



Oregon Department of Environmental Quality

# Overview Document: Ocean Acidification and Hypoxia Technical Workgroup

Oregon Department of Environmental Quality is required to assess water quality and report to the U.S. Environmental Protection Agency on the condition of Oregon's waters on a biennial basis in its Integrated Report. In response to data and information received in past reporting cycles, DEQ convened a scientific technical workgroup to assist in drafting methodologies for assessing the impacts of ocean acidification and marine dissolved oxygen in Oregon's territorial waters for use in the 2024 assessment cycle. The objective of DEQ's ocean acidification and hypoxia (OAH) technical workgroup was to synthesize evidence that could support policy decisions on determining OAH impairment within Oregon's territorial waters.

Ocean acidification and marine hypoxia are complex and challenging issues. West Coast states have yet to routinely assess the water quality impacts of OAH on ocean designated uses, in part because established OAH water criteria and assessment methodologies to conduct such assessments do not yet exist. The workgroup scope was to provide technical expertise to inform DEQ on approaches to interpreting Oregon's narrative water quality standards using ecological and/or chemical benchmarks relevant to the assessment of ocean acidification and marine dissolved oxygen. The scientific technical workgroup was not a decision-making body. Rather, it facilitated the sharing of scientific data and information, and members provided technical review of DEQ's proposed assessment methodologies. The workgroup charter can be found [here](#).

The purpose of this document is to provide a summary of DEQ's OAH workgroup activities, meetings, and engagement process.

## Membership

The OAH technical workgroup was composed of over 40 individuals representing a diversity of scientific, technical, and policy expertise in the field of OAH. Workgroup members brought a range of specialized regulatory, research, and academic perspectives (Table 1) to the meetings and included prominent researchers in the field.

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800-452-4011 | TTY: 711 | [deqinfo@deq.oregon.gov](mailto:deqinfo@deq.oregon.gov)

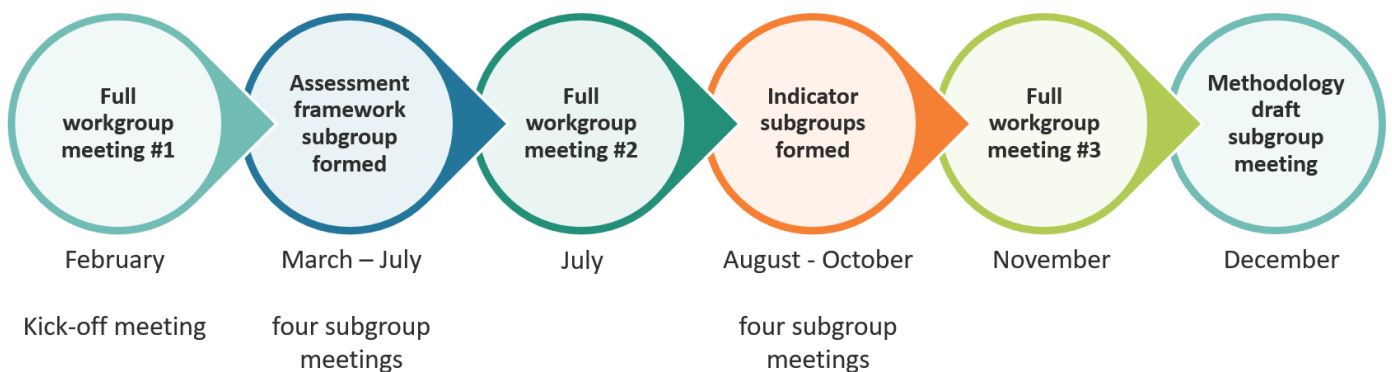
**Table 1: Technical workgroup members represented state, federal and academic/research sectors.**

State Agency Representation	Federal Agency Representation	Academic & Research
Oregon Department of Environmental Quality (DEQ)	Environmental Protection Agency (USEPA)	Oregon State University (OSU)
Oregon Department of Fish and Wildlife (ODFW)	National Oceanic and Atmospheric Administration (NOAA)	University of Washington (UW)- Northwest Association of Networked Ocean Observing Systems (NANOOS)
Oregon Dept. of Land Conservation and Development (DLCD)	Environmental Protection Agency, Office of Research and Development (EPA-ORD)	University of Connecticut (UC)
Southern California Coastal Water Research Project (SCCWRP)		Monterey Bay Aquarium Research Institute (MBARI)
California State Water Board (CA SWRCB)		Oregon Sea Grant (OSG)
Washington Department of Ecology (WA DOE)		
Alaska Department of Environmental Conservation (AK DEC)		
California Ocean Protection Council (CA OPC)		

## Workgroup Timeline and Meeting Topics

In 2022, DEQ conducted 12 OAH technical workgroup meetings, including three full workgroup meetings and nine subgroup meetings across a variety of topics related to the assessment methodology development process (Figure 1). An overview of the meeting timeline and key meeting topic areas is outlined below.

### 2022 OAH Workgroup Timeline



## **Full OAH workgroup meeting #1 – Feb. 17, 2022**

Meeting outcomes:

- Kicked off workgroup process – introductions, roles, charter, expectations
- Information sharing – big picture, CWA policy framework, sideboards
- Discussion – preliminary assessment approach

Meeting presenters/moderators: USEPA, OR DEQ, WDOE, CA SWRCB, AK DEC

### **Assessment framework subgroup meetings:**

Following the first workgroup meeting, it was determined that DEQ needed to provide the full workgroup with a starting point from which to react and provide the technical expertise. To meet this objective, a subgroup was formed to draft an assessment framework, identify critical questions relevant to the process, and delineate between scientific/technical questions (for the workgroup to assist with) and policy questions (for DEQ to answer).

Subgroup's Objective:

1. Develop a draft ocean acidification assessment procedure framework and a set of technical questions to bring to the full workgroup for refinement
2. Discuss how/when marine dissolved oxygen fits into OAH assessment process

### **Assessment framework subgroup meeting #1 - March 31, 2022**

Meeting outcomes:

- Outlined subgroup process and timeline
- Presented and discussed draft OA assessment procedure questions
- Determined how and when dissolved oxygen fits into this process

Meeting presenters/moderators: DEQ, SCCWRP

### **Assessment framework subgroup meeting #2 - April 22, 2022**

Meeting outcomes:

- Discussed draft answers to OA technical questions and DEQ provided draft answers to policy questions
- Discussed remaining subgroup meeting tasks/timeline

Meeting presenters/moderators: DEQ, SCCWRP

### **Assessment framework subgroup meeting #3 - May 27, 2022**

Meeting outcomes:

- Established OA assessment roadmap questions and draft assessment framework
- Drafted answers related to marine Dissolved Oxygen

Meeting presenters/moderators: DEQ, SCCWRP

### **Assessment framework subgroup meeting #4 - July 1, 2022**

Meeting outcomes:

- Continued Marine DO reference condition discussion for chemical data
- Received feedback on full workgroup meeting #2 format and timeline updates

Meeting presenters/moderators: DEQ, SCCWRP

## **Full OAH workgroup meeting #2 - July 8, 2022**

Meeting outcomes:

- Updated full workgroup on subgroup process and progress

- Information sharing – Presented draft OA assessment framework and technical/policy questions
- Discussed draft answers for biological and chemical OA data
- Formed topical (biological and chemical OA data) subgroups for next workgroup phase
- DEQ accepted requests to redefining marine assessment units

Meeting presenters/moderators: DEQ, SCCWRP

### **Indicator and assessment unit subgroups meetings:**

Following the second full OAH workgroup meeting, three subgroups were formed to dive deeper into three topic areas: biological OA data, chemical OA data, and marine assessment unit designations.

#### **Biological OA data subgroup meeting – Aug. 2, 2022**

Subgroup charge:

- Develop recommendations to DEQ for biological OA data impairment thresholds and reference condition characterization

Meeting outcomes:

- Discussed short term and long-term biological indicators
- Discussed reference conditions and threshold development for severe shell dissolution

Meeting presenter/moderator: DEQ

#### **Chemical OA data subgroup meeting – Aug. 10, 2022**

Subgroup charge:

- Develop recommendations to DEQ for chemical OA data impairment thresholds and reference condition characterization

Meeting outcomes:

- Discussed short term vs. long term chemical indicators/metrics
- Discussed chemical impairment threshold development, biological endpoint and taxa considerations, and data integration methods

Meeting presenter/moderator: DEQ

#### **Marine assessment unit subgroup meeting – Aug. 25, 2022**

Subgroup charge:

- Investigate revisions to the existing method for delineating Oregon's for marine assessment units

Meeting outcomes:

- Reviewed the purpose and application of assessment unit
- Reviewed current marine assessment units using a web map
- Explored alternative options for delineation

Meeting presenter/moderator: DEQ

#### **Combined Biological and Chemical OA data subgroup meeting – Oct. 7, 2022**

Recognizing the overlap in content and membership between biological and chemical OA data subgroups, DEQ brought the two groups together for a combined meeting.

Meeting outcomes:

- Summarized the aragonite (chemical OA indicator) impairment threshold, nearshore (inner shelf) reference conditions, and areas of uncertainty
- Summarized the pteropod metric/threshold (biological OA indicator), collection/processing standardization, and areas of uncertainty

- Discussed additional indicator presentation– based on biological vulnerability to seasonal shifts in OA parameters

Meeting presenters/moderators: DEQ, NOAA, OSU

### **Full OAH workgroup meeting #3 – Nov. 9, 2022**

Meeting outcomes:

- Updated workgroup on outcomes of subgroup meetings (biological data, chemical data, and marine assessment unit subgroups)
- Discussed synthesis of subgroup recommendations and next steps

Meeting presenter/moderator: DEQ

### **Methodology draft subgroup meeting – Dec. 7, 2022**

Following the third full workgroup meeting, DEQ convened a subgroup to discuss the process DEQ would undertake to draft assessment methodologies for the 2024 Integrated Report, and how workgroup recommendations would be incorporated.

Meeting outcomes:

- Provided an outline of the assessment methodology documents for OA and marine DO
- Reviewed technical aspects of sections where DEQ was inviting recommendations
- Discussed availability to contribute to these sections
- Outline a plan including a short-term timeline

Meeting presenter/moderator: DEQ

## **Proposed OAH assessment methodology updates**

In consultation with OAH workgroup members, DEQ has developed draft methodologies to assess and interpret Oregon’s narrative water quality standards relevant to OAH impacts. DEQ has developed draft methodologies to assess Oregon’s biocriteria for marine waters and marine dissolved oxygen standards as well as a Technical Support Document detailing the background and rationale of the approaches DEQ is proposing. These updates are outlined in two documents, (1) a Technical Support Document and (2) an Assessment Methodology Document that contains proposed additions to the 2024 draft Integrated Report assessment methodology. DEQ will hold a public comment period for these documents beginning May 2023. Draft documents can be found on DEQ’s [Assessment Methodology Updates webpage](#).

## **Workgroup input and technical review**

Members of the OAH technical workgroup have contributed valuable scientific and technical input to DEQ throughout the development of the Technical Support Document and Assessment Methodology document. In addition to contributions throughout the drafting process, a group of over fifteen workgroup members representing eight affiliate agencies or research/academic entities agreed to participate in an additional workgroup review, providing input to DEQ about the draft methodologies and Technical Support Document on a set of specific technical questions. The workgroup review panel was not a decision-making body. Their role was to provide technical review and input on the approaches DEQ is proposing to use to assess impairment of marine aquatic life beneficial use and where appropriate, make recommendations on revisions to the Technical Support Document and Assessment Methodologies Document. DEQ incorporated input from these independent subject matter experts into the draft documents before the public comment period.

The OAH methodology has been developed in collaboration with the technical workgroup and the workgroup provided tremendous technical expertise for the methodology development and a comprehensive review of

the proposed methodology. Thus, DEQ has solicited and incorporated independent scientific and technical input throughout this technical workgroup process, thereby implementing ORS 468B.039(a).

The following questions were posed to the workgroup review panel:

### **1. Proposed Hybrid Assessment Framework** (Technical Support Document)

- **Q 1.1:** Is the hybrid assessment framework outlined in the Technical Support Document a reasonable approach to incorporate multiple lines of evidence to determine biological impact?

*Background:* Two types of biological impact benchmarks are proposed: one benchmark beyond which there is sufficient evidence of biological impact to determine impairment based on a single data type (independently applicable (IA) benchmark), and another beyond which indicates likely biological impact but requires confirmation from multiple lines of evidence to determine impairment (combined line of evidence, or CLOE, benchmark).

- **Q 1.2:** From a conceptual standpoint, does this benchmark classification structure provide a reasonable pathway to determine biological impact based on individual or combined lines of evidence?

### **2. Ocean Acidification Biocriteria Assessment** (Technical Support Document + Assessment Methodology Document)

*Background:* The proposed OA biocriteria assessment methodology relies on shell dissolution of pelagic zooplankton *Limacina helicina* as the focal indicator of biological impact. The well-defined and established relationship between *L. helicina* shell dissolution and aragonite saturation state is the basis for the assessment. This fits into the assessment framework by identifying impact using both chemical and biological indicators and the ability to estimate natural background conditions.

- **Q 2.1:** Is this indicator an appropriate biological/chemical relationship for DEQ to adopt for water quality assessment of OA stress in Oregon's territorial waters?
- **Q 2.2:** Are there other methods or biological indicators for determining biological impairment that DEQ should consider for marine waters assessment?

*Background:* Two types of biological impact benchmarks are proposed: one benchmark beyond which there is sufficient evidence of biological impact to determine impairment based on a single data type (IA) benchmark, and another beyond which indicates likely biological impact but requires confirmation from multiple lines of evidence to determine impairment (CLOE) benchmark.

- **Q 2.3:** Are the proposed aragonite saturation state benchmarks within this classification system (IA = 1.0 & CLOE = 1.4) appropriate to represent the thresholds where aquatic life use is considered impaired?
  - If they don't adequately represent the aquatic life use impairment cutoff, what are the limitations of the benchmarks and how might they be improved?

- **Q 2.4:** Are the proposed pteropod dissolution benchmarks within this classification system (IA = 62% & CLOE = 40%) appropriate to represent the thresholds where aquatic life use is considered impaired?
  - If they don't adequately represent the aquatic life use impairment cutoff, what are the limitations of the benchmarks and how might they be improved?

*Background:* Defining natural background conditions is an important aspect of this assessment methodology, DEQ outlines the high-level steps and requirements to help define how estimates of pre-industrial CO<sub>2</sub> could be used for this purpose.

- **Q 2.5:** Are there additional considerations that should be included in this section? Are there additional approaches to defining background condition that should be considered?

*Background:* The Assessment and Listing section describes the application of critical assessment windows, natural background condition, and statistical methods for determining impairment.

- **Q 2.6:** Are there additional considerations not currently included in this evaluation that should be addressed in this section?

### **3. Marine DO and Hypoxia** (*Technical Support Document + Assessment Methodology Document*)

*Background:* The proposed marine DO assessment methodology relies on two lines of evidence for category assignment. One line of evidence will rely on quantifying measurable reduction by comparing observational data with background conditions established either through long term observational data sets or modeled conditions. The second line of evidence will use established DO biological impact benchmarks to provide a biological lens to determine whether measurable reduction is likely affecting aquatic life beneficial use support.

- **Q 3.1:** Is this a reasonable approach to assess Oregon's narrative criteria of "no measurable reduction" for aquatic life beneficial use support?

*Background:* DEQ is proposing to use the conventional hypoxia threshold of 1.4 ml/l for the biological impact benchmark.

- **Q 3.2:** Is this an appropriate value to use for to confirm measurable reduction is impacting fish and aquatic life beneficial use support.

### **4. Future Directions** (*Technical Support Document*)

*Background:* DEQ is gathering recommendations on key analyses and next steps to build upon and refine the existing assessment methodologies for OA and marine DO for future integrated report cycles.

- **Q 4.1:** Do you have recommendations for future directions DEQ should consider for future integrated report cycles?

## **Proposed hybrid assessment framework and benchmark classification concepts**

The consensus of the workgroup review panel was that the hybrid framework concept is a reasonable approach to incorporate multiple lines of evidence to determine biological impact. The majority of reviewers agreed that the classification of two benchmarks (one more stringent benchmark applied individually to a single line of evidence, and another applied with confirmation from both lines of evidence), and their use based on data availability was a sound and reasonable approach. One reviewer's opinion was that determining impairment based on a single line of evidence undermines the purpose of the hybrid assessment framework and recommended not listing into Category 5 based on a single line of evidence. Concern also was raised about using the benchmarks chosen to identify biological impairment (Category 5) to assess beneficial use attainment (Category 2), pointing out they were not chosen to identify protection of aquatic life use. Overall, reviewers indicated support of the hybrid framework concept and the proposed benchmark classifications to determine biological impact.

### **Marine OA biocriteria indicator species**

Of those that offered their opinion, there was unanimous support from the workgroup review panel for the use of pteropods (*Limacina helicina*) as the focal indicator species of biological impact, severe shell dissolution as the biological measurement/endpoint, and aragonite saturation state as the chemical metric. Reviewers commented that pteropods are the most suitable indicator for OA stress based on the current state of science. Several reviewers suggested considering other indicators such as Dungeness crab or other shelled invertebrates during sensitive life stages in future Integrated Report cycles.

### **Validity of assessment benchmarks for OA**

#### **Chemical assessment benchmarks**

Comments on the chemical assessment benchmarks were largely in agreement that the Independently applicable (IA) and Combine Lines of Evidence (CLOE) benchmarks were well justified in the text and provide a reasonable pathway to determine aquatic life use impairment. There were some additional considerations raised concerning the natural exceedance of the benchmarks in pre-industrial times and how the comparison with natural background is proposed.

#### **Biological assessment thresholds**

Comments on the biological assessment benchmarks were largely in agreement that the IA benchmark was well justified in the text and provided a reasonable pathway to determine aquatic life use impairment. Multiple reviewers suggested further explanation and justification of the CLOE benchmark was warranted in the text, particularly as it relates to background condition estimates. One reviewer was opposed to using the number assigned to the CLOE at all and suggested the IA benchmark number should be used as the CLOE instead. Additionally, multiple reviewers requested clarification on some elements of the assignment of assessment categories, suggesting more detailed explanation of the hybrid framework categories/combinations was needed.

### **Approach to Background Condition Estimates**

Comments on the proposed approach to define natural background condition were largely supportive, with some key suggestions for improvement. One area of suggested improvement was around the model validation step in the chemical data section and how model uncertainty will be considered. Another concerned the pre-industrial horizon approach, where reviewers suggested additional details on the rationale and application of using pre-industrial horizon estimates to select relevant data for evaluation compared with other commonly used water column metrics. Others found the methodology sound, but expressed concern that sufficient data and models may not be available to conduct an assessment.



## **Dissolved oxygen criteria assessment**

Reviewer responses to the marine DO assessment approach were mixed. One reviewer commented that the combined lines of evidence approach was not needed to interpret Oregon's narrative criteria, and that an either/or approach could be used to assess the two lines of evidence independently. Others were concerned that the approach to quantify measurable reduction based on long term observational data could mis-attribute measurable reduction to change from background where natural inter-decadal DO oscillations may be responsible. Another reviewer felt that an additional independently applicable benchmark was warranted. Others (3 reviewers) were in full support of the methodology as presented.

## **DEQ Recommendations**

Moving forward, DEQ is addressing the points identified by the peer reviewers in multiple steps. The first step involved revisions to the Technical Support and Assessment Methodology documents for the 2024 Integrated Report, while the second step entails long-term updates to the methodology moving forward.

### **Updates to IR 2024 documents**

Aside from grammatical improvements and clarifications throughout the documents, changes to the draft Technical Support and Assessment Methodology documents following the workgroup review fall into three categories:

#### **Increased interpretability of diagrams and concepts**

Reviewers provided critiques of diagrams and figures throughout the documents, and suggested areas where illustrated concepts were not adequately explained in the text or vice versa. This feedback led to changes to the layout of the biocriteria assessment framework to improve interpretability of the figure. Slight modifications were also made to the flowcharts for assigning categories to improve clarity.

#### **Additional justification of benchmarks and natural background**

Through this review, aspects of the chemical and biological assessment benchmarks for OA biocriteria and marine DO were highlighted that warranted additional explanation and interpretation. Adjustments were made to the explanations of the IA and CLOE biocriteria assessment benchmarks for chemical and biological data to better articulate the rationale behind their usage and comparison with estimates of natural background condition. Category determinations were adjusted to reflect concern raised about beneficial use attainment. Additional explanation was also added to the multiple lines of evidence approach proposed in the marine DO assessment.

#### **Adjustments to data requirements**

For many policy related decisions made during the methodology development process DEQ relied on precedent established in the existing draft [Assessment Methodology for Oregon's 2024 Integrated Report](#), which is a culmination of over 20 years of water assessment. Reviewers pointed out some areas where existing precedent could be adjusted to increase certainty about impairment determinations, and adjustments were made to the draft methodologies in response to these recommendations. In some cases, data requirements or approaches used to define background conditions in these methodologies may be more stringent than is required for other parameter assessments. This is reflective of balancing the state of the science on this topic and the level of certainty DEQ needs to classify waters as impaired.

### **Long-term updates**

DEQ expects this assessment methodology will be revised to reflect evolving science used to determine policy decisions. It is important to note that given the improvements to the biocriteria and marine DO methodologies

that DEQ is undertaking, biological and chemical indicators and benchmarks may be subject to change in future assessment methodology cycles. DEQ has gathered recommendations from the technical workgroup on key analyses and next steps to build upon and refine the existing assessment methodologies for OA and marine DO for future integrated report cycles. DEQ may revise and/or adjust elements of these methodologies as additional indicators and methods for evaluating biological impacts become more widely used, and as approaches to assess protection of aquatic life uses in marine waters are advanced.

## Acknowledgements

DEQ would like to acknowledge the valuable contributions of everyone who participated in DEQ's 2022 Ocean Acidification and Hypoxia Technical Workgroup to the development of the Technical Support Document and Assessment Procedure Updates. A full membership list can be found in the [workgroup charter](#).

Recommendations and assistance offered during the workgroup process provided critical scientific and technical elements in the development of methodologies for assessing impacts of ocean acidification and hypoxia in Oregon's territorial waters. Additionally, DEQ would like to acknowledge the following individuals for their significant contributions to the subgroup and workgroup review processes:

<b>Name</b>	<b>Affiliation</b> (see Table 1 for abbreviations)
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Becky Anthony	ODFW
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Jack Barth	OSU
Nina Bednaršek	OSU
Cheryl Brown	EPA-ORD
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Richard Feely	NOAA
Christina Frieder	SCCWRP
Jill Fullagar	USEPA
Rian Hoof	OR DEQ
Kaitlyn Kalua	CA OPC
Justine Kimball	CA OPC
Rochelle Labiosa	USEPA
Jan Newton	UW-NANOOS
Steve Pacella	EPA-ORD
Lori Pillsbury	OR DEQ
Jeremy Reiman	WA DOE
Debra Sturdevant	OR DEQ
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Keara Tusso	CA SWRCB
Steve Weisberg	SCCWRP

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## Contact

Water Quality Assessment Program Contacts:

Lesley Merrick  
Water Quality Assessment Program Lead  
971-323-7228  
[lesley.merrick@deq.oregon.gov](mailto:lesley.merrick@deq.oregon.gov)

Kaegan Scully-Engelmeyer  
Oregon Sea Grant OAH Fellow  
503-575-5224  
[kaegan.scully-engelmeyer@deq.oregon.gov](mailto:kaegan.scully-engelmeyer@deq.oregon.gov)

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