The Oregon Coordinating Council on
Ocean Acidification and Hypoxia

September 15th 2018

1st Biennial Report to the Legislature and Ocean Policy Advisory Council

The Oregon Coordinating Council on Ocean Acidification and Hypoxia

September 15, 2018

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Dr. Kristen Sheeran, Ex-Officio
Governor's Natural Resources Office, Governor Kate Brown

Letter from Drs. Jack Barth and Caren Braby
OAH Council, Co-Chairs

Oregon is a place rich with natural resources, a place of beauty and majesty; steeped in the traditions of self-determination and of living off the land and sea. Oregon's fisheries and aquaculture are central to this history, are enjoyed by Oregonians across the state year-round, and remain key to coastal economics today. Yet, the future sustainability of these marine resources, and Oregonians' ability to rely on them, are uncertain in the face of significant ocean changes and our current status in preparing to adapt to those changes over time.

In 2007, Oregon's Whiskey Creek Shellfish Hatchery was unable to reliably produce oyster larvae, the seed resources needed for the West Coast's over $270 million dollar oyster growing industry. In response, Oregon researchers worked hand-in-hand with the oyster industry to identify the problem: ocean acidification caused by human-produced carbon dioxide (CO_2) entering the ocean. This industry-researcher partnership created practical solutions for continuing successful oyster hatchery production in the face of increasingly acidified conditions of Oregon's ocean waters. The partnership discovered and described the impacts of acidified waters to the oyster industry.

When CO_2 is absorbed by seawater, chemical reactions occur that lower seawater pH (making it more acidic), while changing the saturation states of biologically important calcium carbonate minerals (ions needed for shell formation). Low-oxygen conditions are also on the rise, leading to extended periods of hypoxia in some of Oregon's coastal waters, stressing a wide range of marine animals from crabs to fish. Solutions are needed to help Oregon's wild fisheries and marine resources withstand the projected changes in both ocean acidification and hypoxia.

With this as context, the Oregon Legislature had the foresight to create the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council) through Senate Bill 1039 (2017). Through this legislative mandate, the State committed attention and resources toward understanding OAH impacts and charting a course for considering those impacts in our management decisions going forward.

As Co-Chairs, we have taken on this charge with a sense of urgency and import, knowing that we have the remarkable opportunity to help strengthen Oregon's ecosystem and the fishing and shellfish industries that rely on it. There are solutions within our reach. Working with a dedicated team of Council members, we present to you a dynamic, living document which we intend to be a resource for the State, informing future actions in the following areas:

- Increasing awareness of OAH, including its causes and practical solutions to combat it
- Informing policy directions to Oregon agencies
- Building partnerships among government agencies, local governments, academia, industries, and non-governmental institutions to build OAH solutions
- Investing in programs to address OAH in Oregon
- Charting a course for action for ongoing OAH Council work
- Creating Oregon's first OAH Action Plan

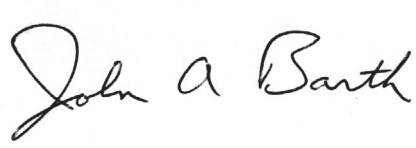
As evident from similar activities in other states, most notably Washington's Blue Ribbon Panel on Ocean Acidification (2012, 2017), Oregon's OAH Council Report will bring value to the State in ways that are not yet anticipated. By articulating our current concerns and ideas for solutions-based actions, we intend to generate broad discussions and activities that will help prepare Oregon for the next fifty years by stimulating actions now.

During late 2018 and early 2019, the OAH Council will lead discussions and activities to create Oregon's OAH Action Plan, our state's commitment to the International Alliance to Combat Ocean Acidification. As requested by Governor Kate Brown, the OAH Council will be central to this public process, which will use the OAH Council Report as a starting point to identify the first actions that Oregon will take over the next several years. As Co-Chairs, we welcome and encourage all Oregonians to help us meet this challenge and to get involved in building solutions.

In addition to the OAH Action Plan process, we will continue the work of the OAH Council over the next year to share information and identify opportunities to act. Through scientific understanding and awareness, we can work together to combat this threat to Oregon's marine ecosystem and coastal economies.

Thank you for the opportunity.

John (Jack) Barth, PhD



Executive Director
Marine Studies Initiative
Oregon State University

Caren Braby, PhD

Marine Resources Program Manager
Oregon Dept of Fish and Wildlife

Letter from Dr. Francis Chan

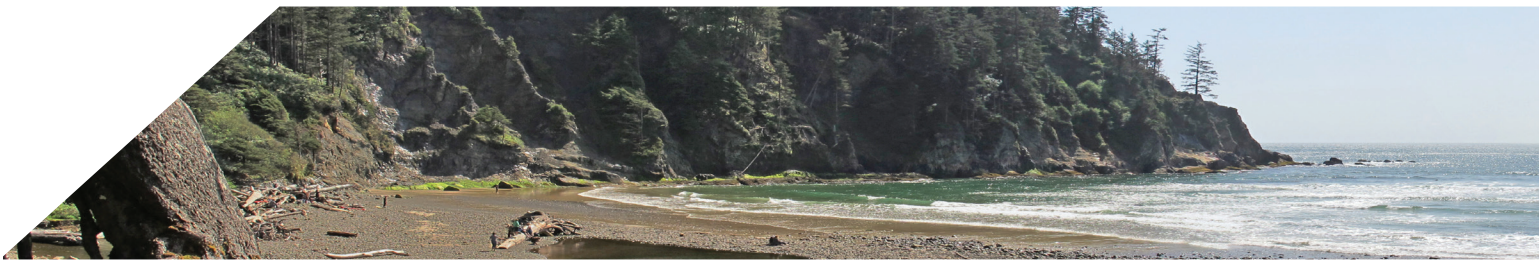
West Coast OAH Science Panel, Co-Chair

It is a time of change for Oregon's productive coastal ocean. As a scientist, I have been studying those changes. By tracking the onset of low oxygen and acidified zones across our state's waters each year, I join many researchers across the West Coast who are working to understand what the future ocean will look like and what actions we should take now to prepare for the changes to come. I recently served as the co-chair of the West Coast Ocean Acidification and Hypoxia Science Panel (WCOAHSP). The Panel consisted of scientists from Oregon, California, Washington and British Columbia and we were tasked with providing a road map for those actions.

I am extremely encouraged to see the translation of the WCOAHSP's findings into the recommendations in this report by the Oregon Coordinating Council on Ocean Acidification and Hypoxia. The OAH Council's recommendations build from and extend those developed by the WCOAHSP's and offer actions that are tailored to Oregon's needs. This is exactly the approach that we had envisioned as regional guidance must be translated into concrete, targeted, and science-based options that can be implemented without haste.

There are costs to inaction. Since the release of the WCOAHSP's report in 2016, the need for action has only intensified. New research points to an ever-growing list of marine organisms that are now known to be vulnerable to the threats of ocean acidification and hypoxia (OAH). This list includes species such as Dungeness crabs, rockfishes, and salmon that underpin livelihoods and connections to the sea for many Oregonians. Since 2016, we have also seen the return of extremely severe low oxygen zones that have resulted in Dungeness crab die-offs and marked depressed catches in fishery surveys. As ocean conditions continue to change as projected, the need for sound information to guide solutions and decisions will only intensify.

Oregon is fortunate to have the OAH Council's thoughtful recommendations to chart a path forward. This is a foundation for actions whose benefits will continue to grow over time, ensuring that Oregon has access to the full range of options to deal with the changes ahead. There is also value to early implementation from the regional and national contexts. Ocean acidification and hypoxia are key issues for any coastal state, but Oregon leadership has been invaluable for OAH science and decision making. People look to Oregon for the forward-thinking actions of our decision makers, the depth of our marine research programs, and for our ability to work collaboratively across universities, agencies, industries, and other stakeholders. As our neighboring states increase their commitment to actions, Oregon has



an opportunity to work in that vanguard. This would support the ability of our state to remain competitive for crucial national funding and to ensure that Oregon's perspectives are contributing to regional and national policy conversations.

With forward-thinking decision makers, invaluable partnerships, and ocean science expertise across all of our universities, Oregon is well poised to act on the OAH Council's recommendations. That is not to say that the global challenges of OAH are not daunting. But as an educator, I see the motivating power of challenges and commitments to actions every day. The path ahead will see a next generation of Oregon students who will become leaders in creative solutions building. This is something that we can make possible today.

Sincerely,

Francis Chan, PhD

Associate Professor, Senior Researcher
College of Earth, Ocean, and Atmospheric Sciences
Oregon State University

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oregonocean.info/index.php/ocean-acidification

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Appendix G: Member Agency Management Responsibilities and OAH Nexus

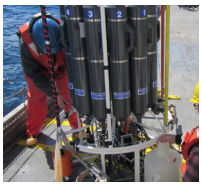
Appendix H: West Coast OAH Science Panel Recommendations

Executive Summary

1st Biennial Report to the Legislature and Ocean Policy Advisory Council

Oregon Coordinating Council on Ocean Acidification and Hypoxia

Oregon is among the first places in the world to observe direct impacts of ocean acidification and hypoxia (OAH), which challenged the oyster culture industry's ability to grow larval oysters starting in 2007. While the oyster industry has implemented solutions for successfully propagating oysters in closed tank systems, OAH events are projected to intensify and threaten our wild fisheries and rich ocean ecosystem. In response, the Legislature passed Senate Bill 1039 in 2017, creating the Oregon Coordinating Council on OAH, mandated to provide recommendations and guidance to the State on how to respond to this issue. The first biennial report from the OAH Council to the Legislature is hereby submitted, in September 2018. The Council report makes recommendations on actions to take in five Theme Areas, each action shaped to help Oregon adapt to an uncertain future of change.



THEME 1

Strengthen Ocean Acidification and Hypoxia Science, Monitoring and Research. Identify and develop information critical for Oregon to understand, adapt to, and mitigate OAH impacts.

THEME 2

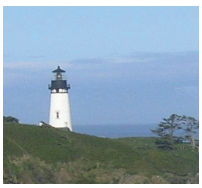
Reduce Causes of Ocean Acidification and Hypoxia. Develop a coordinated approach for CO_2 and OAH management and mitigation, and implement strategies to reduce factors that cause or exacerbate OAH.

THEME 3

Promote Ocean Acidification and Hypoxia Adaptation and Resilience to OAH. Support activities and initiatives that promote adaptation and resilience to OAH conditions, for Oregon's human communities and ecosystems.

THEME 4

Raise Awareness of Ocean Acidification and Hypoxia Science, Impacts, and Solutions. Identify and advance opportunities to raise awareness of and communicate OAH science, impacts, and mitigation solutions.

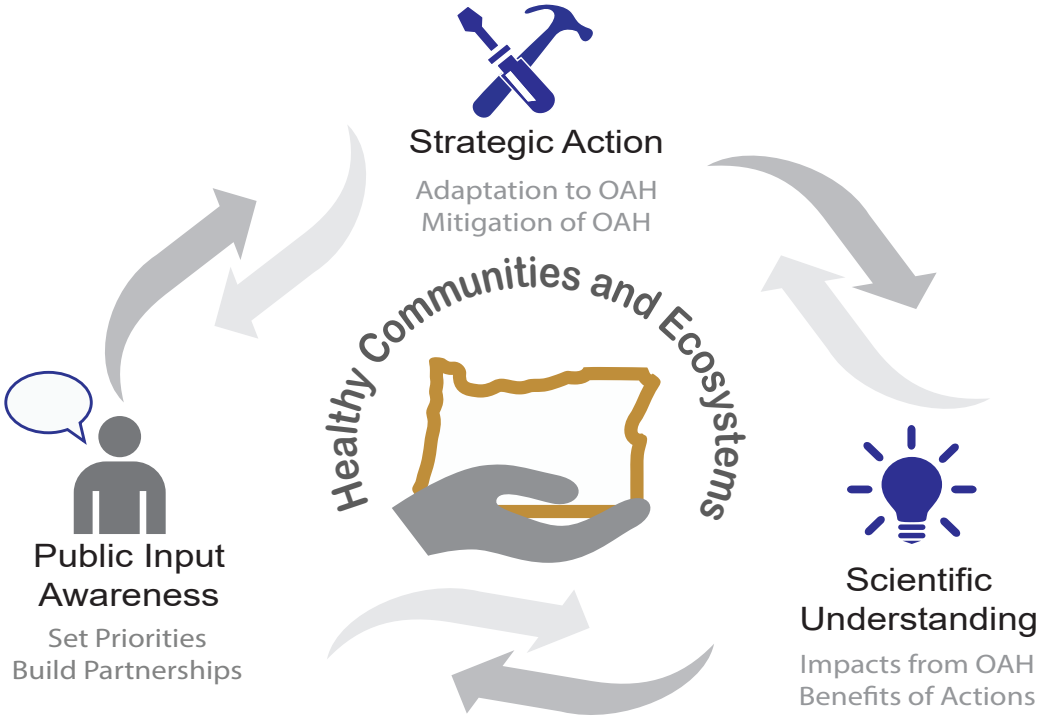


THEME 5

Commit Resources to Ocean Acidification and Hypoxia Actions. Support a sustained, long-term approach to addressing OAH including a policy declaration, funding for actions that require additional capacity, and reinforcement of Oregon's intellectual capital to meet future challenges.

Council Process

To sustain Oregon's marine-based food supply and our cultural and economic well-being, the OAH Council recommends taking strategic action to understand, adapt to, and mitigate OAH in an iterative process, including repeated public input, scientific inquiry and action planning. Oregon must act swiftly to set short-term priorities and make progress quickly in order to maximize our options and effectiveness. However, Oregon also needs a sustained, long-term approach to addressing OAH impacts and much of what the OAH Council recommends will take time to implement.



OAH Council Report (2018) and OAH Action Plan (2019)

The OAH Council met monthly from January to August 2018, with working subgroup meetings between each Council meeting from March-July. During these meetings, each Council member brought their unique perspective (see OAH Report Appendix B for Council members' biographies) and expertise to bear on Council discussions. The final report (submitted September 2018) informs and provides the basis for the development of the Oregon OAH Action Plan, targeted for completion in June 2019. The Action Plan will identify the actions that Oregon is ready to commit to and will flesh out the scope, methods, and resources needed to implement each action. In the five Theme Areas, the OAH Council developed 12 general recommendations, and 38 specific actions. All recommendations and actions were agreed upon as important by all voting members on the Council. However, a general prioritization exercise (in which Council Members anonymously rated each action from lower to higher relative value), and the summarization of results reveal the recommended actions for that merit immediate attention. The Council agreed by consensus to include all 38 actions in the 2018 report.

Actions Recommended for Immediate Attention

Through rating the relative value of each, of the 38 recommendations, the Council recommends the following 7 actions for immediate attention:

- **Support and maintain Oregon's monitoring of OAH oceanographic metrics and biological response metrics (Actions 1.1.a/c)**
- **Incorporate OAH into CO_2 management and mitigation discussions in the state (Action 2.1.b)**
- **Support new initiatives to promote natural ecosystem resilience (Actions 3.2.a/b)**
- **Keep legislators and policy-makers up-to-date on the science, impacts of and solutions for OAH (Action 4.2.a)**
- **Develop high-level policy guidance for the state's government agencies on prioritizing OAH in agency workload (Action 5.1.a)**

Council Guiding Principles

Excess CO_2 in the atmosphere and in the oceans is the core global problem to address; there are meaningful State actions that will help address excess CO_2.

It is essential to develop benefits for ecosystem and human communities alike; they are inter-dependent and are both essential to Oregon's future.

Actions should be specifically relevant to Oregon, and within Oregon's means to accomplish.

Solutions should complement existing management frameworks rather than create new ones; collaborate and align with existing groups to avoid redundancy.

Benefits of actions should be targeted to Oregon; consider and provide benefits to the region and globally, as possible.

Council recommendations are a starting point; iterative refinement and public input is needed as well as input from the Legislature and the Governor.

To learn more about the Council, opportunities to engage, or OAH in Oregon, please contact the Council Co-Chairs or the Council staff:

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Oregon Video on Ocean Acidification

OAH Council Website

oregonocean.info/index.php/ocean-acidification

Introduction

OAH Council Purpose and Need

Oregon is on the front line of changing ocean conditions. Ocean Acidification and Hypoxia (OAH) events have been commonplace in Oregon over the past 10 years, impacting Oregon's economy and marine resources in measurable ways. While Oregon is experiencing these impacts now, similar impacts are projected to affect ocean health worldwide in the decades to come. Oregon has the dubious honor of being among the first to document OAH impacts, and the first to develop a response to adapt to and mitigate these impacts.

Whiskey Creek Shellfish Hatchery, located in Netarts Bay, Oregon, was among the first to observe direct impacts from acidification starting in 2007. First thought to be a result of bacterial contamination, the hatchery larval culture was reduced by 75% or more. In response, Oregon researchers worked hand-in-hand with the oyster industry to identify the problem as stemming from summer upwelling of deep acidified ocean waters, and to develop oyster hatchery practices to mitigate water chemistry. This story and the solutions are now globally renowned (Figure 1). Yet Oregon is dependent on wild stocks and a healthy ocean ecosystem, for which there are not such easy answers.

Oregon's nearshore waters are critical to resources and the economy—and are especially vulnerable. We are observing extreme OAH events in Oregon's highly productive estuaries and nearshore waters (0-12 miles offshore). This region is home to major fisheries (e.g., crabs, clams), all of the State's mariculture operations, and contains critical nursery grounds for economically important species (rockfish, salmon, pink shrimp and Dungeness crab, among others). The dynamic and variable nearshore environment makes it a uniquely challenging area for conducting research and has typically pushed coast-wide studies further offshore (e.g. NMFS' annual trawl survey). The result is a precarious information gap for the area that is currently experiencing OAH.

Figure 1a. Larval oyster grow tanks, oyster seed.

West Coast leaders and researchers are strengthening cross-jurisdictional partnerships regionally and abroad. Universities and governments across the West Coast and British Columbia have responded to our region's acute vulnerability to OAH and research challenges by pulling together to seek proactive, solutions-oriented approaches to this issue. Initial efforts resulted in co-convening of the West Coast Ocean Acidification and Hypoxia Science Panel (including five researchers from Oregon), which produced final recommendations for natural resource managers in April 2016 (Appendix H). In brief, the Science Panel focused on making recommendations for future science and monitoring efforts that would be most informative for managers of natural resources who are determining how to manage for ocean acidification, hypoxia, and climate change. Early recommended actions included strengthening the monitoring network of oceanographic and biological observations on the West Coast, starting with an inventory. The Science Panel emphasized that early action to address OAH would be able to include more diverse (and potentially less punitive) management options, while delayed action would lead to fewer choices and more negative outcomes for human communities and ecosystems.

Monitoring and research are essential to allow us to anticipate and adapt to future increase in OAH, and must be strategically implemented. While we cannot stop increasing intensity and frequency of OAH, we can 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 well enough to anticipate and understand potential impacts, through strategic research investment. To that end, Oregon is poised for research investment in multiple ways. Oregon is home to the newest Ocean Observatory – one of an elite group of permanent long-term oceanographic and biological monitoring installations that are part of the national Ocean Observatories Initiative. This offshore buoy network collects valuable ocean data, including pH, to track changing ocean conditions. Oregon is also home to world-class marine laboratories (Hatfield Marine Science Center, Oregon Institute of Marine Biology), and a system of marine protected areas dedicated to scientific investigation and long-term monitoring. Finally, Oregon has led and completed the West Coast OAH Monitoring Inventory, which is ready to be used for identifying gaps in our monitoring so that our scarce resources can be deployed strategically.

Figure 1b. Adult Pacific Oysters in growing baskets, prepared ready to enjoy.

In 2017, the Oregon Legislature created the Oregon Coordinating Council on Ocean Acidification and Hypoxia (OAH Council) via passage of Senate Bill 1039. The Council has been meeting since January 2018, and is comprised of agencies, stakeholders, Tribes, NGOs and the Governor's office. In developing recommendations, the Legislature asked the OAH Council to address research needs, as well as adaptation and mitigation measures for the State to consider. Concurrently, the Governor has requested that the OAH Council build Oregon's OAH Action Plan as part of Oregon's commitment to the International Alliance to Combat Ocean Acidification. This report will launch the Oregon OAH Action Plan process, which will unfold over the next year and is anticipated to be completed in June 2019 (Figure 2).

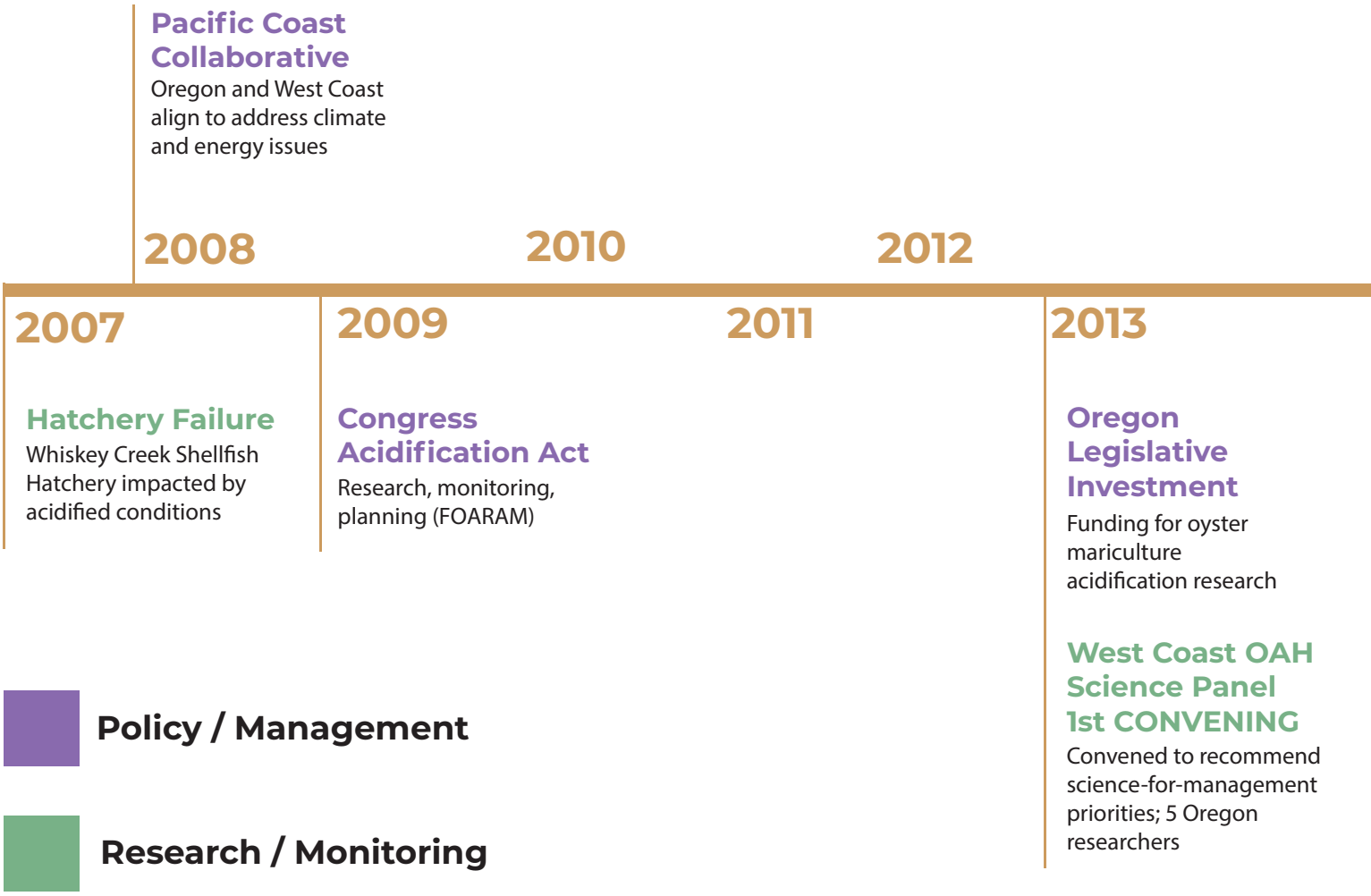

Figure 2: Oregon Ocean Acidification and Hypoxia Selected Events Timeline

2014

2015

2016

Oregon Shellfish Task Force
Recommendations on shellfish, OAH actions, and resilience

Ocean Acidification Alliance
Oregon helped launch this global organization to support OA Action Planning

Oregon OAH Monitoring Group
Formed to connect OAH monitoring professionals throughout Oregon

West Coast OAH Science Panel RECOMMENDATIONS

Regional Monitoring Inventory STARTED
Joint Federal-State Monitoring Inventory Task Force; scientists from Alaska to California

2017

Oregon OAH Council CREATED
SB 1039 passed, creating the Oregon OAH Council

Oregon OAH Action Planning
Governor Kate Brown asks the OAH Council to lead on building Oregon's OAH Action Plan

2018

Oregon OAH Council 1st BIENNIAL REPORT
1st biennial report submitted to legislature and OPAC

Tillamook Pilot Project
OWEB grant awarded to Oregon OAH Monitoring Group collaborative proposal; Tillamook Estuary Partnership lead

Regional Monitoring Inventory COMPLETED
Completed by Joint Federal-State Monitoring Inventory Task Force

2019

Oregon OAH Action Plan SUBMISSION
Plan to be submitted to Govenor for adoption

2020

OAH Council Guiding Principles and Process

The OAH Council has met monthly from January to August 2018, with working subgroup meetings between each Council meeting from March-July. During these meetings, each Council member has brought their unique perspective and expertise to bear on Council discussions. The Council has focused on three areas:

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

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

CAPACITY: Considered the various options of how the recommended action areas could be refined and ultimately implemented.

Excess CO_2 in the atmosphere and in the oceans is the core global problem to address; there are meaningful State actions that will help address excess CO_2.

It is essential to develop benefits for ecosystem and human communities alike; they are inter-dependent and are both essential to Oregon's future.

Actions should be specifically relevant to Oregon, and within Oregon's means to accomplish.

Solutions should complement existing management frameworks rather than create new ones; collaborate and align with existing groups to avoid redundancy.

Benefits of actions should be targeted to Oregon; consider and provide benefits to the region and globally, as possible.

Council recommendations are a starting point; iterative refinement and public input is needed as well as input from the Legislature and the Governor.

Throughout the course of these discussions, the Council has built set of guiding principles, which shape the scope and content of the recommendations.

Recommendations should be created through careful and thoughtful Council deliberations as a starting point for developing Oregon's OAH Action Plan.

Oregon's OAH Council deliberations and the Oregon OAH Action Plan are intended to be on-going and iterative (Figure 3). This will enable the Oregon to address both short and long-term goals over time, as well as adapt to new information, newly devised strategies and newly developed solutions. Currently, in addition to biennial reports to the Legislature and OPAC in even-numbered years (per SB 1039), the Council proposes developing Oregon OAH Action Plans every four years in odd-numbered years starting with 2019. The timing of the Action Plans (mid-year in odd-numbered years) is intended to coincide with the beginning of the budget cycle for Oregon Agencies, which will allow better integration of any new guidance or policies from the Legislature and Governor to be incorporated in agency priorities.

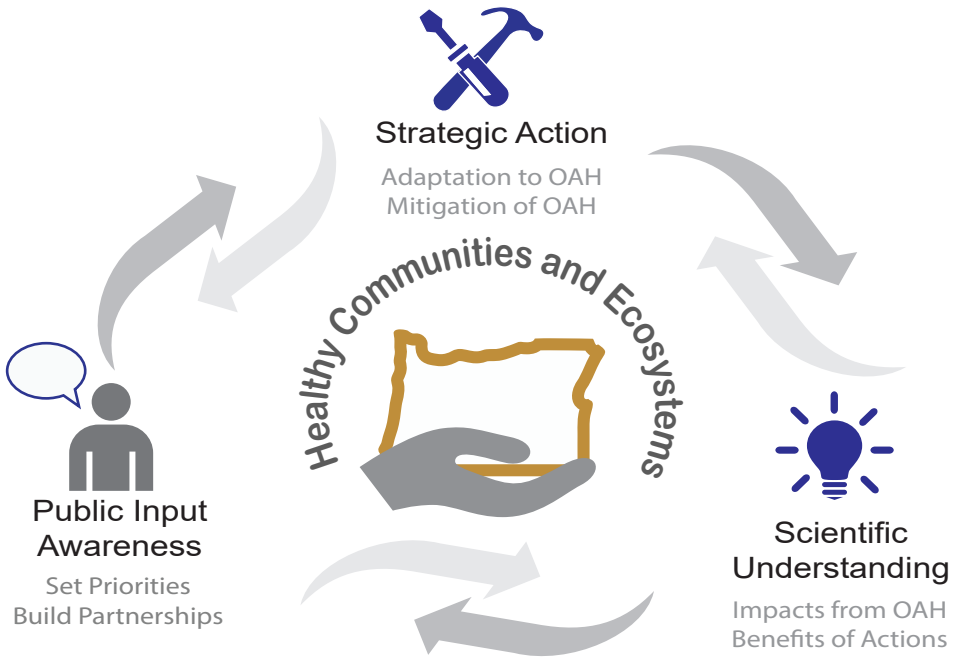

Figure 3: Council process

Based on these guiding principles and the legislative mandate (Senate Bill 1039), the OAH Council developed recommendations in five themes, as described in detail below. Potential opportunities for action were explored and identified through review of other OAH Action Plans developed by other entities (US, States, Nations), review of existing processes and activities in Oregon, and through the deliberations of OAH Council working groups, each comprised of a subset of Council members. After each working group developed a set of potential recommendations, all were integrated into a single set organized around themes, which were further refined and adopted by the Council as a whole. As described in the guiding principles above, the recommendations in this report are a starting point, from which strategic shovel-ready projects should be selected and funded, in developing Oregon's OAH Action Plan. Additional input from the Legislature, the Governor and other Oregonians will be necessary to finalize the Action Plan, intended for adoption by the Governor in 2019.

Senate Bill 1039 Quick Reference Guide

Throughout the OAH Council process in 2018, we have returned to SB 1039 for discussions and recommendations on-point to the tasks requested of the OAH Council. Below is a brief table, describing the content of the bill and how this relates to the sections of this report. Additional detail for Senate Bill 1039, Sec 3. (1) (b) (A-G) may be found in Table 2. For full bill language, see Appendix A (pages 46 - 48).

SB 1039		**OAH Council Report Section**	**Page**
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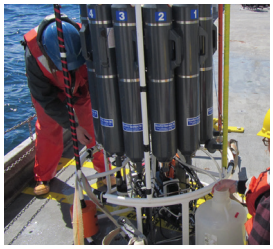
Sec 2.(1)	Council establishment and makeup	Appendix B: Council Member Biographies	49
Sec 2. (2 - 8)	Council terms of service and operating framework	Appendix D: Council Procedures	APD
Sec 3. (1) (a) (A-B)	Review and utilize relevant scientifically supported information	Letter from Dr. Francis Chan Appendix D: Council Meeting Summaries	8 APD
Sec 3. (1) (b) (A-G)	Identify actions and initiatives on Oregon OAH vulnerabilities	Recommendations: Themes 1-5 (see Table 2)	23
Sec 3. (1) (c)	Advise and assist State agencies with actions and initiatives	Recommendations: Theme 3 Appendix G: Member Agency Management Responsibilities	32 APD
Sec 3. (2) (a-c)	Develop socio-economic OAH Vulnerability Report	Recommendations: Theme 1	26
Sec 3. (3) (a-c)	Develop research recommendations to address gaps	Recommendations: Theme 1, 4, 5	26 34
Sec 3. (4)	Biennial report to the Legislative Assembly and the Ocean Policy Advisory Council	Introduction – OAH Council Process and Guiding Principles	20
Sec 3. (5)	Agencies assistance to the coordinating council	Appendix G: Member Agency Management Responsibilities	APD

APD denotes electronic appendices
For electronic copies of report appendices vist the Council's website: oregonocean.info/index.php/ocean-acidification

Recommendations

The OAH Council has developed recommendations in five thematic areas:



THEME 1

Strengthen Ocean Acidification and Hypoxia Science, Monitoring and Research. Identify and develop information critical for Oregon to understand, adapt to, and mitigate OAH impacts.

THEME 2

Reduce Causes of Ocean Acidification and Hypoxia. Develop a coordinated approach for CO_2 and OAH management and mitigation, and implement strategies to reduce factors that cause or exacerbate OAH.

THEME 3

Promote Ocean Acidification and Hypoxia Adaptation and Resilience. Support activities and initiatives that promote adaptation and resilience to OAH conditions, for Oregon's human communities and ecosystems.

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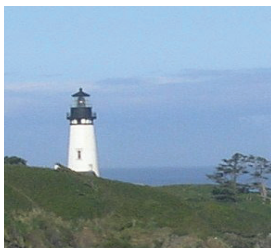
Raise Awareness of Ocean Acidification and Hypoxia Science, Impacts, and Solutions. Identify and advance opportunities to raise awareness of and communicate OAH science, impacts, and mitigation solutions.



THEME 5

Commit Resources to Ocean Acidification and Hypoxia Actions. Support a sustained, long-term approach to addressing OAH including a policy declaration, funding for actions that require additional capacity, and reinforcement of Oregon's intellectual capital to meet future challenges.

Within each theme, the OAH Council identifies high-level recommendations, each of which is further described by more specific actions. Table 2 (below) describes how each Theme relates to Section 3.1.b of Senate Bill 1039.

Table 2. Senate Bill Enrolled 1039
Section 3.1.b (A)-(G) legislative text, related to the OAH Council Themes (1)-(5).

Senate Bill 1039, Section 3.1.b (A)-(G) Actions and Initiatives		**Council Recommendation Themes**				
		1	2	3	4	5
(A)	*Develop strategies to mitigate OAH*	✓	✓			✓
(B)	*Strengthen scientific monitoring, research and analysis*	✓				✓
(C)	*Identifying habitats vulnerable to corrosive sea water*	✓				✓
(D)	*Identifying the socioeconomic and ecosystem impacts*	✓				✓
(E)	*Steps to increase public awareness of the science*		✓	✓	✓	✓
(F)	*Developing long-term coordination strategy*	✓	✓	✓	✓	✓
(G)	*Leveraging opportunities for research partnerships*		✓	✓	✓	✓

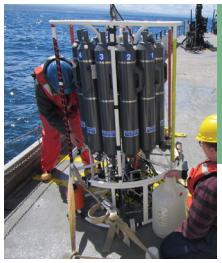
In these five Theme Areas, the OAH Council developed 12 general recommendations, and 38 specific actions. All recommendations and actions were agreed upon as important by all voting members on the Council. However, a general prioritization exercise (in which Council Members anonymously rated each action from lower to higher relative value), and the summarization of results reveal the recommended actions that merit immediate attention:

Species Important to Oregon: pink shrimp, Dungeness crab.

- **Support and maintain Oregon's monitoring of OAH oceanographic metrics and biological response metrics (Actions 1.1.a/c)**
- **Incorporate OAH into CO_2 management and mitigation discussions in the state (Action 2.1.b)**
- **Support new initiatives to promote natural ecosystem resilience (Actions 3.2.a/b)**
- **Keep legislators and policy-makers up-to-date on the science, impacts of and solutions for OAH (Action 4.2.a)**
- **Develop high-level policy guidance for the state's government agencies on prioritizing OAH in agency workload (Action 5.1.a)**

Each of these priority actions is designated with an asterisk * in the full description below.

Species Important to Oregon: littleneck clams, rock kelp.



Theme 1

Strengthening Ocean Acidification and Hypoxia Science, Monitoring, and Research

Identify and develop information critical for Oregon to understand, adapt to and mitigate OAH impacts.

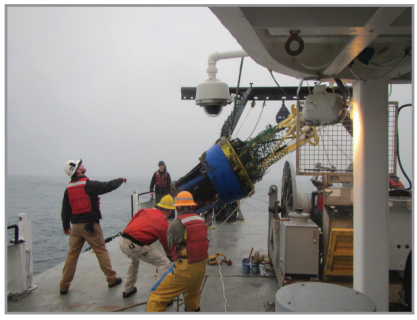
Recommendation 1.1

Expand and maintain a robust long term monitoring network that captures OAH oceanographic trends (e.g., pH, pCO_2 and/or alkalinity, oxygen, temperature, salinity, nutrients) and biological responses to OAH (e.g., productivity, abundance, distribution), through collaborative efforts in the State and West Coast region. (**see bill Sec 3.1.a; Sec 3.1.b.B/G; Sec 3.3.a-c**)

Action 1.1.a *

Maintain and support oceanographic and biological monitoring at significant research reference sites that provide high value to Oregon due either to prior State investments, the geographic location and/or historical data collection activities at that site.

i. Build long-term OAH monitoring into Oregon's Marine Reserves, to provide biological-oceanographic coupled observations, and to maximize the State's investment in the Marine Reserves system.



ii. Reinstate an oceanographic monitoring station for Yaquina Bay (Oregon's third largest estuary system for Pacific oyster production) collaboratively with shellfish industry, academic institutions and State agencies; build on dataset from historical instrumentation project run by the USEPA.

iii. Support continued funding of the Newport Hydrographic Line (currently funded by NOAA) and of the South Slough National Estuarine Research Reserve moorings, to ensure continuance of these long-term data sets that document coupled observations of oceanographic and biological response metrics.

Action 1.1.b Evaluate Oregon's OAH oceanographic monitoring network to identify priorities for strategic augmentation; evaluation to include (but not be limited to):

i. Regularly assess and update the West Coast OAH Monitoring Inventory so that it continues to be a valuable resource for future management activities.

ii Evaluate the West Coast OAH Monitoring Inventory (2018) to identify gaps in monitoring coverage (e.g., oceanographic model evaluation, gaps analysis).

iii Improve oceanographic modeling outputs by working with modelers (e.g., Live Ocean project) to validate models and further develop longer-term annual, multi-year, and decadal scale West Coast OAH projections.

Action 1.1.c *

Expand and implement monitoring to track the biological responses to OAH, to inform State natural resource decisions and management activities. Priorities for biological monitoring include (but are not limited to):

i Organisms that commercially, recreationally and culturally meaningful to Oregonians and ecologically important to Oregon ecosystems. (**see Recommendation 1.2.a**)

ii Organisms prioritized by researchers as scientifically valuable for providing biological indices for Oregon's coastal ecosystems.

iii Organisms that can be collected by a wide range of practitioners (e.g., managers, academics, fishers, fisheries observers, citizen scientists, State agencies, Federal agencies) and data in formats that can be made accessible to the public.

iv Organisms targeted by long-term monitoring programs, including but not limited to Oregon's Marine Reserves monitoring programs and the Newport Hydrographic Line. (**see Action 1.1.a.iii**)

Action 1.1.d Design and implement vessel-based OAH monitoring data collection programs in Oregon to strengthen spatio-temporal mapping and modeling of OAH.

i Design a program for vessel-based monitoring of oceanographic metrics; include development of instrumentation packages, with considerations including resolution scale, accuracy, and ease of use by potential participants (e.g., fishing industry members, research vessels, citizen scientists, recreational users).

ii Implement the program for vessel-based monitoring of oceanographic metrics; implementation considerations to include instrument purchase, calibration, and maintenance; data management (e.g., processing/QAQC/storage); and data accessibility to the public. Consider implementation on other "Platforms of Opportunity".

Recommendation 1.2

Develop an OAH assessment and research plan for Oregon, to be implemented in collaboration with partners, that includes characterizing OAH vulnerabilities and adaptation/resilience strategies for Oregon ecosystem and socio-economic assets. (**see bill Sec 3.1.a and Sec 3.1.b.A/B/G; Sec 3.1.b.D, Sec 3.2.a-c**)

Action 1.2.a Develop and conduct an ecosystem vulnerability assessment to identify species vulnerable to OAH from among Oregon's commercially, recreationally, culturally, and ecologically important species. From this, identify research priorities for building adaptation and resilience strategies for species and species groups including (but not limited to):

i. Fisheries species such as clams, Dungeness crab, pink shrimp, halibut, rockfish, and urchins.

ii. Cultured species such as Pacific oysters.

iii. Ecologically significant species such as mussels, abalone, native oysters, kelps, and seagrasses.

iv. Public health concern species such as those causing Harmful Algal Blooms (HABs).

Action 1.2.b Design and conduct a socio-economic vulnerability assessment for Oregon to identify communities and industries vulnerable to OAH, and to identify research priorities for building adaptation and resilience strategies for those vulnerable communities and industries including (but not limited to):

i. Shellfish industry (e.g., hatcheries, equipment suppliers, farmers).

ii. Seafood industry (e.g., processers, marketers, consumers).

iii. Coastal tourism industry, reliant on marine-related activities (e.g., clamming, fishing, crabbing, animal/scenic viewing).

iv. Coastal communities reliant on activities vulnerable to OAH impacts.

Action 1.2.c Support research needed to build effective adaptation, resilience and mitigation strategies addressing ecosystem and socio-economic vulnerabilities. (**as identified in Action 1.2.a and 1.2.b above; communicate these research goals as described in Action 4.2.d**)

i. Support research priorities for Oregon's oyster industry, including projects such as seed development by the Molluscan Broodstock Program (MBP) at Oregon State University.

ii. Evaluate whether Oregon's Marine Reserves serve as an adaptation and resilience strategy, considering their long-term monitoring of ecosystem trends, OAH hotspots and refugia.

Action 1.2.d Establish research priorities to determine the benefits of conserving and restoring native species and vegetation in building ecosystem and socio-economic resilience. (**see Recommendation 3.1 and 3.2**)

i Determine adaptation, resilience and mitigation benefits of Submerged Aquatic Vegetation (SAV) protection and restoration for Oregon's coastal ecosystems and human communities; include SAV potential to provide short-term buffering of acidified waters, long-term sequestration of carbon, and general ecosystem services that promote resilience. As appropriate, use results to incorporate protection/restoration of SAVs into existing and new management frameworks.

ii Determine adaptation, resilience and mitigation benefits of native oyster protection and restoration; include native oyster potential to promote short-term OAH buffering through estuary shell bed restoration, food web stabilization due to native oyster tolerance to OAH conditions, long-term carbon dioxide removal through shell carbon burial, or other ecosystem resilience benefits.

Recommendation 1.3

Establish research priorities to inform decision-making on mitigation alternatives for excess CO_2 in marine waters (e.g., removal of excess CO_2 from marine waters through engineering or sequestration solutions) and OAH mitigation strategies (e.g., reduce pollutants that exacerbate OAH and biological impacts of OAH), to address the OAH vulnerability impacts to Oregon's ecosystem and human communities.
(**see bill Sec 3.1.b.F**)

Action 1.3.a Establish research, monitoring and analysis priorities to identify types and sources of water pollutants that amplify or exacerbate OAH, characterize their relative contributions in coastal watersheds and marine and estuarine waters, and inform development of strategies to facilitate reductions (i.e., mitigate pollutants that exacerbate OAH; **see Recommendation 2.3**).

i Support efforts to characterize local pollution sources (e.g., sea and land wastewater discharges, runoff from urban and rural lands, natural sources), and determine impacts on water quality in estuaries and marine waters, by conducting studies and developing Total Maximum Daily Loads (TMDLs), as needed, to inform and guide local and state efforts to protect and restore water quality.

ii Produce periodic summary reports for coastal watersheds to provide information on locations and magnitudes of water pollutants that are likely to exacerbate OAH in estuaries and nearshore. Identify data gaps and other issues/needs that warrant further attention in order to understand and effectively mitigate significant sources of OAH exacerbating pollutants.

Action 1.3.b Establish research priorities to identify effective measures to remove excess CO_2 from marine waters through technological means, sequestration, or bioremediation (e.g., culture and harvest kelp, thus removing CO_2 from local waters).

Theme 2

Reduce Causes of Ocean Acidification and Hypoxia

Develop a coordinated approach for CO_2 and OAH management and mitigation, and implement strategies to reduce factors that cause or exacerbate OAH.

Recommendation 2.1

Develop and implement aligned strategies between CO_2 and OAH management and mitigation efforts, to create a comprehensive and non-redundant approach to reduce excess CO_2 and OAH. (**see bill Sec 3.1.b.F**)

Action 2.1.a Strengthen communication and coordination on CO_2 and OAH management and mitigation among the OAH Council, State agencies, and other government entities (e.g., Oregon Global Warming Commission).

Action 2.1.b * Promote integration of OAH management and mitigation into Oregon's CO_2 management and mitigation discussions and decision-making.

Action 2.1.c Strengthen communication, coordination, and collaboration between State and Federal programs, and within the West Coast region, to improve management and mitigation outcomes in Oregon.

Recommendation 2.2

Reduce water pollutants that amplify or exacerbate OAH impacts (**as identified in Action 1.3.c**), to make permanent improvements in water quality. (**see bill Sec 3.1.b.F**)

Action 2.2.a Evaluate existing voluntary and regulatory water quality protection programs in Oregon, and subsequently implement recommendations to address gaps in resources and/or authorities that may prevent the state from effectively addressing sources of water pollution that exacerbate OAH conditions.

Action 2.2.b Ensure that existing regulations are achieving the expected water quality outcomes.

i. Evaluate compliance with existing water quality regulations; provide state agencies adequate resources to implement rigorous compliance programs, where gaps are identified to exist.

ii. Enforce compliance, as necessary, and continually evaluate effectiveness and adapt programs and regulations as needed. This includes, but is not limited to, regulatory programs addressing waste water discharge, runoff from urban, agricultural and forested lands, and septic systems.

Action 2.2.c Promote voluntary actions to protect and restore coastal and marine water quality by leveraging national and regional programs, existing networks and funding sources.

i. Promote and incentivize local voluntary actions with State outreach and extension programs to focus on local and individual decisions that make a difference.

ii. Incentivize septic system evaluation to identify and address failing systems to reduce potential water pollution.

Theme 3

Promote Ocean Acidification and Hypoxia Adaptation and Resilience

Support activities and initiatives that promote adaptation and resilience to increasing OAH conditions for Oregon's human communities and marine ecosystems.

Recommendation 3.1

Incorporate OAH adaptation and resilience strategies (**developed in Action 1.2.d**) into existing planning and decision-making frameworks to strengthen Oregon's marine ecosystems and human communities. (**see bill Sec 3.3.c**)

Action 3.1.a Conduct an inventory of Oregon State agency programs and authorities that are relevant to OAH; identify opportunities to incorporate OAH adaptation and resilience strategies into current and future management actions, including implementation of Statewide Planning Goals. (**as referenced in Action 1.2.c**)

Action 3.1.b Anticipate specific management and regulatory decision-making processes, into which OAH adaptation and resilience strategies can be incorporated.

i Work with OPAC and OPAC's STAC in the 2019 revision process for Oregon's Rocky Shores Strategy, Part 3 of Oregon's Territorial Sea Plan; ensure that OAH adaptation and resilience strategies are incorporated into long-term planning outcomes for Oregon's Rocky Shores management.

ii Work with the Oregon Legislature, ODFW, and STAC in the 2023 review process of the Marine Reserves Program; ensure that OAH adaptation and resilience strategies and OAH hotspot/refugia considerations are incorporated into long-term planning for Oregon's system of Marine Reserves.

Recommendation 3.2

Support new OAH resilience initiatives (**as developed in Recommendation 1.2, and Action 1.2.d**) to sustain Oregon's habitats, species, and human communities. (**see bill Sec 3.1.b**)

Action 3.2.a Promote SAV conservation and restoration strategies and opportunities to achieve short-term buffering, carbon sequestration and ecosystem services benefits.

*

Action 3.2.b Promote native ecosystem resilience in management decisions.

*

i Preserve current and establish new native oyster beds to promote ecosystem resilience and withstand OAH impacts.

ii Preserve, restore and establish other native species, including top predators, for their ability to promote ecosystem resilience and withstand OAH impacts.

Theme 4

Raise Awareness of Ocean Acidification and Hypoxia Science, Impacts, and Solutions

Identify and advance opportunities to raise awareness of and communicate OAH science, impacts, and mitigation solutions.

Recommendation 4.1

Develop and implement foundational communications and awareness strategies on OAH science, impacts, and solutions (e.g., 10-year plans), working collaboratively with partners. (**see bill Sec 3.1.b.F**)

Action 4.1.a Formulate an Oregon OAH Communications Needs Assessment based on what information is already known and what information is needed or desired by Oregonians.

i. Develop and implement informal surveys – use "comment books" as a "free thought" exercise for the public to write questions or concerns.

ii. Develop and implement formal surveys conducted throughout Oregon.

Action 4.1.b Build solutions-oriented messages on OAH science, impacts and solutions. Messages should include: simple language, positive tone, local connections, and actions for individuals and governments.

i. Connect OAH with other climate issues by collaborating with other commissions and working groups, including the Oregon Global Warming Commission.

ii. Connect education and outreach actions with audience values, including economy, personal time, and outdoor recreation.

iii. Highlight OAH economic impacts at local and regional levels, in OAH outreach documentation and materials. (**see Action 1.2.b**)

iv. Use successful environmental messaging (e.g., protecting the ozone, reducing acid rain) as models to develop OAH messaging.

Action 4.1.c Create an information resource and outreach catalog for the OAH Council and others that highlights OAH science, impacts and solutions using the positive messages strategy. (**see Action 4.1.b**)

i Develop or leverage digital resources (e.g., a web portal) for outreach materials (e.g., one-page briefs, curricula, media library/catalogs), and a centralized repository of hands-on collections of materials and demonstrations.

ii Prepare standardized PowerPoint slides and one page briefs for use by state agencies and the OAH Council.

Action 4.1.d Build and implement evaluation methods and tools, to determine how to improve and refine the communications strategies described in **Actions 4.1.a-4.1.d**. Use evaluation results to iteratively modify future communications strategies.

Recommendation 4.2

Develop audience-specific materials and strategies on OAH science, impacts and solutions to increase awareness and understanding in key audiences; build on strategies developed per **Recommendation 4.1**. (**see bill Sec 3.1.b.E**)

Action 4.2.a Policy makers and legislative staff: Inform decision-makers on the science, impacts and solutions, to help them shape strategic policy decisions.

*

i Keep legislators informed about OAH science, impacts, and solutions. Include information on adaptation and mitigation strategies, as well as research needs, that are customized to Oregon.

ii Provide field trip opportunities for legislative staff to visit science laboratories and industry sites (e.g., fishing boats, shellfish farms).

iii Provide "science in Salem" opportunities, during which hands-on information is provided to the legislative offices of state agencies and other state government offices.

iv Encourage funding State agency and government entity positions (at every level) that have a dedicated focus on oceans, including focus on local OAH impacts and implementation of solutions.

Action 4.2.b At-risk industries and professions: Communicate with industries affected by OAH to strengthen cultural values of healthy and sustainable seafood and seafood industry and build relationships to strengthen collaborative solutions development.

i. Convene specialists and/or industry representatives across industries and regions using round tables and workshops (include a diversity of participants including fishermen, seafood processers, shellfish producers, retail food industry practitioners.

ii. Attend and leverage existing industry association meetings and conferences and share information about OAH science, impacts and solutions at these forums.

Action 4.2.c K-12 school educators and students: "Next generation" engagement with local-based school curriculum development in alignment with curriculum standards.

i. Encourage the state legislature to continue funding of OAH STEM curriculum and supplies in public schools and out-of-school education programs.

ii. Work with the Department of Education to incorporate OAH science into Oregon State education standards at elementary, middle, and/or high school education levels (e.g., Next Generation Science Standards (NGSS), common core).

iii. Promote long-term teacher training strategies on OAH issues.

iv. Help teachers develop, adapt, and/or implement curricula on OAH and associated climate issues for primary, secondary, and higher education.

Action 4.2.d Academics and researchers: Communicate research needs to build OAH solutions, as identified by the OAH Council and the OAH Action Plan (**see Recommendation 5.3**).

i. Develop new, or leverage existing, seminar series by academic and management presenters for both community members and academics audiences.

ii. Attend national conferences and workshops and provide informational materials with a unified message and information on Oregon OAH research priorities.

iii. Communicate OAH research priorities to other State entities engaged in marine research (e.g., OOST, Sea Grant, academics).

iv. Communicate OAH research priorities to Federal partners (including but not limited to Federal agencies).

Action 4.2.e Media: Encourage media to accurately report on OAH science impacts and solutions by providing informational materials with clear take home messages.

i Develop visuals and clear messages for media to use that are available on an easily accessible repository.

ii Implement an OAH media-specific strategy, with clear timeframes and measured messaging outcomes with positive messages.

Action 4.2.f Local governments: Promote "best practices" and decision-making to reduce OAH impacts and stresses, including reducing water pollutants that exacerbate OAH (**as referenced in Action 2.3.c**).

i Support local government development of OAH impacts information needs assessments, to identify local interests and concerns about OAH impacts and solutions.

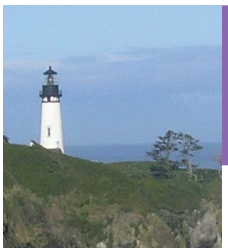
ii Develop workshops to be delivered by local governments in explaining to the community members why certain actions will be taken.

Action 4.2.g Informal education venues: Bring outreach on OAH science, impacts, and solutions to statewide outreach venues and engage the general public.

i Partner with informal venues (e.g., Hatfield Marine Science Center Visitor Center, Charleston Marine Life Center, Oregon Museum of Science and Industry, Creative Minds Learning Centers) and regular public/community events (e.g., OSU marine science days, Oregon Coast Aquarium's Our Oceans Day, State Fair, State of the Coast) to showcase exhibits on OAH.

ii Work with industry to provide informal experiential opportunities for general public to understand seafood industry and OAH vulnerability.

iii Write general interest articles on OAH science, impacts and solutions.



Theme 5

Commit Resources to Ocean Acidification and Hypoxia Actions

Support a sustained, long-term approach to addressing OAH, including a policy declaration, funding for actions that require additional capacity, and reinforcement of Oregon's intellectual capital to meet future challenges.

Recommendation 5.1

Develop State policy and maintain policy expertise for addressing OAH science, adaptation, and mitigation priorities at the highest levels. (**see bill Sec 3.1.a**)

Action 5.1.a *

Develop and implement policy, directing agencies to address OAH priorities in agency planning.

Action 5.1.b

Prioritize staffing in the Governor's Natural Resources Office to include expertise to provide leadership on ocean science and policy, to help guide and address OAH action priorities.

Recommendation 5.2

Develop and diversify the portfolio of funding sources for implementing Oregon's OAH science, adaptation, and mitigation priorities. (**see bill Sec 3.1.a**)

Action 5.2.a

Continue and expand State support for science funding entities in Oregon that provide grant funds to OAH science and response (e.g., Oregon Watershed Enhancement Board (OWEB), Oregon Ocean Science Trust (OOST)).

Action 5.2.b

Ensure the Oregon Ocean Science Trust (OOST) has the institutional structure needed to receive and redistribute funds to support the State's OAH priorities.

Action 5.2.c Facilitate the acquisition of funding from a diversity of sources to address the State's OAH priorities.

i. Create an OAH funding resources catalog to facilitate entities pursuing grant funding to support Oregon's OAH priorities.

ii. Identify and make use of opportunities to direct non-traditional State revenues towards Oregon's OAH priorities (e.g., fines, restitution, settlement agreements).

iii. Consider applying mitigation revenue streams to OAH adaptation and resilience investments.

iv. Support federal funding of Oregon Sea Grant, NOAA's Ocean Acidification Program, NOAA's Coastal Hypoxia Research Program, and other federal programs that invest in OAH science, impacts, and solutions in Oregon.

Recommendation 5.3

Strengthen Oregon's OAH intellectual capacity and support the integration of OAH research priorities into academic planning. (**see bill Sec 3.1.b.A/B/E, Sec 3.3.a-c**)

Action 5.3.a Maintain Oregon's leadership role on OAH science by supporting prioritization of OAH research, education and outreach by Oregon universities.

i. Facilitate and support the role Oregon universities play in providing OAH instrumentation expertise and trainings for scientists, managers, stakeholders and others.

ii. Support the development of an OAH center of excellence within an Oregon university, which can provide leadership on academic planning of OAH science for the State.

Action 5.3.b Strengthen young professional academic training programs that can fulfill OAH research, monitoring and analysis needs for Oregon's OAH priorities, as well as train tomorrow's scientific leaders.

i. Establish an Oregon OAH fellowship program (postdoctoral fellows and graduate student fellows), collaboratively administered and directed by OOST and the OAH Council (through the OSU and ODFW Co-Chairs), to address OAH priorities.

OAH Council Next Steps

This report, created over the first eight months of the OAH Council's existence, is our first submission to the Oregon Legislature. It includes a wide-range of recommendations that build upon the work already completed or being done in Oregon and the region; it includes actions that range from fairly simple short-term steps to actions that will take partnerships and multiple years to implement.

As the Council continues to deliberate and receive feedback on this report, the recommendations outlined herein will be further refined and prioritized. While our second report to the legislature will not be until September 2020 (and in every even year after that), we will be using this Council report as the starting point for building and finalizing Oregon's OAH Action Plan in 2019, which will include a public process and prioritized actions. The Council will be involved in developing the draft OAH Action Plan, designing and conducting the public process, and will recommend a final draft to the Governor for adoption. Details and exact timeline of that process are currently in development.

Oregon's ***OAH Action Plan***, as requested by Governor Brown, will also become Oregon's submission to the International Alliance to Combat Ocean Acidification, and thus will be shared with the region and world as an example of how Oregon is demonstrating leadership on addressing OAH impacts. It will serve as a model for others to apply to their own geographical and political context, and will help demonstrate that local actions are meaningful in fighting the global challenges of climate and ocean changes.

These first two steps – the first OAH Council Report to the Legislature and the first Oregon OAH Action Plan – herald the beginning of what needs to be a long-term, sustained approach to addressing OAH in Oregon. For the benefit of our human communities and the marine ecosystem on which they rely, Oregon's approach moving forward needs to continue to adapt

Oregonians harvesting marine resources: pink shrimp boat, clamming along shore.

to new science, successful strategies, and to the changes we know are coming. ***Investments will be needed including additional resources to agencies (e.g., staffing, funding), and collaborators (including researchers, fishermen, NGOs, and others) to implement Oregon's OAH Action Plan.*** Many of these resources have been described in Theme 5 of this report.

There are steps that Oregon is already taking to address OAH impacts. The OAH Council itself will continue to serve as a public convening entity to provide opportunity for discourse, provide information and to facilitate alignment and collaboration in the State on OAH and climate issues. The Council intends for the recommendations to inform decisions and management activities, as opportunities and capacity are available, for all who are ready to take action to address OAH impacts. The Council has taken a thoughtful and collaborative, science-based approach to developing these recommendations and encourages participation by all in the implementation of these ideas. We have much to do, with little time, and the risks are great. ***Inaction is not an option but together we can better prepare Oregon for the changes ahead.***

To learn more about the Council, opportunities to engage, or OAH in Oregon, please contact the Council Co-Chairs or the Council staff:

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oregonocean.info/index.php/ocean-acidification

Oregonians harvesting marine resources: crab pots, oyster farm.

Additional Information

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Oregon Department of Fish and Wildlife
Oregon Department of Transportation
Oregon Department of Parks and Recreation
Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO)
Oregon Sea Grant
Oregon Marine Reserves

Acronyms

CO_2 – Carbon Dioxide
DEQ – Oregon Department of Environmental Quality
FOARAM – Federal Ocean Acidification Research and Monitoring Act of 2009
HAB – Harmful Algal Bloom
IWG-OA – Interagency Working Group on Ocean Acidification
MBP – Molluscan Broodstock Program
NGSS – Next Generation Science Standards
NMFS – National Marine Fisheries Service
NOAA – National Oceanographic and Atmospheric Administration
OA – Ocean Acidification
OAH – Ocean Acidification and Hypoxia
ODFW – Oregon Department of Fish and Wildlife
OOST – Oregon Ocean Science Trust
OPAC – Oregon Ocean Policy Advisory Council
OSU – Oregon State University
OWEB – Oregon Watershed Enhancement Board
pCO_2 – partial pressure of carbon dioxide
pH – Power of Hydrogen (measure of acidity)
QAQC – quality assurance, quality control
SAV – Submerged Aquatic Vegetation
STAC – Science and Technology Advisory Council, advisory to OPAC
STEM – Science, Technology, Engineering, Math
TMDL – Total Maximum Daily Loads
USEPA – United States Environmental Protection Agency
WCOAHSP – West Coast Ocean Acidification and Hypoxia Science Panel

Definitions

as referenced in this report

Abundance: The number of individuals per species or defined area.

Adaptation: Adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities related to OAH or OAH stressors.

Alkalinity: The capability of water to neutralize acid, as an expression of buffering capacity.

Biological Impact: The resulting changes in ecosystems, habitats, communities, and species or as a direct or indirect result of OAH or OAH stressors.

Biological Index: Synthesis of diverse biological information which numerically depicts associations between human influence and biological attributes. It is composed of several biological metrics.

Biological Metric: A measure of the biological activity or of a species that is used in monitoring to document biological responces to OAH.

Buffering: The ocean's ability to maintain a stable pH as acids or bases are introduced.

Distribution: Spatial and temporal arrangement of species or populations

Ecosystem Service: The direct and indirect contributions ecosystems provide to human well-being.

Harmful Algal Bloom (HAB): Occurs when certain types of microscopic algae grow quickly in water, and form biotoxins which can accumulate in seafood and harm seafood consumers.

Marine Resource: The physical aspect of species and habitats, which can provide a benefit to humans.

Mitigation: Efforts to reduce the amount and rate of current and future OAH impacts or OAH stressors.

Next Generation Science Standards: A multi-state effort to create new education standards that are rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education.

Nutrient Load: The quantity of nutrients entering an ecosystem in a given period of time.

Oceanographic Monitoring: The use of tools, such as satellites, thermometers, vessel-based instrumentation, and tide gauges to collect bio-physical-chemical data on the oceans.

Oregon's Territorial Sea Plan: A detailed plan describing state and federal agency management and stakeholder uses within the state's territorial sea (from shore to three nautical miles offshore). https://www.oregon.gov/LCD/OCMP/Pages/Ocean_TSP.aspx

Productivity: The synthesis of organic compounds from atmospheric or aqueous carbon dioxide. It principally occurs through photosynthesis, but it also occurs through chemosynthesis.

Resilience: The capacity of hman and ecosystem communities to prevent, withstand, respond to, and recover from a disruption caused directly or indirectly from OAH or OAH stressors.

Submerged Aquatic Vegetation (SAV): Plants such as eelgrass, seagrass, kelp, seaweeds, which inhabit brackish to open ocean waters.

Water Pollutant: The contaminants (CO_2 from fossil fuel combustion, sewage, road runoff, processing waste) introduced into the natural environment that directly or indirectly amplify the intensity or rate of OAH or OAH impacts.

Water Quality: The chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose.

Appendix A:
Senate Bill 1039 Full Text

Sponsored by Senators ROBLAN, KRUSE
79th OREGON LEGISLATIVE ASSEMBLY AN ACT

Relating to ocean chemistry.

Whereas Oregon is an epicenter for the global manifestation of ocean acidification and hypoxia; and

Whereas the natural seasonal process of upwelling transports corrosive waters into the nearshore and estuaries, causing marine waters within this state's jurisdiction to be especially vulnerable to ocean acidification; and

Whereas ocean acidification, hypoxia and changes in ocean temperature are intensifying; and

Whereas Oregon has rich and vibrant wild marine fisheries, including shellfish fisheries; and

Whereas ocean acidification and hypoxia are known to cause mortality and reduced growth and productivity in marine organisms, including in species that form the foundation of the marine food web; and

Whereas negative impacts from ocean acidification, hypoxia or both have already been observed in species that are commercially, culturally and economically important to this state, including oysters, mussels and crabs; and

Whereas Oregon's coastal communities and economies are important to this state and are dependent on a thriving marine ecosystem; and

Whereas Oregon has academic institutions with world-class expertise in ocean issues, including ocean acidification and hypoxia; and

Whereas Oregon has played a leading role in fostering collaborative ocean acidification and hypoxia monitoring, research and action; and

Whereas the partnerships between the shellfish industry and university scientists in this state are an example to the nation for building innovative solutions to address ocean acidification and hypoxia; and

Whereas an Oregon Ocean Acidification and Hypoxia Center of Excellence is explicitly identified in the Oregon State University Marine Studies Initiative Strategic Plan as a possible center of excellence to be housed in the Marine Studies Initiative to leverage and build upon existing state contributions to ocean acidification and hypoxia research; and

Whereas the Ocean Policy Advisory Council and the Oregon Ocean Science Trust have identified ocean acidification as a priority issue for Oregon; and

Whereas the West Coast Ocean Acidification and Hypoxia Science Panel, comprised of eminent scientists from Oregon and other west coast jurisdictions, working in collaboration with ocean management counterparts in Oregon, Washington, California and British Columbia, recently issued recommendations and associated specific actions that can be implemented immediately to respond to ocean acidification and hypoxia; now, therefore,

Be It Enacted by the People of the State of Oregon:

SECTION 1.

The Legislative Assembly finds and declares that ocean acidification and hypoxia severely endanger the state's commercially and culturally significant ocean resources. The Legislative Assembly therefore declares it to be the policy of the state to ensure a coordinated, effective response to ocean acidification and hypoxia. To facilitate efforts that are coordinated and effective, it is the state's policy to support ocean acidification and hypoxia actions and initiatives that are developed through close collaborations between federal, state and local agencies, academic institutions and commercial industries, among others.

SECTION 2.

(1) The Oregon Coordinating Council on Ocean Acidification and Hypoxia is established, consisting of 13 members as follows:

(a) The Governor or the Governor's designee;

(b) The director of an initiative for integrative marine studies at Oregon State University or the director's designee;

(c) The State Fish and Wildlife Director or the director's designee;
(d) The Director of Agriculture or the director's designee;
(e) The Director of the Department of Environmental Quality or the director's designee;
(f) The Director of the Department of Land Conservation and Development or the director's designee; and
(g) Seven members appointed in consultation with the Governor's office as follows:

(A) One member representing the Oregon Ocean Science Trust, appointed by the executive director of the Oregon Ocean Science Trust;
(B) One member representing the Sea Grant College of Oregon State University, appointed by the director of the Sea Grant College;
(C) One member representing a conservation organization, appointed by the Ocean Policy Advisory Council;
(D) One member representing fishing interests, appointed by the State Fish and Wildlife Commission;
(E) One member representing the shellfish mariculture industry, appointed by the State Board of Agriculture;
(F) One member representing the academic research community with relevant expertise, appointed by the scientific and technical advisory committee to the Ocean Policy Advisory Council; and
(G) One member representing the interests of federally recognized Oregon Indian tribes, appointed by the State Fish and Wildlife Commission in consultation with the Commission on Indian Services.

(2) (a) The term of office of each member of the coordinating council appointed under subsection (1)(g) of this section is four years, but a member serves at the pleasure of the appointing authority. The terms must be staggered so that no more than two terms end each year.
(b) Before the expiration of the term of a member, the appointing authority, in consultation with the Governor, shall appoint a successor to take office upon the date of that expiration. A member is eligible for reappointment. If there is a vacancy for any cause, the appointing authority, in consultation with the Governor, shall make an appointment to become immediately effective for the unexpired term.

(3) The State Fish and Wildlife Director or the director's designee and the director of an initiative for integrative marine studies at Oregon State University or the director's designee shall serve as cochairpersons of the coordinating council.

(4) A majority of the members of the coordinating council constitutes a quorum for the transaction of business.

(5) The coordinating council shall meet at times and places specified by the call of the chairpersons or of a majority of the members of the coordinating council.

(6) The coordinating council may adopt rules as necessary for the operation of the coordinating council.

(7) The members of the coordinating council are not entitled to compensation but are entitled to expenses as provided in ORS 292.495. Claims for expenses incurred in performing functions of the coordinating council shall be paid out of funds appropriated to the State Department of Fish and Wildlife for purposes of the coordinating council.

(8) The State Department of Fish and Wildlife shall provide staff support to the coordinating council.

SECTION 3.

(1) The Oregon Coordinating Council on Ocean Acidification and Hypoxia shall:
(a) Review and utilize relevant, scientifically supported information, including the recommendations of the West Coast Ocean Acidification and Hypoxia Science Panel and other available information, reports and studies, to:
(A) Identify research and monitoring activities necessary to better understand the changing ocean chemistry and the potential impacts of ocean acidification and hypoxia; and
(B) Recommend prioritized state actions to address ocean acidification and hypoxia;
(b) Identify actions and initiatives to address Oregon's vulnerabilities to ocean acidification and hypoxia that may include, but need not be limited to:

(A) Developing optimal strategies for mitigating the effects of ocean acidification and hypoxia;
(B) Taking steps to strengthen existing scientific monitoring, research and analysis regarding the effects and trends in ocean acidification and hypoxia;
(C) Identifying habitats that are particularly vulnerable to corrosive sea water, including areas experiencing multiple stressors such as hypoxia, sedimentation and harmful algae blooms;
(D) Identifying the socioeconomic and ecosystem impacts of intensifying ocean acidification;
(E) Taking steps to increase public awareness of the science and impacts of ocean acidification and hypoxia;
(F) Developing a long-term ocean acidification and hypoxia coordination strategy among state agencies, academia, the federal government and industry; or
(G) Leveraging opportunities for research partnerships with academia, tribes and the commercial fishing industry, in order to advance the understanding of ocean acidification and hypoxia in Oregon; and

(c) Advise and assist the State Department of Fish and Wildlife and all other represented public agencies in coordinating and carrying out, as directed by the agencies' governing bodies, the actions and initiatives identified under paragraph (b) of this subsection.

(2) The coordinating council may develop a Socioeconomic Vulnerability to Ocean Acidification Report. A report developed under this subsection may include, but need not be limited to, information identifying:
(a) Coastal communities in this state that may be impacted by ocean acidification;
(b) The impacts of ocean acidification and hypoxia on the communities identified under paragraph (a) of this subsection; or
(c) The gaps in understanding that exist regarding the impacts of ocean acidification and hypoxia on economically or commercially important species, particularly species that support commercial, recreational and tribal fisheries and shellfish aquaculture in this state.

(3) The coordinating council may develop recommendations for the Oregon Ocean Science Trust, state agencies, academia or other organizations on high-priority, strategic research that may be done to address gaps that exist in the understanding of ocean acidification and hypoxia. Strategic research recommendations developed by the coordinating council may include, but need not be limited to, research related to:
(a) The impacts of ocean acidification and hypoxia on marine organisms and the marine ecosystem;
(b) The economic impacts of ocean acidification and hypoxia on communities in this state; or
(c) Developing adaptation and mitigation strategies for conserving and enhancing the resilience of marine organisms and ecosystems for future use and enjoyment by Oregonians and visitors to this state.

(4) The coordinating council shall submit a biennial report to the Legislative Assembly and to the Ocean Policy Advisory Council by September 15 of each even-numbered year on the coordinating council's activities and recommendations.

(5) All agencies of state government, as defined in ORS 174.111, are requested to assist the coordinating council in the performance of its duties and, to the extent permitted by laws relating to confidentiality, to furnish such information and advice as the members of the coordinating council consider necessary to perform their duties.

SECTION 4.
Notwithstanding any other provision of law, the General Fund appropriation made to the State Department of Fish and Wildlife, Fish Division, by section 1 (1), chapter 544, Oregon Laws 2017 (Enrolled House Bill 5010), for the biennium beginning July 1, 2017, is increased by $162,286 for the purpose of implementing sections 2 and 3 of this 2017 Act.

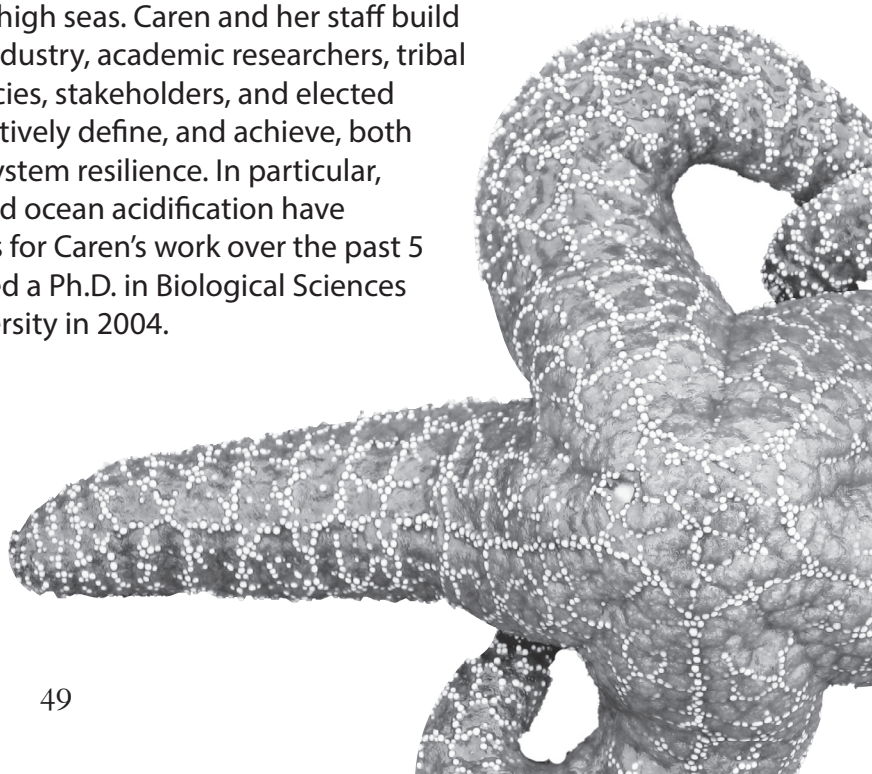
Appendix B:
Council Member Biographies

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

Jack Barth is the Executive Director of Oregon State University's Marine Studies Initiative. He is also a Professor of Oceanography in Oregon State University's College of Earth, Ocean, and Atmospheric Sciences (CEOAS). Jack received a Ph.D in Oceanography in 1987 from the Massachusetts Institute of Technology and Woods Hole Oceanographic Institution Joint Program in Oceanography. His research seeks to understand the complex spatial structure and time variation of coastal ocean circulation and water properties, and how these influence coastal marine ecosystems. Jack is particularly interested in marine low-oxygen zones and has led a number of research, technology development, and ocean observing system projects off Oregon and around the world. He presently serves on the Oregon Ocean Policy (STAC) Advisory Council's (OPAC) 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 from the estuaries to the high seas. Caren and her staff build partnerships with industry, academic researchers, tribal governments, agencies, stakeholders, and elected officials to collaboratively define, and achieve, both economic and ecosystem resilience. In particular, changing oceans and ocean acidification have become focal points for Caren's work over the past 5 years. Caren recieved a Ph.D. in Biological Sciences from Stanford University in 2004.

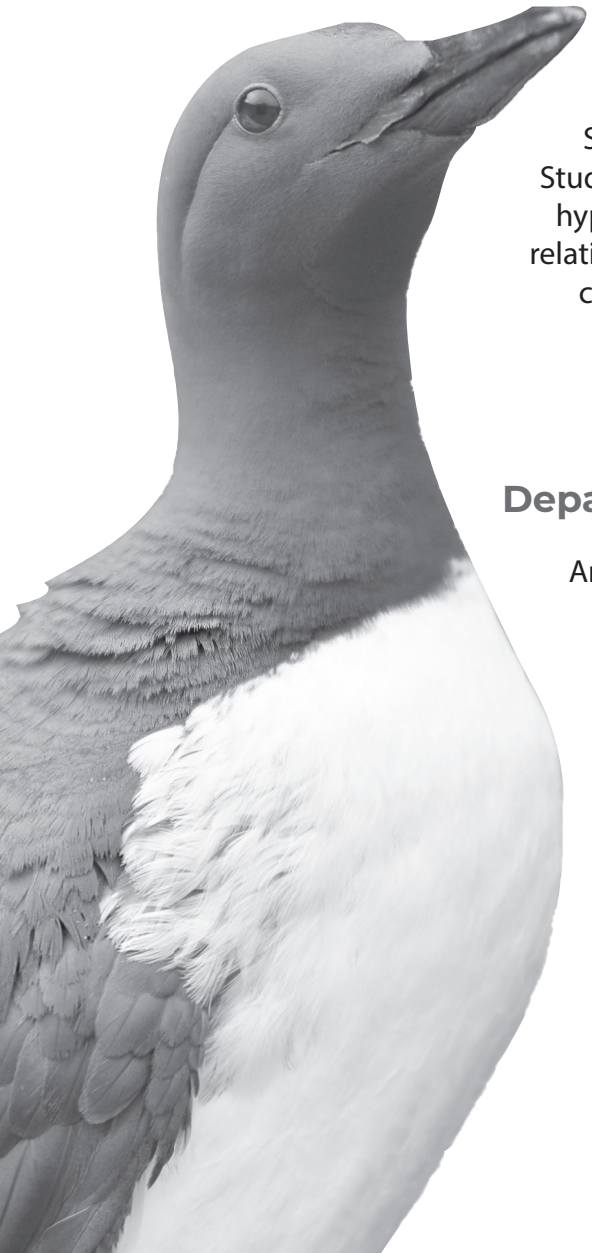


FRANK BARCELLOS
Oregon Department of Aguriculture

Frank Barcellos is one of two Food Safety Program Managers for the Oregon Department of Agriculture (ODA). Frank relocated to the Pacific Northwest to share his knowledge and experience with the Oregon Dept. of Agriculture. He has esponsibility 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 ocean acidification and hypoxia are from the perspective of the relationships between coastal communities and resources, including the connections of dairy farming nutrient runoffs into shellfish estuaries.

KAREN TARNOW
Oregon Department of Environmental Quality

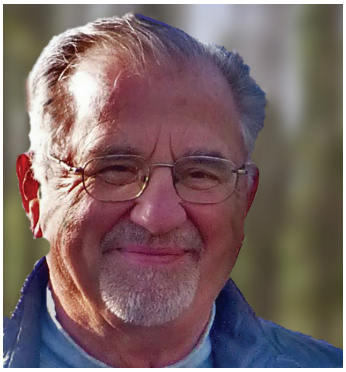
Karen Tarnow is the senior water quality policy analyst at the Oregon Department of Environmental Quality (DEQ) specializing in legislative and policy issues. She graduated from the Yale School of Forestry and Environmental Studies with a M.S. degree in Environmental Studies. Her interests in ocean acidification and hypoxia are through the lenses of interagency relations and communications that can improve current policies and inform future legislative developments.



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 Oregon State University. Andy is the Co-Chair of the West Coast Ocean Data Portal and is a staffer to the 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



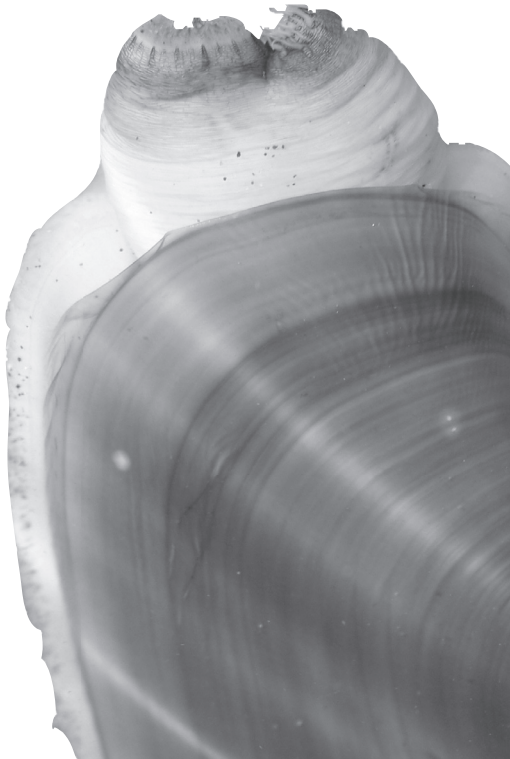
James Sumich has worked in the field of marine science in Oregon and throughout the West Coast for over 50 years, receiving his M.S. and Ph.D. degrees from Oregon State University. Recently retired as Professor of Marine Biology and Zoology at Grossmont Community College, California, his research interests 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 numerous problems associated with increasing atmospheric CO_2 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, multi-party 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.



AL PAZAR
Fishing Representative

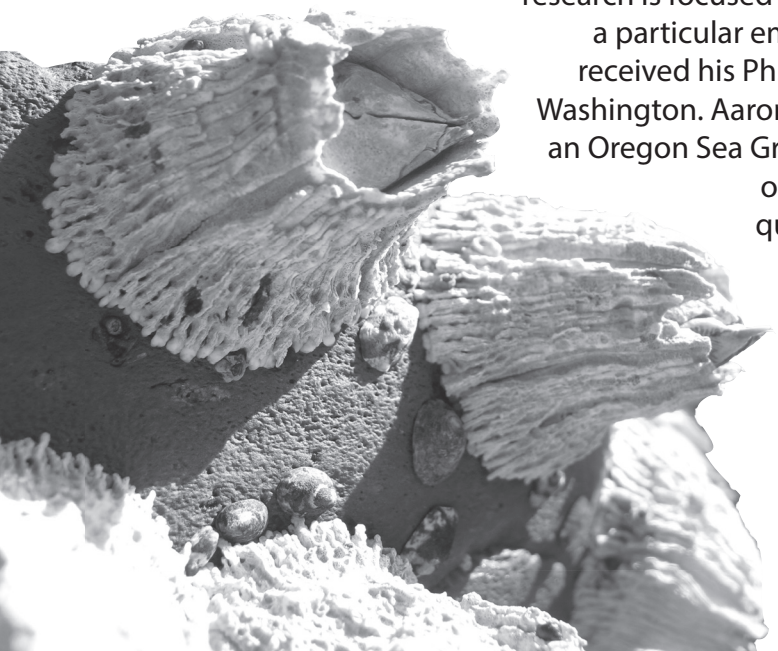
Al Pazar is a commercial fisherman and research vessel owner/operator, who has lived and worked in Oregon for 32 years. He has long been interested in collaborative research, working with various agencies (including the NOAA, ODFW, OSU, and the Oregon Institute of Marine Biology) and served on the Oregon Dungeness Crab Commission. Since first experiencing the effects of hypoxia in the crab fishery in 2008, Al has been active in learning and researching acidification and hypoxia. Over the last few years, he has directly assisted in countless research and data collection initiatives with regional managers and scientists, directly adding to our regional knowledge of changing ocean chemistry.

LIU XIN
Shellfish Industry Representative

Liu Xin has been living and working in Oregon for over 26 years, and is the owner of Oregon Oyster Farms, Inc. in Newport, Oregon, and Co-Owner of Pearl Point Oyster Farm LLC, in Netarts Bay, Oregon. He has a strong background in applied and experimental research, earning a B.S. degree in Environmental Chemistry from the Ocean University of China and a M.S. degree in Aquaculture from Oregon State University. Liu has a strong interest in OAH, since oyster farming deals with water every day. OAH has showed great impact on our oyster industry and oyster hatcheries, and industry members throughout the North Pacific. No seed, no production, no company.

DR. AARON GALLOWAY
Academic Representative

Aaron Galloway is an Assistant Professor at the University of Oregon, Department of Biology, located at the Oregon Institute of Marine Biology. His research is focused on trophic interactions, with a particular emphasis on fatty acids. Aaron received his Ph.D. degree from University of Washington. Aaron has recently been awarded an Oregon Sea Grant to investigate OA effects on young Dungeness crab, by quantifying body condition as well as escape and feeding behavior responses to current and future OA levels on the Pacific coast.



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 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.

Appendix C:
Letter from Governor Kate Brown

KATE BROWN
Governor

September 26, 2017

Dear fellow members of the OA Alliance:

With this letter, and pursuant to my announcement on December 13, 2016, Oregon hereby affirms our membership in the International Alliance to Combat Ocean Acidification. In doing so, Oregon endorses the Global Call to Action on Ocean Acidification, committing to advance the key goals of the Alliance that:

- Advance scientific understanding of ocean acidification.
- Reduce the causes of acidification.
- Protect the environment and coastal communities from the impacts of a changing ocean.
- Expand public awareness and understanding of acidification.
- Build sustained support for tackling this global problem.

In addition, I commend the 2017 Legislature for their hard work in passing Senate Bill 1039, which established Oregon policy on ocean acidification and formed the Oregon Ocean Acidification Coordination Council (Council). The Council is comprised of stakeholders, managers, and researchers and will play an important role in shaping Oregon's future related to changing ocean conditions. I call on the newly-formed Council to lead the development of Oregon's Ocean Acidification Action Plan, consistent with Senate Bill 1039 and with Oregon's pledge to answer the Alliance Call to Action, and thereby continue our work to address ocean acidification in Oregon's waters.

Sincerely,

Kate Brown

Governor Kate Brown

KB:ec

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As enacted through: Enrolled Senate Bill 1039
Oregon Law 2017 ORS 196.572