



APPENDIX H

Establishing ocean acidification and hypoxia research priorities

A strategy for aggressively expanding options for management action

To manage effectively for ocean acidification and hypoxia (OAH), West Coast managers need an arsenal of tools and options that are grounded in sound science. However, OAH research is still largely in its infancy, generally limiting the management options available. While the amount of OAH research being conducted has exploded over the past decade, many critical knowledge gaps remain. This document outlines the Panel's recommendations for aggressively expanding the breadth and depth of OAH research in order to meet the demands for management-relevant information on the West Coast and beyond. Organized around five major research areas, this research portfolio has been designed with the assessment that absent a coordinated and strategic prioritization of research foci, current research trajectories are unlikely to meet growing needs for management-relevant knowledge. To that end, scientists must go beyond answering academically stimulating questions; they also must maintain a relentless focus on providing managers with concrete, actionable options for immediately combatting the threats posed by OAH. Scientists are invested in seeing their OAH work translated into viable management options, but need help from West Coast managers in coalescing around a shared research vision and coordinating efforts for maximum impact and efficiency. The recommendations outlined in this Appendix are expanded in the Panel's more detailed document "*Research Priorities to Inform Decisions and Develop Solutions.*"

Understand drivers of OAH

Scientists understand at a conceptual level that local nutrient and carbon inputs can exacerbate the impacts of OAH. However, management recommendations about reducing these local inputs are qualified by the lack of clear understanding about precisely where on the West Coast local inputs are sufficiently large to be meaningful relative to the global scale inputs that drive OAH. Furthermore, more clarity is needed about the relative importance among local inputs (non-point source vs. wastewater discharge vs. local atmospheric inputs) to prioritize for reduction. Thus, the Panel recommends investing in research that enhances our understanding of the relative importance of local vs. global contributions to OAH. West Coast managers should focus on developing key datasets, and coupled physical-biogeochemical models, validated with observations, that quantify the relative impacts of various nutrient, carbon and carbon dioxide sources on exacerbating OAH. Investments should also continue in developing new, accurate, cost-effective and easily deployed ocean sensors for OAH parameters. These models should be evaluated in the context of decision-making processes, and observational data should be collected to enhance model validation. As scientists learn more, they can adjust and adapt strategy options for source reduction that will maximize effectiveness and minimize cost.

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Assess vulnerability to changing conditions

A key management information need is understanding how fast seawater chemistry is changing, at what locations seawater chemistry will change the most, and what levels of chemical change will trigger substantial changes in biological communities. Scientists along the West Coast are in various stages of developing coordinated monitoring programs, conducting laboratory and field experiments, and refining numerical models to address such questions. However, additional research is needed to transition these studies from individual research projects to more concerted, connected sets of research activities that address the underlying management questions. In addition, current efforts need to be expanded to downscale global models to project change along the West Coast, elucidate the biological effects of multiple stressors within the context of real-world exposure conditions and enhance the translation of physiology-scale findings to population- and ecosystem-scale projections.

Understand evolutionary response to OAH

Although organisms have the potential for evolutionary adaptation to cope with OAH stress, scientists have insufficient information to predict whether, where, and how fast that genetic adaptation will occur. Thus, research is needed to understand rates of natural genetic change in response to OAH, and how evolutionary potential is distributed among taxa and localities. Moreover, West Coast managers need to understand how this potential for adaptation can best be incorporated into management strategies, such as use of refugia to protect the genetic diversity that now exists in local biota, especially those that are routinely exposed to high levels of OAH stress. Research will also allow assessment of the potential value and consequences of purposeful interventions, such as selective breeding and translocation. With sufficient knowledge, managers can determine whether and where opportunities exist to use evolutionary potential to address OAH's impacts on biological communities.

Explore sequestration and other carbon removal solutions

The acidification of seawater can be mitigated in two main ways: a) a biologically-based approach, in which seagrasses, kelp and other vegetation remove carbon dioxide from seawater and convert it into living tissues, and b) a chemically-based approach, in which the addition of base minerals such as carbonates is used to neutralize acidity. These approaches are appealing because they operate at the local level, but their applications to date have been limited and focused mostly on laboratory or small-scale settings. The Panel recommends supporting research on the type, capacity, cost-effectiveness, and safety of these removal processes as a means to determine which, if any, of these could become part of an effective marine conservation strategy.

Advance living marine resources management

Because the Panel has recommended that managers undertake actions that enhance the ability of organisms to cope with increasing OAH stress – critically important in the context of managing living marine resources such as commercial fisheries – the growing adoption of ecosystem approaches to fisheries management offers opportunities for fisheries managers to consider the potential regional effects of OAH as they update fisheries management plans. Critical to understanding OAH in an ecosystems context is that different areas are more vulnerable or resistant than others. Ecosystem models that support ecosystem-based fisheries management need to be developed and validated on local scales, and ecological risk assessments that increase understanding of fisheries vulnerabilities need to be conducted.

This report was produced by the West Coast Ocean Acidification and Hypoxia Science Panel (the Panel), working in partnership with the California Ocean Science Trust. The Panel was convened by the Ocean Science Trust at the request of the California Ocean Protection Council in 2013, working in collaboration with ocean management counterparts in Oregon, Washington, and British Columbia. Ocean Science Trust and the Oregon Institute for Natural Resources served as the link between the Panel and government decision-makers. The information provided reflects the best scientific thinking of the Panel. More information on the Panel can be found at www.westcoastOAH.org. Cover image: Carliane Johnson / SeaJay Environmental.

