH to Oregonians across the state.***
- ***Developing a multi-agency assessment for anticipated needs to address OAH within regulatory and management frameworks.***
  (Report to be submitted to the legislature in Feb 2021)

In order to benefit of our human communities and the marine ecosystem on which they rely, we must continue to act through partnerships and coordination of resources throughout Oregon, in a process that is guided and informed by strong science. Oregon's history is one of cultural and economic value of ocean and estuaries. Yet, our ocean is changing, and each of these species, and the human communities that rely on them, are already showing signs of impairment from OAH ***(Figure 1)***.

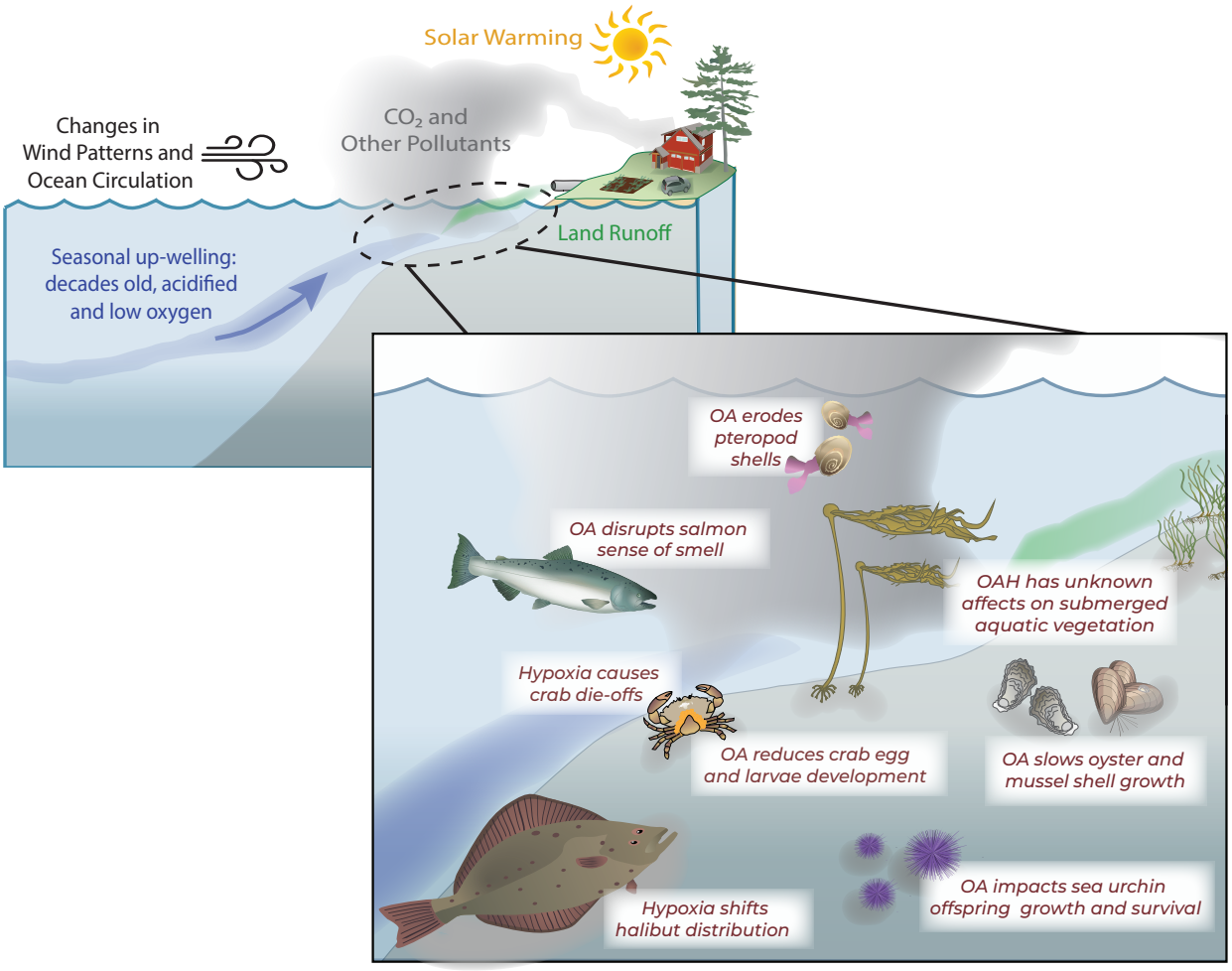


Figure 1. Schematic of the climate and other human drivers causing OAH, and the resulting OAH impacts on Oregon's iconic coastal ocean ecosystem.

In 2020, Oregon's coastal tourism, and seafood businesses were profoundly disrupted by the response to the pandemic and changing markets worldwide. Nevertheless, we are also resilient and in this time of change we have the opportunity to build a resilient future for Oregon on all fronts, including resilience to climate and ocean change. Ocean conditions further exacerbate these vulnerabilities and markets, underscoring the need to implement OAH actions that create community resilience and promote adaptation to rapid economic and environmental changes.

To learn more about OAH science, impacts, and solutions, please visit the Oregon OAH Council's website:

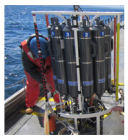
oregonocean.info/index.php/ocean-acidification

Oregon's OAH Action Plan

Development and Adoption

Oregon's OAH Action Plan (adopted by Governor Brown in 2019), is the 6-year roadmap for Oregon's efforts on OAH from 2019 to 2025. ***(see Appendix A - The 2019 OAH Action Plan)*** The Action Plan, which has been submitted to the International Alliance to Combat Ocean Acidification, serves as a model for others, relevant to their own geographical and political context, and demonstrates that local actions are meaningful in fighting the global challenges of climate and ocean changes ***(Figure 2)***.

The actions highlighted below represent a series of strategic first steps that Oregon has prioritized and committed to taking in OAH **science**, **mitigation**, **adaptation**, **awareness**, and **policy**.



1) Advance scientific understanding to address OAH vulnerabilities

- Invest in Oregon's existing research sites and tools
- Invest in monitoring of ocean life
- Assess the socio-economic impacts of OAH in Oregon

2) Develop and use strategies to reduce causes of excess CO_2 and other causes of OAH

- Enhance local and global communication networks working on CO_2 reduction
- Support research on effective and efficient ways to reduce excess CO_2 and OAH stressors
- Implement measures to reduce excess CO_2 and OAH stressors in Oregon

3) Support resilience to OAH in Oregon's ecosystems and communities

- Support data collection, synthesis, and modeling
- Restore, protect, and sustain native shellfish stocks and submerged aquatic vegetation
- Develop Best Management Practices based on current ecosystem and economic research

4) Share OAH science, impacts, and solutions to raise awareness

- Build OAH communications plan and outreach materials
- Provide timely updates to Oregon's decision-makers and affected communities
- Evaluate the effectiveness of OAH communications

5) Build sustained support and mobilize agencies to address OAH

- Governor issues a 2019 policy to address Oregon's OAH priorities
- Leadership, coordination, and policy guidance by Governor's Natural Resource Office
- Oregon agencies work to fill gaps in State OAH efforts

Figure 2. Diagram of OAH actions, and accompanying steps, that the OAH Council prioritized and committed to through the adoption of the 2019 OAH Action Plan.

To protect Oregon's environmentally sustainable marine-based food supply as well as our cultural and economic well-being, the OAH Council is facilitating strategic, scientific-based actions to adapt to and mitigate OAH throughout the state.

The OAH Council used a collaborative, science-based approach to developing and prioritizing actions in the OAH Action Plan, to ensure that Oregon is not only mitigating the causes, but proactively addressing and preparing for current and future impacts from OAH on our ecosystems and coastal communities. Public comment received on the 2018 Legislative Report also helped shape the Council's prioritization processes. In addition, Council staff conducted targeted survey and interview to gather input from over 70 experts across the state and provided the results to the Council to help inform the prioritization process. ***(see Appendix B - Community Survey)***

Members of the OAH Council carefully deliberated on and selected actions to prioritize, based on urgency of the need, the anticipated impact, and an available pathway (including staffing, funding) for implementation of each action. All recommendations and actions were agreed upon as important by all voting members on the Council. From the 38 specific actions developed in the 2018 OAH Legislative Report, the 6-year OAH Action Plan identified 5 actions, one from each of the 5 key themes. Identified actions are those that Oregon is ready to commit to and will flesh out the scope, methods, and resources needed to implement each action in future OAH Council Legislative Reports.

As a public convening entity, the OAH Council is committed to continuing to provide OAH information to the public and to facilitating alignment and collaboration in the State on OAH and climate issues. ***(see Appendix C - OAH Council Meeting Summaries)*** Currently, the OAH Council has been focusing on implementing actions prioritized in the 2019 OAH Action Plan. This 2020 Report to the Legislature focuses on updates on recent implementation of actions, as well as, plans for the next 1 – 3 years, and shows how our local, state-based action is making meaningful impact on the global issue of climate and ocean change.

The following section "Progress on Implementing the OAH Action Plan" describes the past successes and next steps that the OAH Council is taking in implementing actions in five thematic areas. In addition, each section includes a "Current Project Highlight", which provides additional detail for one of the actions listed.

Progress on Implementing the OAH Action Plan

1) Advance Scientific Understanding

Invest in Oregon's monitoring network to document oceanographic and biological conditions, and socio-economic vulnerabilities relating to Ocean Acidification and Hypoxia (OAH).

The Oregon OAH Action Plan identifies strategic augmentation of ocean monitoring and research that is essential to inform the State on how to mitigate and adapt to future OAH changes. While we must actively work to reduce the causes of OAH, we must also work to adapt to the effects and minimize the economic impacts of OAH by incorporating the best scientific information into management planning and decision-making. However, this will only be possible if we understand OAH trends well enough to foresee potential impacts. Currently, the State has a robust ocean monitoring network that produces long-term time series for physical, chemical, and biological properties of Oregon's nearshore ocean and some estuaries – however, there are large gaps in our monitoring networks that need to be filled (both geospatial and temporal monitoring).

OAH Council achievements this biennium (2018-2020):

- Continued to convene the Oregon Ocean Monitoring Group (OOMG) – a group of ocean monitoring experts and stakeholders (consisting of state and federal resource managers, academics, industry, and NGOs) with the aim of increasing Oregon OAH Monitoring. The group has been meeting since 2017.
- Facilitated data collection for the innovative collaborative OAH monitoring pilot project in Tillamook Bay - initiated by partners of the OOMG in 2018 as a two-year project funded by the Oregon Watershed Enhancement Board (OWEB).
- Established Yaquina Bay working group to build a long-term monitoring site to complement an historical time-series in the Bay. ***(OAH Action Plan - Step 1.1.1)***

OAH Council benchmarks for the next biennium (2020-2022):

- Securing funding for continued OAH monitoring in Tillamook Bay and Yaquina Bay to establish both of these areas as long-term monitoring sites. ***(OAH Action Plan - Step 1.1.3)***
- Securing funding and resources to co-locate OAH monitoring (intertidal and subtidal) alongside existing Marine Reserves biological sampling to leverage Oregon's existing research investments. ***(OAH Action Plan - Step 1.1.2)***

Current Project Highlight: Building long-term Yaquina Bay Monitoring
Start year 2020; continuous thereafter

Yaquina Bay has been used by communities for cultural, recreational, and commercial purposes for generations, including activities such as shellfish harvesting, fishing and fish processing, logging, shipping, tourism, aquaculture, and agriculture. The Bay is home to the Hatfield Marine Science Center (HMSC) a world class marine science facility housing academics and researchers from Oregon State University (OSU), state and federal resource managers, and the Oregon Coast Aquarium. The Bay is also the home of NOAA's Pacific Marine Operation Center and its research vessel fleet. Yet, OAH has the potential to adversely affect Yaquina Bay, and more monitoring is needed to track long-term changes.

Since the early 2000s, Yaquina Bay has been monitored for OAH and other OAH stressors through a series of short-term monitoring and research projects led by OSU as well as by the U.S. Environmental Protection Agency and the Oregon Department of Agriculture. However, due to a lack of resources, including funding and staff availability, many of these important monitoring programs have lapsed.

In order to start the process of building long-term OAH monitoring in Yaquina Bay, the OAH Council has organized a Working Group consisting of 14 regional experts and stakeholders who encompasses multiple perspectives and professional backgrounds. This Working Group has been meeting regularly since Spring 2020 to develop a research and data management plan for new monitoring as well as a community outreach plan to share project findings. ***(see Appendix D – Yaquina Bay OAH Monitoring Project)***

The goals of this Working Group include:

- Identify spatial, temporal, and technology gaps in monitoring data
- Pursue collaborations and resources to deploy new and maintain current monitoring
- Create pathways for real time accessibility of monitoring data
- Communicate findings in formats that inform community planning and state resource management

Part of the Working Group's charge is to identify OAH monitoring barriers and how to overcome them, including finding new external sources of funding for this effort. However, external project resources are unlikely to be forthcoming, unless there is also an investment from the State. **The OAH Council recommends that the State invest financial resources to implement monitoring in Yaquina Bay, to collect data that are essential to plan for current and future OAH impacts on our communities and ecosystems. State investment in this monitoring network station would inform help inform and direct the State's adaptation needs and priorities.**

Identified Barriers by this Working Group include:

- Funding to purchase and maintain additional high-resolution monitoring station(s) equipment in key location(s)
- Staff resources for maintaining equipment in the water, and to process data to allow for real-time access to datasets
- Additional analytical equipment to process discrete carbonate samples

Progress on Implementing the OAH Action Plan

2) Reduce Causes

Develop and integrate strategies to reduce causes of excess carbon dioxide (CO2) and Ocean Acidification and Hypoxia (OAH).

The Oregon OAH Action Plan identifies reducing causes and co-stressors of OAH as an integral step to combat OAH. It is the long-term goal of the OAH Council, and the State of Oregon (per EO No. 20-04), that Oregon measurably reduces CO2 emissions and stressors that compound OAH impacts to achieve ecosystem and economic benefits for both ocean and inland systems. While Oregon's emissions is only part of the global problem, Oregon is working to address our carbon footprint in a variety of ways that complement and reinforce the OAH Council's work.

OAH Council achievements this biennium (2018-2020):

- Participated in the development of the Oregon Department of Fish and Wildlife's (ODFW) Climate and Ocean Change Policy, which includes measures to protect ocean fisheries and habitats as well as reduce the agencies energy requirements. ***(see Appendix E – ODFW Climate and Ocean Change - OAH Council Letter)*** *(OAH Action Plan Step 2.2.3)*
- Participated in and reviewed Oregon's 2018/2020 Water Quality Assessment by providing public comment on the draft assessment and hypoxia data sources for future analysis. ***(see Appendix F –2018/2020 Oregon Water Quality Assessment - OAH Council Letter)*** *(OAH Action Plan Step 2.2.3)*
- Participated in and reviewed Oregon's 2020 Climate Adaptation Framework process by providing public comment on the draft plan and suggestions on how be further incorporate OAH and other ocean changes into the framework. *(OAH Action Plan Step 2.2.3)*

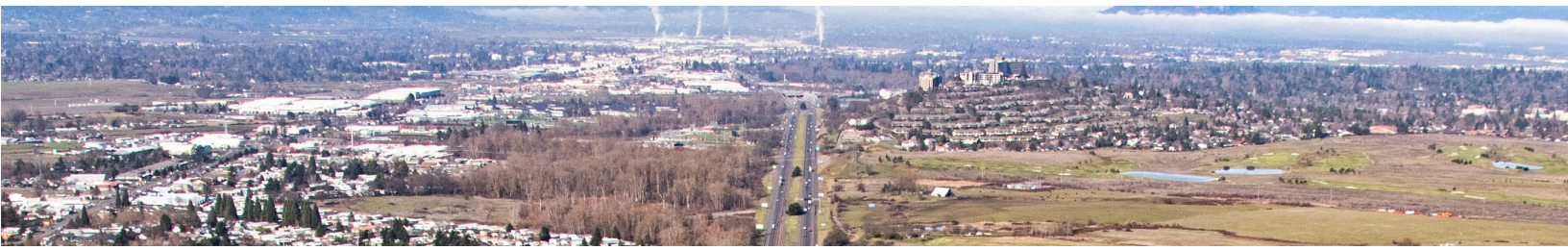
OAH Council benchmarks for the next biennium (2020-2022):

- Co-authoring the ocean change section of the 2021 Oregon Climate Change Research Institute (OCCRI5) Report to the legislature. *(OAH Action Plan Step 2.2.3)*
- Facilitating further OAH data acquisition, and convening of regional experts when applicable, for Oregon's future Integrated Water Quality Reports – developed by the Oregon Department of Environmental Quality to meet the requirements of the federal Clean Water Act. *(OAH Action Plan Step 2.2.3)*

Current Project Highlight: Oregon 2020 Climate Adaptation Framework
2020 Start year; continuous thereafter

Over the past year, the OAH Council has worked collaboratively with our partners throughout the State on climate and ocean change initiatives. Oregon has taken great strides to understand the effects of climate change on our ecosystem and economy, while providing leadership across the West Coast on CO2 emissions policy. Of particular note, is the 2020 Oregon Climate Adaptation Framework, which updates the 2010 Oregon Climate Change Adaptation Framework - outlining the approach needed to best leverage State resources.

A work group comprised of staff from 25 state agencies, coordinated by the Department of Land Conservation and Development (DLCD), prepared the 2020 Climate Adaption Framework. Agency members of the OAH Council have served on the interagency working group and have helped draft the framework, including some of the ocean change content. The OAH Council as a whole also has had the opportunity to provide public comments on the Framework, and have offered several suggestions on how to strengthen the ocean change adaptations sections to better reflect Oregon Coastal communities' unique needs for climate adaptation. The final draft of the framework is expected to be completed in early 2021. The Council is currently working on finishing their final review of the 2020 Climate Adaptation Framework, which sill be submitted to DLCD by October 31st 2020.



Progress on Implementing the OAH Action Plan

3) Create Resilience

Support activities and initiatives that promote adaptation and resilience to Ocean Acidification and Hypoxia (OAH), for Oregon's human communities and ecosystems.

The Oregon OAH Action Plan identifies the need for the state to promote OAH resilience and adaptation in our management decisions and in regional planning for ecosystems and coastal communities. To support both thriving marine habitats (e.g., submerged aquatic vegetation (SAV)) and economies in light of current and future ocean changes, it is essential to build strong collaborations among stakeholders in order to maximize resources and time. By supporting community-driven climate resilience and adaptation measures Oregonians from vulnerable coastal communities and industries will become part of the solution to help mitigate OAH impacts.

OAH Council achievements this biennium (2018-2020):

- Advised the West Coast Ocean Data Portal (WCODP) on ongoing ocean acidification data synthesis – information can aid adaptation and resiliency planning within Oregon communities. ***(OAH Action Plan Step 3.2.1)***
- Participated in the Oregon's Territorial Sea Plan, Part 3: Rocky Habitat Management Plan Update, which now includes new information and considerations for ocean change, OAH adaptation planning, and protections for SAV. ***(OAH Action Plan Step 3.1.1)***
- Served on the advisory boards of several regional scientific research projects focused on OAH adaptation and resiliency planning within Oregon communities and ecosystems. ***(OAH Action Plan Step 3.1.1)***
    - NOAA Grant (2018-2020): "Vulnerability and Adaptation to Ocean Acidification among Pacific Northwest Mussel and Oyster Stakeholders"
    - Lenfest Grant (2019-2022): "Geospatial Patterns and Species Impacts of Changing Ocean Chemistry on the West Coast"
    - NOAA Grant (2020-2024): "Assessing Community Vulnerability to Ocean Acidification Across the California Current Ecosystem"

OAH Council benchmarks for the next biennium (2020-2022):

- Building academic-resource management partnerships to explore the role of SAV in ecosystem resiliency to OAH impacts – initiated in 2020 through the submission of grant proposals to the U.S. Fish and Wildlife Service and the National Estuaries Partnership. ***(OAH Action Plan Step 3.2.2)***

Current Project Highlight: West Coast Ocean Data Portal OAH Data Synthesis
Start year 2020; continuous thereafter

Oregon has had a central role in the West Coast Ocean Data Portal (WCODP) – a regional partnership of academic institutions, stakeholders, and state and federal governments with the goal of increasing access to data and information to inform decision making. WCODP is currently in the preliminary stages of creating a West Coast "Ocean Health Scorecard." This scorecard will not only collect and synthesize ocean data, including an ocean acidification indicator, but will also define standards and critical thresholds concerning priority ocean health issues across the region. As such, this scorecard will provide an important tool to be used for community adaptation and resilience planning as well as for possible management purposes (e.g., State Water Quality Assessments).

Agency staff on the OAH Council, particularly from the Oregon Department of Land Conservation and Development (DLCD) and the Oregon Department of Fish and Wildlife (ODFW) have been active in the design of the "Ocean Health Scorecard". As this project moves forward, the Oregon Ocean Monitoring Group (OOMG) and the OAH Council have been asked to help compile and review Oregon ocean information, particularly on ocean acidification, and to provide context for how this information might be used by Oregon communities. The growing interest in this topic led to the inclusion of the Ocean Status Update section in this report ***(see Report pages 21 - 25)***.

Progress on Implementing the OAH Action Plan

4) Expand Public Awareness

Communicate Ocean Acidification and Hypoxia (OAH) science, impacts, and solutions to raise awareness and support decision-making.

The Oregon OAH Action Plan identifies that it is important that ocean experts and stewards continue to make OAH information accessible to all Oregonians with the goal of empowering coastal communities to take informed action today to build a more robust future. This can only occur through clear, strategic, and compassionate communications. As Oregon continues to observe the impacts from OAH, it is key that we support equity and environmental justice in our communications – as many underserved communities in rural and urban centers are expected to be disproportionately impacted by climate change due to limited access to resources and information. Communities' resiliency depends on us taking steps forward today in awareness of and planning for ocean change. By creating strong, diverse partnerships of informed individuals (who not only understand OAH science, but are well informed on their possible mitigation, adaptation, and resiliency options to take action) Oregon can continue our path towards combating OAH. ***(see Appendix H – OAH Outreach Materials and Activities)***

OAH Council achievements this biennium (2018-2020):

- Pursued nationally recognized science communication trainings for Council staff in order to continue to hone OAH Council outreach materials' visuals and messages (including the acceptance into the 2020 COMPASS Leaders for Sea Change Fellowship).
- Shared OAH science, impacts, and solutions information with Oregonians throughout the state in venues such as – State of the Coast, Oregon Coastal Economic Summit, as well as at various fishers' club meetings and fisheries regulatory council meetings. ***(see Appendix G – OAH Council Developed OAH Outreach Materials)*** ***(OAH Action Plan Step 4.2.3)***
- Convened an advisory Working Group with regional education specialists and industry to identify OAH outreach needs. ***(OAH Action Plan Step 4.1.1)***
- Developed an online library of outreach materials focusing on commercial species vulnerable to OAH, the science of OAH, and Spanish translations of materials – made publically accessible on the OAH Council website. ***(OAH Action Plan Step 4.2.3)***

OAH Council benchmarks for the next biennium (2020-2022):

- Developing a communications plan to meet the needs of diverse stakeholders and provide solutions-oriented messages on OAH science and impacts. ***(OAH Action Plan Step 4.1.2)***
- Convening and facilitating workshops and informational sessions on the OAH impacts and solutions. Projects currently under development include a November 2020 State of the Coast remote session and April 2021 Fishermen's-Scientist roundtable. ***(OAH Action Plan Step 4.2.2)***

Current Project Highlights: New Communications Working Group Initiatives
Start year 2020; continuous thereafter

Current and projected OAH impacts will be harmful to ocean life and the economic stability of all Oregonians - yet it will take a strong common purpose, meaningful local action, and broad partnerships (regionally, nationally, and internationally) in order to successfully implement solutions. The OAH Council is dedicated to recognizing the variation in the populations of the people that will be affected by these changes, and provide information that speaks to these differing interests and needs. In order to truly mitigate change, we must listen to and learn from affected communities, and understand their concerns and needs, so that we can incorporate those needs into solutions.

To this end, the OAH Council has organized a Working Group consisting of 11 members, including regional education and outreach specialists, as well as industry members, representing multiple perspectives and professional backgrounds. This Working Group has been meeting since Winter 2019 with the aim to identifying key audiences and connecting newly developed messages to audiences' personal interests, emotions, and beliefs. ***(See Appendix H – Education and Outreach Working Group - OAH Communications Planning)***

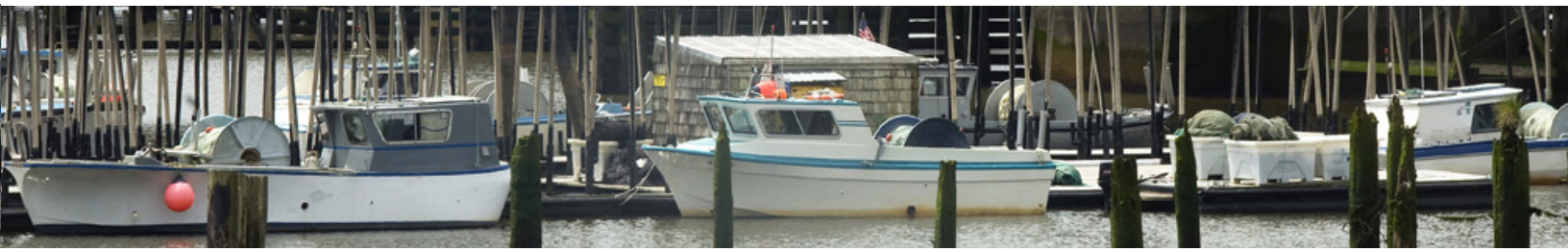
The goals of this Working Group include:

- ***Instilling OAH Understanding***
- ***Removing OAH Misconceptions***
- ***Acknowledging OAH Uncertainty***
- ***Building Motivation for OAH Action***
- ***Creating Hope for the Future***

The Working Group is currently developing a communications plan to meet the needs of diverse stakeholders and provide solutions-oriented messages to all Oregonians. A media firm who specializes in climate risk communications and messaging will ideally create the OAH Communications Plan (with anticipated delivery in 2023). In addition, the Working Group is working on several new initiatives including the development of a Fishermen's Roundtable.

2021 Fishermen-Scientist OAH Roundtable: *(Proposed for Spring 2021 – in person)*

In 2016 and 2017, Oregon Sea Grant, OSU and ODFW, along with others partners from around the State hosted two Ocean Acidification (OA) Fisherman's Roundtables, both in Newport, in order to share the current status of OA science and actions in Oregon. These roundtables were considered by the attendees (industry, managers, academics, decision-makers) to be valuable platforms for open dialog about the current status of our oceans health; these conversations spurred multiple collaborative research projects as a result. It is the goal of this workshop to describe the collaborations that have occurred, and focus on recent observations and opportunities to collaborate in the future. The Working Group has applied for and was awarded a small external grant to help support this workshop.



Progress on Implementing the OAH Action Plan

5) Build Sustained Support

Mobilize agencies to address Ocean Acidification and Hypoxia (OAH) priorities.

The Oregon OAH Action Plan identifies that developing a long-term OAH coordination strategy among state agencies, academia, the federal government, and industry will be a central and pivotal piece of Oregon's ongoing efforts to combat OAH. Oregon's ongoing leadership has already been invaluable for OAH science and decision-making both regionally and nationally, providing a model for other governments to follow. Moving forward, the state has already committed to continuing to support strong science-informed climate and ocean change policy through a series of important actions.

OAH Council achievements this biennium (2018-2020):

- Consulted with the Governor's Office on a new Executive directive that encourages state agencies to consider addressing OAH in their regulatory and management frameworks – accomplished through the Governor's letter to the OA Alliance adopting Oregon's 2019 OAH Action Plan. ***(see Appendix J – Governor Brown's Letter of Commitment to OAH Action)*** ***(OAH Action Plan Step 5.1.1)***
- Encouraged state agencies to propose anticipated needs in their biennial agency budget development process – Oregon Department of Fish and Wildlife (ODFW) and Department of Land Conservation and Development (DLCD) both included new ocean change measures in their proposed 2021-2023 biennium budgets to the Governor's Office in 2020. ***(OAH Action Plan Step 5.2.1)***
- Coordinated with state agencies to begin the process of identifying OAH priorities in their agencies current and future regulation and management frameworks. ***(OAH Action Plan Step 5.2.3)***

OAH Council benchmarks for the next biennium (2020-2022):

- Developing a multi-agency assessment report to describe current programs and anticipated needs to address OAH within current and future regulatory and management frameworks. (Report to be submitted to the legislature in Feb 2021) ***(OAH Action Plan Step 5.2.3)***

Current Project Highlight: Multi-agency OAH Needs Assessment
Start year 2019; continuous thereafter

In order to combat OAH long-term it is essential that all agencies develop clear defined goals to address projected ecosystem and economic impacts from OAH – as and where it is applicable. While OAH issues have been incorporated to some extent into some agencies regular planning processes for budget, staffing, and management outcomes, there are additional opportunities to integrate OAH into the day-to-day work of the State's policies and agency programs. The OAH Council's member agencies and 4 additional agencies are developing a multi-agency OAH needs assessment report which will include:

- ***An evaluation of current and potential management strategies for each agency, and management gaps that relate to OAH***
- ***Description of funding needs for OAH, for current and future budgeting processes***
- ***Recommendations on how to further promote inter-agency communication and collaboration on actions in the OAH Action Plan***

As a first step, the OAH Council identified eight key State agencies whose authorities have the most direct nexus with OAH impacts, adaptation, and mitigation. ***(see Appendix A – 2019 OAH Action Plan - OAH Action Plan Appendix D)*** These eight agencies will report to the legislature in February 2021, on existing programs and policies that are already at work to address OAH impacts, as well as the opportunities and resources needed to better-prepare Oregon for future ocean change. A key aspect of this combined report will be the opportunities to coordinate and effectively use limited resources.

Outline of state agency authorities and priorities outlined in the Oregon OAH Action Plan:

Oregon Department of Fish and Wildlife
- Emerging fisheries, resilient fishing communities, OAH research & monitoring

Department of State Lands
- Submerged aquatic vegetation, removal/fill permitting, mitigation of development impacts, authorization of use of state-owned navigable waterways

Department of Land Conservation and Development
- Ocean planning, coastal zone management, federal consistency, statewide planning goals, climate adaptation framework

Department of Environmental Quality
- Water quality, point and non-point source pollution, total maximum daily loads (TMDLs)

Oregon Department of Agriculture
- Food safety, aquaculture and agriculture permitting and practices

Oregon Department of Forestry
- Forested watersheds, carbon offset and mitigation, nonpoint source pollution on forested lands

Oregon Health Authority
- Impacted coastal communities

Oregon Department of Energy
- Carbon mitigation framework, impacts on ecosystem and economics.

Ocean Status Update

How much ocean change has occurred?

Fossil fuel combustion and related accumulation of carbon dioxide (CO_2) and other greenhouse gases have led to climate change, ocean acidification and ocean deoxygenation (hypoxia). The earth's ocean has absorbed 30% of the excess CO_2 produced from fossil fuel combustion since the Industrial Revolution (mid 1800s). When absorbed by seawater, CO_2 undergoes chemical reactions that lower seawater pH (making it more acidic), and thus hampers shell formation in marine life. Hypoxia (low oxygen) conditions are also on the rise as a result of climate change, due to changing wind and weather patterns. This is leading to extended periods of hypoxia in some of Oregon's coastal waters, impacting a wide range of marine animals from crabs to fish. This has led to ecosystem and economic impacts, which are already reverberating through our tourism and seafood industries **(Figure 3)**.

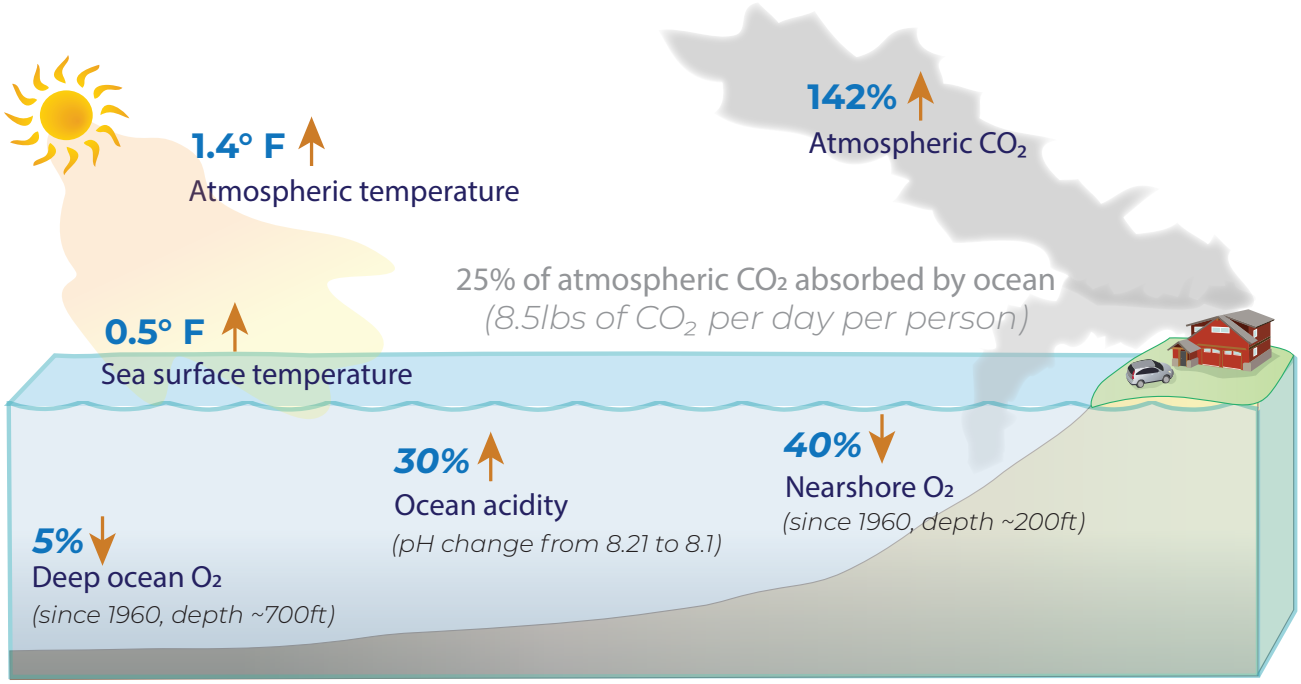


Figure 3. Schematic of anthropogenic climate driven changes in ocean and atmospheric conditions since the late 1800's.

References for schematic: *Pierce, S. D., J. A. Barth, R. K. Shearman and A. Y. Erofeev, 2012. Declining oxygen in the Northeast Pacific. J. Phys. Oceanogr., 42, 495-501. Schmidtko, S., L. Stramma & M. Visbeck, 2017. Decline in global oceanic oxygen content during the past five decades. Nature, 542, 335–339. https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature*

What is happening in the ocean in recent years?

In an ongoing effort to highlight recent scientific work from our region, and because of growing interest in Oregon on "What is happening in the ocean in recent years?" We present examples of the changes we are observing in the ocean over recent years. Moving forward, the OAH Council hopes this "Ocean Status Update" section will become a regular feature in our reports to the legislature, and will help to provide scientific context to Oregon's ongoing OAH ***science***, ***mitigation***, ***adaptation***, ***awareness***, and ***policy*** efforts.

The work of the OAH Council has been, and will continue to be, guided by strong science. As a region, the West Coast is at the forefront of oceanographic monitoring and OAH science with some of the world's premier long term oceanographic and intertidal data sites right off Oregon's coast including: NSF's Ocean Observatories Initiative , NOAA's Northwest Association of Networked Ocean Observing Systems and the Newport Hydrographic Line, and the Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO). The results of climate and ocean change have had far-reaching consequences, for both the ocean ecosystem and the economy, consequences that we, as a society, are only just beginning to understand and quantify, but world-class science institutions in Oregon and across the West Coast gives us a great advantage to both understand and develop solutions for OAH.

The Pacific Ocean, similar to other world ocean basins, is an interconnected system,with multiple climate and ocean change impacts manifesting and influencing each other at the same time. As we observe changing ocean conditions, we are seeing signs of shifting food webs, loss of fishery productivity and lost economic opportunities that are connected to OAH changes. This "Ocean Status Update" highlights a few recent oceanographic events that help describe Oregon's changing ocean conditions, including ocean warming, hypoxia, and the presence of Harmful Algal Blooms.

For more information on these topics, and other oceanographic indicators of climate and ocean change please visit the National Oceanographic and Atmospheric Administration's website:

https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-publications-reports

Ocean Warming and "The Blob" of 2015 – Oregon's first acknowledged Marine Heatwave

"The Blob", as it was initially dubbed, was a large mass of relatively warm water in the northeast Pacific Ocean caused by weak winter winds that failed to cool down the summer-warmed surface waters. First detected in late 2013, growing in 2014, and causing basin-wide ecosystem shifts by 2015, this marine heatwave was associated with the largest marine harmful algal bloom ever documented. The above-average warm sea surface temperature hugged the coast of Oregon (and California, Washington, Alaska) for multiple years. In 2019, the marine heatwave re-surfaced in the summer (having temporarily subsided to deeper depths), but then weakened by December 2019 ***(Figure 4)***. The lasting effects of both the 3-year 2015 event and the 6-month 2019 event on Oregon's ocean ecosystem are still unfolding. In general, these warming events can have long-lasting effects on oceanographic conditions. During the 2015-2019 period, in addition to the massive harmful algal bloom that closed fisheries and caused harm to ocean species, Oregon experienced multiple intense seasonal hypoxia events across the continental shelf that disrupted fishing and stock assessments, and documented species range shifts of dozens of ocean species.

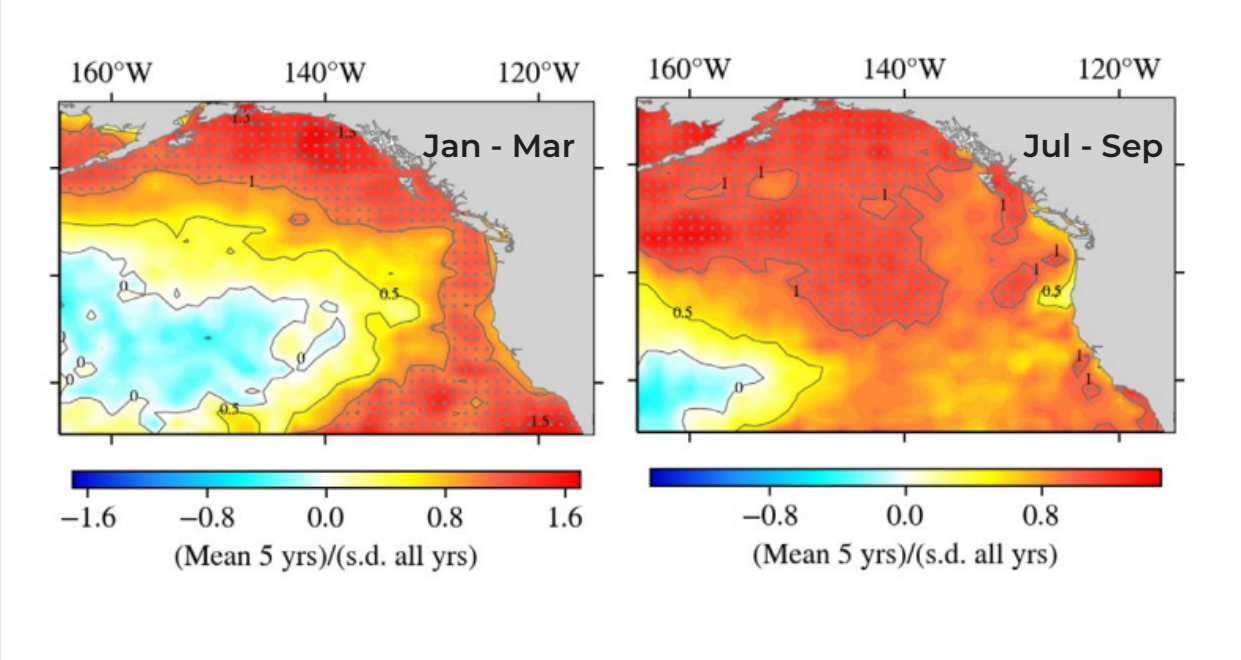


Figure 4. Mean Sea Surface Temperature (SST) anomalies in degrees Celsius (1°C = 1.8° F) for 2015-2019 (5 yrs), based on 1982-present satellite time series in winter January- March; left) and summer (July-September; right). Warm colors (yellow-red) indicates areas that are anomalously warmer than the 38-year average. Cool colors (aqua-blue) indicate areas that are anomalously cooler. (Reprinted from the 2020 California Current Integrated Ecosystem Assessment – CCIEA)

Ocean Hypoxia

Historically, it was normal for the Oregon coast to experience small areas of low oxygen (hypoxic) water occasionally near the sea floor along the outer and middle portions of the continental shelf. This is caused by Oregon's summer winds blowing from north to south, driving the surface waters offshore, and causing deeper, lower oxygen waters to rise toward the surface in a process called upwelling. Yet, the frequency of hypoxic events in Oregon's waters is increasing, and the low oxygen areas reach closer to shore, affecting our productive coastal ecosystems. The first zero oxygen event (anoxia) off Oregon was documented in 2006. Recently, hypoxia events are observed annually in late summer, and are occasionally severe (e.g. 2018 and 2019 offshore of Newport, ***Figure 5***).

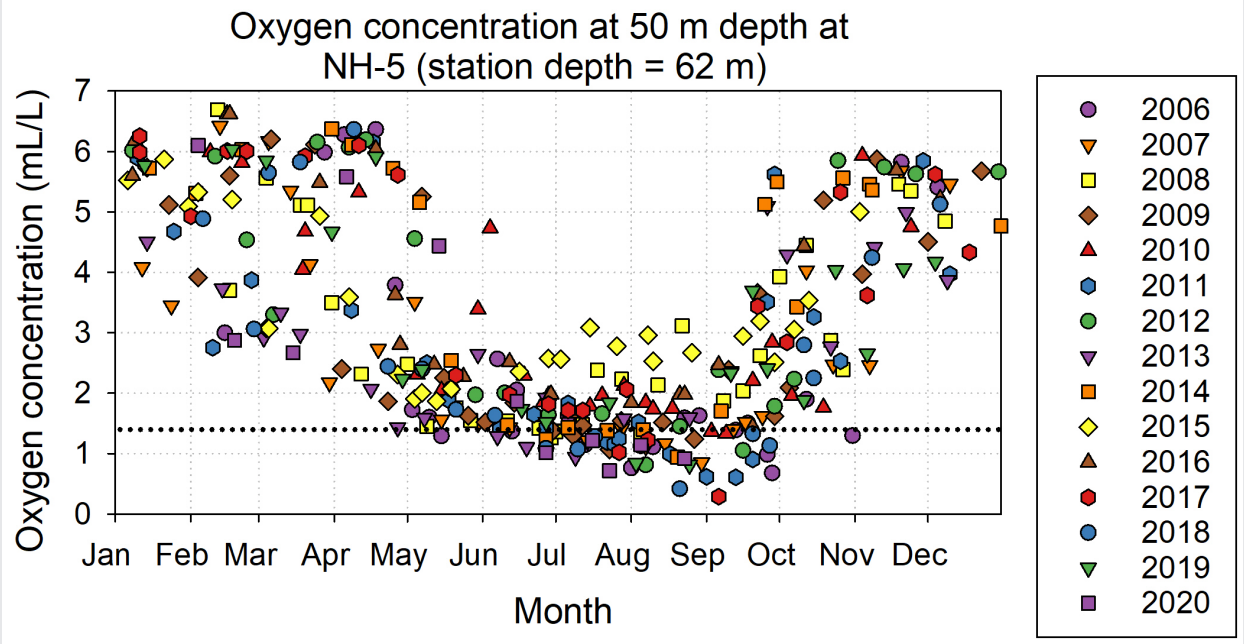


Figure 5. Oxygen concentration in bottom waters at a baseline station NH 05 (Newport Hydrographic line 5 miles off shore). Hypoxia is defined as waters with oxygen concentrations <1.4 ml/L, and is observed only during the coastal upwelling season, especially during Jun-Sep. (Reprinted from the NOAA Fisheries Summary of Ocean Indicators)

Harmful Algal Blooms (HABs)

HABs have been responsible for closures of shellfish and crab fisheries off the Oregon coast in recent years, resulting in negative social and economic impacts for coastal communities and across the state ***(Figure 6)***. Several studies have shown definitive evidence that HABs are impacted by warming oceans and increased ocean acidification (1,2). Ocean acidification may also increase the risk of more severe harmful algal blooms. This has been documented in the phytoplankton species *Pseudo-nitzschia* (which causes Domoic Acid), that has been shown to produce more toxins in lower pH water (3).

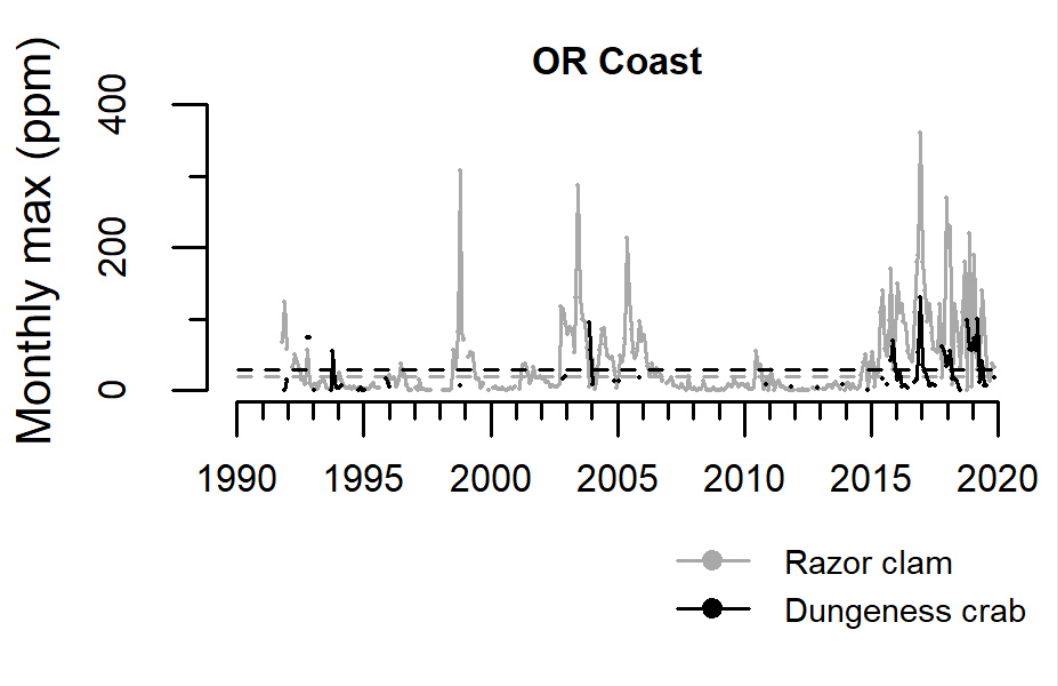


Figure 6. Monthly maximum domoic acid concentration (ppm) in razor clams (gray) and Dungeness crab viscera (black) through 2019 for Oregon. Horizontal dashed lines are the management thresholds of 20 ppm (clams in gray) and 30 ppm (crabs in black). (Reprinted from the 2020 California Current Integrated Ecosystem Assessment – CCIEA)

References: (1) Gobler, C.J., 2020. Climate change and harmful algal blooms: insights and perspective. Harmful Algae, 91, p.101731. (2) Raven, J.A., Gobler, C.J. and Hansen, P.J., 2020. Dynamic CO2 and pH levels in coastal, estuarine, and inland waters: Theoretical and observed effects on harmful algal blooms. Harmful algae, 91, p.101594. (3) Wilson, J.R., Wilkerson, F.P., Blaser, S.B. and Nielsen, K.J., 2020. Phytoplankton Community Structure in a Seasonal Low-Inflow Estuary Adjacent to Coastal Upwelling (Drakes Estero, CA, USA). Estuaries and Coasts, pp.1-19.

Regional Partners

Building Momentum for Action (2018 - 2020)

Oregon, the West Coast, and our nation have begun to make progress towards coordinated efforts to combat OAH. Below are several key state, regional, and national milestones, completed since 2018 OAH Legislative Report - each of which highlight strategic actions in OAH science, mitigation, adaptation, awareness, and policy.

It is critical we continue to build on these actions.

Oregon OAH Action Plan (August 2019): was developed from 2018-2019 by the OAH Council as our State's roadmap for action, and submitted this roadmap to the International Alliance to Combat Ocean Acidification. As requested by Governor Kate Brown, the OAH Council was central to this public process, which used the 2018 OAH Council legislative OAH Report as a starting point to identify the first actions that Oregon will take over the next several years.

Scoping Assessment For Pacific Northwest Blue Carbon Finance Projects (October 2019): was an assessment that investigated former tidal wetland sites in three estuaries (Skagit Delta, WA, Snohomish Estuary, WA, and Coos Estuary, OR) for their potential to be restored as carbon offset projects supported in part by carbon financing.

Oregon Executive Order 20-04 (March 2020): has directed State agencies to take actions to reduce and regulate greenhouse gas emissions to combat climate and ocean change – including OAH. Specifically, the Governor's order updates State carbon reduction goals, setting targets of a 45% reduction below 1990 levels by 2035, and an 80% reduction by 2050. It also directs agencies to alter building codes to prioritize energy efficiency, decrease reliance on fossil fuels, and make provisions for reducing state-wide food waste.

Federal Clean Water Act OAH Assessment (April 2020): was developed by the Oregon Department of Environmental Quality (DEQ). With the submission of this assessment Oregon became the first state in the nation to evaluate and include OAH ocean water conditions as part of its assessment of Oregon's waters under the federal Clean Water Act. Through this action the State formally recognized that OAH is a real and present danger and cause for concern for our coastal communities and ecosystems. Identification of the impacts of OAH on marine waters is the first step towards development of a strategic approach to identify the broad-scale underlying mechanisms contributing to these conditions, and how contributions from local sources could be addressed through water quality management. This assessment will be updated with new science every two years as DEQ is required to biennially assess and report the condition of Oregon's water quality to the U.S. Environmental Protection Agency (EPA).

Oregon campus of the NOAA Regional Institute for Climate, Ocean and Ecosystem Research (May 2020): has been formed with a regional consortium of faculty and staff from Oregon State University (OSU), University of Washington, and University of Alaska Fairbanks. The Institute will operate for four years (from 2021 – 2024) with the goal of contributing expertise, research capacity, technological development, and public outreach focused on a wide range of climate and ocean stressors including OAH. Federal funding for the consortium could be renewed for two cycles. OSU's existing Cooperative Institute for Marine Resources Studies (CIMRS) continues to also work on OAH-related science as it impacts the ocean's living marine resources.

Oregon's Territorial Sea Plan, Part 3: Rocky Habitat Management Plan revision (June 2020): has been developed by OPAC and will be finalized and adopted by LCDC in 2021. This updated plan (first adopted in 1994) includes policies, management prescriptions, and site-specific recommendations to guide management by local, state and federal agencies at nearly 90 sites on the Oregon coast. The draft includes new information and considerations for ocean change and OAH adaptation planning, including new policy on subtidal habitat and submerged aquatic vegetation (SAVs), such as kelp.

The Federal Climate Crisis Action Plan (July 2020): is the US Congressional roadmap to build a prosperous, clean energy economy that values workers and advances environmental justice. Created by members of the congressional working group including Oregon Representative Suzanne Bonamici, this Climate Action Plan stresses that the U.S. government has a moral, scientific, and economic duty to meet the climate change challenge. Specifically this plan outlines 12 key pillars designed to harness the technological innovation, entrepreneurs, the strength of our workers, and ongoing scientific developments in order to make directed and meaning full actions against climate and ocean change.

Moving Forward

Oregon's approach to addressing OAH impacts will take time and resources to implement. State investments, establishing clear priorities, and collaborations will be needed in order to implement the OAH Actions needed to make Oregon more resilient to future economic and environmental change.

Oregon benefits both culturally and economically to the natural beauty and bounty of the ocean and the health of its ocean and estuarine fisheries. Salmon, halibut, Dungeness crab, razor clams, oysters, pink shrimp, lamprey, rockfish, and other species have supported Oregon's indigenous people and coastal economies for generations. Yet, Oregon's ocean is changing, and each of these species, and the human communities that rely on them, are already showing signs of impairment from increasing intensity and durations of ocean acidification and hypoxia (OAH). Action is needed to help them adapt and become more resilient to change.

The Council encourages all who are ready and willing, to take action to address OAH impacts. There has already been some encouraging signs of State support over the last year from the Oregon Ocean Science Trust (OOST). The OOST is now authorized through the passage of SB753 (which established the legal framework) to work with outside partners to secure funding for ocean monitoring and health related research projects. The OOST has developed a new work plan for the next several years, and the OAH Council is ready to engage with OOST to meet common goals.

In the next biennium (2021-2023), the OAH Council recommends that Oregon focus on implementing steps outlined within the OAH Action Plan, specifically those relating to building resiliency in our coastal communities and ecosystems. Resiliency planning will not only help combat OAH but will assist communities as they begin to "rebuild" their stability given current economic uncertainties. This will require State prioritization and investment to be successful. When considering State investments we recommend both investing in our people and natural places to create value and benefits from sustainable ecosystem services. It may not be possible to implement all actions immediately; but through deliberate and thoughtful prioritization by the OAH Council members, the Action Plan continues to document what needs to be addressed first.

Together we can better prepare Oregon for the ocean changes happening now and to come.

The work of the OAH Council is ongoing, and the Council will continue to advise the State on current and future impacts that OAH and ocean change will have on our communities, so that the best science-based information is supporting decision-making.

Below is a timeline and preliminary estimated funding needs for OAH Actions as outlined in this OAH Action Plan in the following Action Categories: 1. Advance scientific understanding, 2. Reduce Causes, 3. Create Resilience, 4. Expand Public Awareness, 5.Build Sustained Support.

Values are ranges of preliminary estimates of costs for action, and were used to show the scale at which each action could be implemented. A dash (--) denotes actions for which there is uncertainty about whether there will be costs associated with the action, but costs may eventually be attributable to its implementation. An asterisk (*) denotes actions for which one or more external regional or national grant applications have been submitted to partially support estimated funding needs - at this time no grants have been awarded. TBD denotes funding needs yet to be determined *(no range set at this time)*.

Start Year	Action	Step	Estimated Funding Needs
2019	2	1. The OAH Council works with the Governor's Natural Resource Office to establish regular communication and coordination pathways with state agencies and other State entities to address excess CO_2 and OAH stressors locally and globally.	--
	4	1. 1. The OAH Council convenes an advisory working group with regional education/ outreach specialists to identify OAH outreach needs.	--
	5	1. 1. Governor issues a 2019 policy, directing relevant state agencies to consider work they are doing and their plans to address OAH priorities in the context of this Action Plan: Agencies document both existing and needed programs and regulations.	--
	5	1. 2. Agencies propose anticipated needs in biennial agency budget development process, starting with agency budget proposals for the 2021-2023 biennium.	--
	5	2. Governor's Natural Resources Office provides leadership, coordination, and policy guidance to agencies on OAH action priorities.	--
2019 - 2020	1	1. 1. Re-establish oceanographic monitoring to complement an historical time-series in Yaquina Bay.	*$50K-$200K (biennial costs)*
2019 - 2021	4	1. 2. The OAH Council develops a communications plan and outreach materials to meet the needs of diverse stakeholders and provide solutions-oriented messages on OAH science and impacts.	*$50K-$150K (onetime costs)*
2019 - 2025	4	2. 3. The OAH Council provides information in a variety of forms to impacted audiences including policy makers, at-risk industries, and coastal communities.	--
2020	4	2. 1. The OAH Council reports to the Oregon legislature on recommended OAH actions, through a biennial report (see step 1).	--
	4	2. 2. The OAH Council convenes "State of OAH" workshop for communities on OAH science, impacts, and solutions with policy makers as well as communities and at-risk industries.	*$25K-$100K (per workshop)*
2020 - 2023	3	1. 1. Allocate state funding for competitive grants and/or match to identify how to achieve ecosystem and economic resilience for Oregon.	*$200K-$300K (per project)*
	3	2. 1. Allocate state funding to support data collection, synthesis, and modeling to inform strategies that promote OAH resilient ecosystems: Develop maps to address the following information needs.	*$50K-$150K (onetime costs) **
	3	2. 2. Allocate state funding to support data collection, synthesis, and modeling to inform strategies that promote OAH resilient ecosystems: competitive grants and/or match to conduct ecosystem modeling.	*$200K-$400K (per project) **

Year	Action	Step	Estimated Funding Needs
2021	1	2. 1. Conduct a workshop to determine priority biological metrics for monitoring in Oregon coastal waters, including consideration of research results from regional partners.	*$25K-$100K (onetime costs)*
	3	1. 2. Industry and academics support continued research of resilient shellfish aquaculture strains.	*$200K-$600K (biennial costs)*
	5	1. 2. The OAH Council incorporates agencies' reports into ongoing development of recommendations to the State.	--
2021 - 2023	1	1. 2. Co-locate OAH oceanographic monitoring (intertidal and subtidal) alongside existing Marine Reserves biological sampling to leverage Oregon's existing research investments in Marine Reserves.	*$300K-$500K (biennial costs)*
	1	1. 3. Provide sustained funding for OAH oceanographic monitoring in Tillamook Bay.	*$50K-$100K (biennial costs)*
	1	1. 4. Support the maintenance of existing and installation of new climate grade OAH instruments in communities and at-risk industry locations.	*$100K-$200K (biennial costs)*
	1	2. 3. Augment on-going funding for the Newport Hydrographic Line to add biological and chemical OAH monitoring sensors and analysis to get the most value out of this existing monitoring program.	*$50K-$200K (biennial costs)*
	2	2. Fund competitive grants; funds could be used for match to attract additional investment or for full implementation); use outcomes to inform decision-making and future investments.	*$200K-$300K (per project)*
	2	3. Relevant state agencies implement measures to reduce excess CO_2 and OAH stressors.	*TBD*
	4	3. 1. The OAH Council develops communications evaluation tools to assess the OAH Council's outreach efforts and inform future outreach activities.	*$25K-$75K (onetime costs)*
2021 - 2025	5	3. State agencies implement measures to fill gaps, as described in agency OAH planning, in alignment with the Oregon Climate Adaptation Framework (2010), and with guidance from the Governor's Natural Resources Office.	*TBD*
2023	4	3. 2. The OAH Council revises outreach efforts and materials based on evaluation.	*$25K-$50K (onetime costs)*
2023 - 2024	1	2. 3. Augment Oregon Department of Fish and Wildlife's (ODFW) Shellfish assessment team to increase frequency and spatial scale of shellfish and submerged aquatic vegetation (SAV, e.g., eelgrasses) observations.	*$400K-$550K (biennial costs)*
	3	3. Agencies will develop Best Management Practices (BMPs), based on current ecosystem and economic research (as determined in Step 1) focused on Oregon's estuaries and nearshore.	*TBD*

About the Oregon Coordinating Council on Ocean Acidification and Hypoxia

In 2017, the Oregon Legislature created the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council) via Senate Bill 1039. This bill passed with strong support from both legislative chambers and parties in recognition of the real and present threats that OAH impacts pose to our coastal communities and ecosystems. Through this legislative mandate, the State committed attention and resources toward understanding OAH impacts and charting a course for preparing for those impacts in our management decisions going forward. Subsequently, in 2018 Governor Brown committed the OAH Council to create Oregon's OAH Action Plan Oregon's roadmap to address OAH impacts. ***(see Appendix A - OAH Council Meeting Summaries)***

The OAH Council has been convening regularly, since January 2018, and is comprised of 13 members including State agencies, stakeholders, Tribes, NGOs and the Governor's office. During these public meetings, each Council member and members of the public have brought their unique perspective and expertise to bear on Council discussions - the OAH Council strives for an open and inclusive process.

Council members serve voluntarily for a 2 – 4 year appointment. In 2020, the OAH Council welcomed three new members as part of our staggered appointment schedule. The new seats include a new fisheries representative, commercial shellfish representative, and academic representative. The Council's diverse membership is critical for bringing together Oregonians and for the OAH Council moving forward.

The OAH Council continues to provide information and recommendations to the legislature and the Governor with a sense of urgency and importance, knowing that we have the remarkable opportunity to help strengthen Oregon's ecosystem, and the fishing and shellfish industries that rely on it. The OAH Council also recognizes that this will be an ongoing and dynamic process and will continue to keep the legislature, the Governor and Oregon Ocean Policy Council (OPAC) abreast of those changes through biennial reports, as directed in SB 1039.

OAH Council Guiding Principles

UNDERSTAND: *Develop an understanding of OAH science, how Oregon is impacted by increasing occurrence of OAH impacts, and what other entities in Oregon and the West Coast are working on these issues.*

RECOMMEND: *Identify action areas that are supported by all Council members, drawing from personal and professional experience, Council discussions, and presentations from subject matter experts.*

IMPLEMENT: *Consider the various options of how the recommended action areas could be refined and ultimately implemented.*

Council Member Biographies

DR. JOHN (JACK) BARTH, COUNCIL CO-CHAIR
Oregon State University

Jack Barth is the Executive Director of Oregon State University's (OSU) Marine Studies Initiative and is a Professor of Oceanography in OSU's College of Earth, Ocean, and Atmospheric Sciences. Jack received a Ph.D in Oceanography from the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution Joint Program. His research seeks to understand how coastal ocean circulation and water properties influence coastal marine ecosystems. Jack is interested in marine low-oxygen zones and has led a number of research, technology development, and ocean observing system projects. He serves on the Oregon Ocean Policy Advisory Council's Scientific and Technical Advisory Committee.

DR. CAREN BRABY, COUNCIL CO-CHAIR
Oregon Department of Fish and Wildlife

Caren Braby provides strategic leadership on all things 'ocean' within the state of Oregon and across the West Coast, as the Manager of the Marine Resources Program for the Oregon Department of Fish and Wildlife. Her work is grounded in both fishery and ecosystem issues, and is directed at facilitating and inspiring stewardship of ocean resources. Caren and her staff build partnerships with stakeholders and elected officials to collaboratively define, and achieve, both economic and ecosystem resilience. In particular, changing ocean conditions (particularly OAH) have become focal points for Caren's work over the past 7 years. Caren received a Ph.D. in Biological Sciences from Stanford University.

FRANK BARCELLOS
Oregon Department of Agriculture

Frank Barcellos is a Food Safety Program Managers for the Oregon Department of Agriculture. Frank relocated to the Pacific Northwest to share his knowledge and experience with the Oregon Dept. of Agriculture. He has responsibility over Dairy, Shellfish, and Personnel in his new position in Oregon. After graduating from University of Oklahoma with a degree in Microbiology, Frank worked for Oklahoma Department of Agriculture for over 40 years. His interests in OAH are from the perspective of the relationships between coastal communities and resources (e.g., dairy farming nutrient runoffs into shellfish estuaries).

JENNIFER WIGAL
Oregon Department of Environmental Quality

Jennifer Wigal serves as the Water Quality Deputy Administrator for the Oregon Department of Environmental Quality, where she has provides leadership to Oregon's water quality programs. Jennifer has over 20 years' experience working in water quality programs at the state and federal level. Jennifer received her Masters in Environmental Engineering from Johns Hopkins University and a B.S. in Civil Engineering from Washington State University.

ANDY LANIER
Department of Land Conservation and Development

Andy Lanier is the Marine Affairs Coordinator with Oregon's federally approved Coastal Management Program. He holds a M.S. degree in Marine Resource Management from OSU. Andy is the Co-Chair of the West Coast Ocean Data Portal and is a staffer to the Oregon Ocean Policy Advisory Council. Throughout his career he has been dedicated to promoting the inclusion of science based considerations regarding ocean acidification and hypoxia into state management and policy.

DR. JAMES SUMICH
Oregon Ocean Science Trust

James Sumich has worked in the field of marine science throughout the West Coast for over 50 years, receiving his M.S. and Ph.D. degrees from OSU. Recently retired as Professor of Marine Biology and Zoology at Grossmont Community College, California, his research interests have focused on the biology of gray whales and other mysticetes. James currently serves as a Trustee for Oregon Ocean Science Trust, where he provides scientific guidance to the board on the development of the Trust's scientific grant program. James's interest in OAH stems from his growing concern that local or regional solutions are increasingly crucial to address the problems associated with increasing atmospheric CO2 levels.

DR. SHELBY WALKER
Oregon Sea Grant

Shelby Walker is the director of the Oregon Sea Grant. She joined Oregon Sea Grant, coming to them from the NOAA Office of Oceanic and Atmospheric Research's Office of Policy, Planning and Evaluation, where she was responsible for NOAA research planning efforts and served as associate director for the NOAA RESTORE Act Science Program. Prior to NOAA, she was an associate program director in the National Science Foundation's Ocean Sciences Division, where she helped lead the Ocean Technology and Interdisciplinary Coordination Program. She holds a Ph.D. degree in Marine Science from the College of William and Mary, and is a former Sea Grant Knauss Fellow.

FRAN RECHT
Conservation Organization Representative

Fran Recht is the Habitat Program Manager for the Pacific States Marine Fisheries Commission. In her position she acts to conserve and restore freshwater, estuarine and ocean habitats. She works by advancing policies and actions through work with collaborative, multiparty groups such as the Pacific Fishery Management Council, the Pacific Marine and Estuarine Fish Habitat Partnership, forest service stewardship groups, and local watershed councils. She also brings her academic background in biochemistry and marine resource management to this issue.

VACANT
Shellfish Industry Representative

BRANDII HOLMDAHL
Fishing Representative

Brandii Holmdhl has worked in seafood processing and fishing, as well as political, regulatory, and educational aspects of commercial seafood for over 28 years. She is driven by opportunities to share knowledge and innovation. Brandii believes that one of the most important aspects of improving seafood harvest quality and sustainability is to create educational opportunities. To this end, she has taught classes, spoke at industry events, and worked with fishermen in AK, WA, and OR to guide them through independent marketing and processing. Brandii has also wrote a technical column for Fishermen News. Currently, she serves on the National Fisheries Institute and AK Seafood Marketing Institute committees.

DR. JESSICA MILLER
Academic Representative

Jessica Miller is a Professor of Fisheries and Wildlife at OSU and a member of the Coastal Oregon Marine Experiment Station at Hatfield Marine Science Center. She leads the Marine & Anadromous Fisheries Ecology Program and teaches courses on the early life history of fishes. She is also OSU's Project Director for the Living Marine Resources Cooperative Science Center, a NOAA-funded effort to promote underrepresented communities in marine science. Her research combines field and lab studies with biogeochemistry to address questions in marine and fisheries ecology that contribute to management and conservation. She received a BA in Zoology from the University of Montana, a MS in Fisheries from University of Washington, and a PhD in Biology from the University of Oregon.

JOHN SCHAEFER
Tribal Government Representative

John Schaefer earned his B.S. degree from Oregon State University in biology, and has acted as the water protection specialist and biologist for the Confederated Tribes of the Coos, Lower Umpqua & Siuslaw Indians (CTCLUSI) since 2015. As part of the Department of Natural Resources & Culture team, John represents the CTCLUSI natural resource interests at local stakeholder meetings and watershed councils. Prior to working for the tribes, John was shellfish biologist for ODFW for over ten years. He is a Coos Tribal member with interests in first foods and other cultural resources, and is dedicated to preserving natural resources and creating local adaptation actions, in light of changing ocean conditions from OAH.

DR. KRISTEN SHEERAN, EX-OFFICIO
Governor's Office Representative

Kristen Sheeran serves as Climate and Energy Policy Advisor to Governor Kate Brown and is the Director of the Carbon Policy Office. An economist by training, she has researched and practiced in the field of energy and environmental policy for over fifteen years. Kristen earned her Ph.D. degree in economics from American University and B.S. degree in economics and political science from Drew University. Her career spans leadership positions in the private, public, and non-profit sectors. She has published numerous articles on carbon policy and other related climate issues.

Table of Contents

***Appendix G* - Council Developed OAH Outreach Materials**

Take Action (English and Spanish Versions)
Research Needs
Species Highlights – Dungeness crab
Species Highlights – Oysters
Species Highlights – Salmon
Hypoxia – Effects on Oregon Coastline

***Appendix H* - Education and Outreach Working Group – OAH Communications Planning Project**

Project Scope and Planning
Fishermen's Round-table Proposal
Working Group Meeting Summary 01/14/20
Working Group Meeting Summary 05/27/20
Working Group Meeting Summary 08/05/20

***Appendix I* - Governor Brown's Letter of Commitment to OAH Action**

Submitted to the Oregon Legislature and the Oregon Ocean Policy Advisory Council

As directed by Oregon Senate Bill 1039 (passed in 2017)