Workshop to Enhance Collaborative West Coast Ocean Acidification and Hypoxia Biological Monitoring

November 15 and 16, 2022

Hosted by the California Current Acidification Network
Sponsored by NOAA Ocean Acidification Program

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The workshop and document was initiated by and implemented by the California Current Acidification Network (C-CAN) Steering Committee.

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I. Workshop background

About C-CAN

The California Current Acidification Network (C-CAN) was established in 2010 from a shared desire among scientists, industry stakeholders, tribes, and natural resource agencies to understand the connection between coastal acidification and biological effects on hatchery operations and fisheries (C-CAN 2013). Once it became apparent that ocean acidification and hypoxia (OAH) were having a profound effect on biota and industries that depend on those biota, C-CAN held workshops to establish a set of monitoring principles that allow for collaboration among the participating parties and yield information valuable to industry and ocean managers alike (McLaughlin et al 2013). For water chemistry, many of those principles were quickly adopted and implemented, with industry collecting robust nearshore data and the scientific community working with them to ensure the newest technologies and quality assurance protocols were implemented.

The Challenge

While C-CAN facilitated development of a comprehensive, coordinated network for monitoring ocean chemistry, the basic biological principles that C-CAN identified have not yet been fully implemented. While the amount of biological monitoring associated with ocean acidification (OA) is growing, most of the new monitoring is conducted by independent researchers and with less collaboration between scientists and industry than has been achieved for chemistry monitoring.

The Opportunity

The amount of biological monitoring being conducted on the west coast is increasing. NOAA has enhanced the amount of biological collection on their west coast cruises and the State of California has made a sizeable investment to enhance consistency in those data collection/processing approaches between NOAA and the large California monitoring programs. Oregon and Washington scientists are also starting to coalesce around similar monitoring techniques. However, industry has not been integrated into that monitoring network, potentially missing an opportunity for adding other cost-effective modes of data collection.

Workshop Goal

To build and strengthen partnerships among fisheries, aquaculture companies, tribes, agencies and scientists to achieve co-development of knowledge about acidification effects on West Coast biota and the industries that depend on those services. Specifically, learn what industry is observing on their farms and in their fisheries and determine how the existing biological monitoring systems can evolve through inclusion of collaborative industry data collection.

Workshop Logistics

The workshop was held on November 15 and 16, 2022, in person at the University of Washington Center for Urban Horticulture in Seattle, Washington and remotely at the NOAA Channel Islands Marine Sanctuary office in Santa Barbara, California and the Humboldt Bay Aquatic Center in Eureka, California. The two satellite sites in California allowed for participants that were unable to travel to Seattle to view the talks live from Seattle and participate in their own breakout groups. COVID precautions were in place and participants were asked not to attend in person if they felt unwell.

Participants for the workshop were selected from stakeholders that had participated in the 2010 C-CAN creation meeting or their successors. Keeping the goal of the workshop front and center, the committee ensured a well represented small group of 35 to 40 participants over the disciplines of aquatic farmer, fisherman, tribal natural resource manager, governement entity, and academic. A list of participants and their affiliations is provided in Appendix A.

The workshop included a half-day plenary session each day of invited speakers to set the stage, with the workshop focusing on three breakout sessions that comprised the majority of the workshop. The agenda and questions for each breakout session can be found in Appendix B. A facilitator and recorder were assigned to each breakout group. Materials were provided ahead of time for those gathered to better understand the present state of knowledge. You can find these materials in Appendix C.

Breakout Group Discussions

Discussions were broken down to four groups, one each in Eureka and Santa Barbara and two groups in Seattle. The groups were asked to consider three questions that were additive and reflected their unique knowledge of the California Current conditions relative to their industry or agency. The first question, ‘What are the biological information needs you have in your business/work?’ The second question, ‘How well are the biological information needs being met currently? Is the right data being collected? Is it the right quality? Is it synchronous? Is it collected with supporting chemistry data?’ The third question ‘How do we improve the current situation and enhance collaboration such that needs are being met?’.

II. A look back: the creation and evolution of C-CAN

C-CAN is a collaboration of interdisciplinary scientists, resource managers, industry and others from local, state, federal, and tribal levels dedicated to advancing the understanding of ocean acidification and its effects on biological resources of the US west coast. C-CAN's mission is to coordinate and encourage development of an ocean acidification monitoring network for the west coast that serves publicly available data; Improve understanding of linkages between oceanographic conditions and biological responses; Facilitate and encourage the development of causal, predictive and economic models that characterize these linkages and forecast effects; and Facilitate communication and resource / data sharing among the many groups, organizations and entities that participate in C-CAN or utilize C-CAN as an informational resource.

The overarching goal of C-CAN is to facilitate collaboration and coordinate measurement, best practices and communication to define the effects of ocean acidification and develop strategies for adaptation:

- Establishing a Chemical Monitoring System — Development of a chemical monitoring network including desired sampling elements, protocols, training, and technical guidance to ensure data uniformity across users, expansion of the network's capacity, and access to a common data management structure
- Linkage to Biological Effects — Linkage of physical and chemical data to biological data to develop relationships between ambient conditions and biological response
- Support for Causal, Predictive, and Economic modeling — Facilitating use of C-CAN data, and knowledge of C-CAN participants, to assist development of models that determine the interaction of numerous stressors to forecast oceanographic conditions over a variety of spatial and temporal scales in the nearshore environment
- Communication — Facilitation of communication among disparate interest groups that participate in C-CAN or are clients for its products

III. State of the science - Biology

Fishing communities across the CCE appear to be heading toward a tipping point whereby certain fisheries, like crab, may experience collapse. Faster growing species are less resilient meaning the commercially and culturally important abalone, scallops more resilient (long-lived). Maintaining long-lived biomass should be a priority. Upper size limits. Reserves offer this, but they are not a panacea. Priority species were presented and discussed as follows:

Crabs - For Crab, the biggest vulnerability is late in life and the biggest threat is hypoxia OR change in diet. Tanners, box, brown, Dungeness crabs do not respond well to hypoxia. Yet many commercial crustaceans in California are not getting the same attention as the Dungeness. OA impacts to crustacean fishery species (brown, red, yellow, box) are similar to what's been done for Dungeness. But we're not sure how the adults that are deeper (box and king crab for example), are responding. We need to gain a better familiarity with the different species' megalopae to understand when things are changing, different, and therefore impacted. Programs like CalCOFI do not capture much crab megalopae. In this southern area of the CCE, market squid and lobster are well accounted for while lobster are not abundant because they can be so dispersed. Infographic/outreach on OAH and Alaskan crab fishery can help to communicate to local fishers that what happened in Alaska may very well happen to local crustacean fisheries.

Urchins - What makes a fat and happy purple urchin grow? What's the diet that makes fat and marketable purple urchins? Diet studies of red and purple urchins (similar to that of the pinto abalone study) can help establish a live market and to make them profitable. Red urchins are at a competitive disadvantage when compared to purples in the face of OAH (Domham paper - showed red urchins have slower growth, etc.). While we have larval settlement studies that fishermen helped fund, the struggle to acquire that understanding remains. What are the environmental (temp) thresholds for purple urchins? I.e. will the next strong El Nino wipe out masses of purples? Time will tell.

Lingcod - egg masses can't move and are subject to environmental condition changes. What fishes make these egg masses and who else may be similarly impacted by OAH? Must consider time of year for these egg masses.

Squid - consistent catch around Santa Barbara Channel, but temperature dependency on either side of their ranges (too warm in San Diego, too cool in Monterey). How do we define a true range shift or expansion?

Other species of interest. Sea cucumbers - we think they go deeper and then come back but still so much is unknown. Separate the indicators to crustaceans, echinoderms, etc. How is maternal investment in rockfish impacted by OAH? With the understanding of anchovy habitat compression, does that extend to other species such as rockfish?

IV. Stakeholder information Requirements

1. *What do our stakeholders need? What will they use? Not one size fits all.*

West coast stakeholders are diverse and require dynamic ocean and coastal information to inform a range of decisions. Their needs range from needing fine-scale local information (shellfish growers) to annual summary of status and change (state managers) to needing to know which and when a species of interest will experience effects (fishing community). In order to address stakeholder needs, researchers must apply a 'toolkit' of solutions and maintain agility to pivot as systems undergo change. Staying local for sustainability requires us to build resilience to avoid the local resource if focused on too heavily? Although the fishing community can be at odds with managers, they can pick up a hammer if needed.

2. ***Fisheries managers - What we need to know?***

How can C-CAN provide agencies and industries with the best information that will allow industry to adapt smoothly and safely? California Department of Fish and Wildlife (CDFW) wants to know which species may go the same route of Alaskan crab. We are working to identify the best indicators in order to track and predict fishery collapses. If we see the signs, where can fishers shift their attention? How do they do that under legal permits to take advantage of burgeoning species shifting or expanding into the area? What information is needed to see if hatchery problems (i.e. oysters) are occurring in the wild, and to what extent.

Experimental permits from state fish and wildlife agencies can be part of the solution– as new warmer species come into the picture, identifying and supporting fishers in having the options for something to fish as their typical catch moves away. The new, adaptive permitting process puts the funding onus on the fishers to fund the research necessary to make a management plan. For instance, octopus permitting failed because no one had money to do research on the stock, catch, etc. How to deal with the permit models? Can't change it with folks still deep in it. Some work is going on with CDFW and NOAA Fisheries, but <u>NMFS stock assessors may not be considering OAH.</u> Switching permits is not often financially feasible - how "adaptable" are relatively young fishermen? What is their outlook in the next 30 years? Stronger engagement is needed.

3. ***Fisheries and shellfish industries information needs***

Fishery mechanistics include the scientific underpinnings of how chemical processes are impacting biology. For industry, monitoring information allows us to track a stock so that we can prepare when it looks like we're approaching a tipping point. Potential obstacles to converting data into action includes: Many fishermen don't believe this is real and happening now, and won't until something hits them in the face. Not every fishery will collapse - lobster for example may be more profitable in the northern area of its range (i.e. Santa Barbara). Fishermen are pretty resilient and are willing and capable to sit it out, change fisheries, or do something else. Some fishermen have said "what about addressing things like nutrient runoff versus telling us to stop fishing so much?" Often fishermen are seemingly the target since you're fishing it, but there are many impacts that can't be pinned on fishing pressure - so it's not always fair they're the ones being asked to change or stop,

V. Our challenges

1. Communication and engagement challenges

C-CAN has a role in communicating predictions and providing information that people need. But how can we more clearly define the OA problem? Does the research community fully understand the scope and the kinds of threats it presents? Furthermore, our ability to actually mitigate the problem is fairly limited at the very local scale, at least in non-urban areas and those defined by upwelling dynamics.

Our attempt to bridge science to community has mostly focused on working with non-scientists. Specifically, the *Headlights* project which deployed a suite of burke-a-lators across shellfish aquaculture sites on the west coast. C-CAN continues to focus on solutions but in the lens of biological impact of OA and multi stressors. We explored the use of in situ cameras and tagging efforts to understand habitat changes. There was a lot of interest in better documenting Crab movement related to hypoxic events.

Building information solutions that reach beyond instruments and platforms to provide an integrated solution requires looking to integrate near-shore carbon networks that incorporate carbon storage information and observing stations. Focus on blue carbon efforts can build resilience in ecosystems and grow the Blue Economy (e.g. kelp aquaculture, DAC and alkalinity enhancement efforts. Through identifying and supporting carbon negative opportunities for specific regions given local interest and capacity, we can build locally-driven excellence to monitor and predict OA events.

Each group participating in the C-CAN collaboration needs to understand the needs and capabilities of the other - what are each group's constraints that they operate under? Not that many fora available to bring in many people with different interests/needs to get to know one another. We can keep collecting data, but what are we going to do with all that information? There's CalCOFI data that could be analyzed and provide valuable information - but who is going to do that? Who is going to analyze new data from additional data collection efforts?

2. Where are our gaps?

To understand vulnerabilities of species that occupy essential CCE habitats, the monitoring network must increase measurement of OA and relevant biology in benthic, pelagic, and nearshore environments. Building upon existing long-term stations including NOAA and partner moorings and survey stations with special consideration for Offshore Wind (OSW) development areas. Including the fishing fleet in the collection of subsurface data. Long-range AUVs, ROVs, and bottom landers equipped with OAH sensors, imaging, eDNA capabilities, sediment traps, and diver deployed data loggers can help achieve a more complete observing network. Moorings and surveys, combined with animal tracking provides information on biological response to changes in OAH. Imaging and eDNA are increasing in application and utility but challenges remaining include analytical timeliness, data processing and storage capability.

Observing and monitoring systems should increase paired monitoring of ocean acidification and other co-stressors, such as dissolved oxygen, nutrients, and harmful algal bloom species. Many species of interest are exposed to multi-stressor environments, and understanding the conditions they are exposed to will help inform experiments on species response. Target major rivers capable of creating corrosive conditions. Partner with USGS, EPA and other monitoring groups. Shore stations, moorings, MPAs, tribes, NEPs, NERRS,

Monitoring efforts can be targeted to address near urban and agricultural areas and in coordination with state and local quality monitoring programs. Plankton and zooplankton species, community structure and composition (including HABs), pteropods/ crab larvae, This will inform the impacts of OCA on species and delineate ecosystem response to OCA over time. Along-shore glider transects with BGC sensors, coastal moorings; co-located with offshore wind. Shore stations, seawater intake systems, stream gauges. Aquaculture monitoring sites. High DEIJA capacity building/workforce development potential.

Generally there is a lack of high-quality information about northern California. Could this area be a hotspot/refugee? Is there missing information that could aid in understanding what is occurring? More monitoring is needed. Story around snow crabs. Siren around climate impacts. Highlighting OA change. Concerns about finish and offshore windfarms. Monitoring across spatial gradients is important for long-term trend assessment and model predictions. Increase spatial coverage in OCA monitoring, particularly in the nearshore area and at depth. Increase monitoring in coastal and estuarine environments. Oregon and Northern California. Additional biological monitoring co-located with chemical ocean acidification monitoring. Monitoring can inform how local atmospheric inputs, riverine inflow, local pollution inputs, and other factors contribute to near-shore coastal acidification in critical ecosystems.

The network continues to struggle with the need for **more frequent monitoring in biologically significant nearshore habitats.** Capturing daily pH fluctuations and the range of variability are necessary for a more accurate understanding of biological responses to OCA. MPA monitoring is limited. Event response.

After learning that the greatest concern for Dungeness crab is late in life exposure to hypoxia, the group recognized the need for better information on crab distribution, movement, and abundance, and corresponding oxygen data. Previous lightrap monitoring efforts along the coast have ceased. The use of tags was explored for tracking movement during lifecycle stages. Other species of concern include abalone, urchin and sunflower stars and related kelp forest dynamics. There is also uncertainty whether the seasonal hypoxia experienced in OR and WA occurs in Northern Calfiornia waters, where D crab are most abundant.

VI. Solutions - Workshop key findings

1. *'Turning the Headlights on High' - Bio reboot*

A successful outcome of the initial C-CAN Workshop in 2010 was momentum towards building a cohesive, nearshore monitoring network capable of detecting climate-quality changes in ocean chemistry relevant to industry. This novel monitoring concept was one of the original community-led efforts that included shellfish growers from the onset. In total, five then state-of-the-art Burke-o-lator systems, named for its beloved developer Burke Hales of OSU, were deployed at shellfish aquaculture farms across the U.S. West Coast. These instruments, operated and maintained by an in-region marine carbon expert and other academic support, provided realtime carbonate chemistry data on the suite of carbonate parameters to provide a complete picture of seawater composition locally where the shellfish were grown. This information could then be used to make operational decisions such as whether to buffer acidified intake waters with soda lime, whether to delay outplanting of spat, and allowed shellfish growers the insight to understand success and challenges associated with seawater dynamics.

We have learned a lot since the initial Headlights project wrapped in 2018. Firstly, there are certain challenges involved when operating technologies that require a high degree of analytical skill outside of a chemistry laboratory. When the Burke-o-lator would break, there was no one onsite to fix them. Moreover, the data from the BoL could be hard to interpret, and derived information products to serve the data in useful formats were never fully developed. Lastly, in some locations, the partnership and translational information fell short as programs endured turnover both in technical and aquaculture staff.

Many of the original Headlights participants are still active in C-CAN and voiced strong interest in reigniting the program to building a biological observing component. It was agreed that some sites would no longer require the full BoL systems but could likely manage with an easier to operate instrument, even while missing certain parameters and degree of quality assurance. As for the biological build-out, Imaging FlowCytobots were discussed as a potential expansion of the chemical monitoring, as was eDNA.

2. **Standardizing across existing monitoring programs**

We need to better standardize OAH and relevant biological monitoring technique across existing programs to enable synthesis and understanding of status and trend across the California Current System. California and Washington are working to standardize the collection of OA data across existing, high-quality monitoring programs. But much work remains in standardizing biological data collection, including metadata standards and submission to archives for public dissemination. <u>Enumerate commercial crustacean fishery larvae in CalCOFI data</u> (jars of preserved samples since 1949).

Which technologies would be best suited for systematic O2 monitoring throughout the southern CA Bight (sensors on fishermen's gear, buoys, gliders, etc.) that could provide data to managers quickly enough to make appropriate decisions.

3. **Ecosystem modeling to scale from observations to stakeholder application**

Importance of predictive models – fisheries, fish, shellfish, everyone. <u>Food web studies to target certain species we know will have negative responses to OAH</u> and the subsequent impacts to the rest of the web (i.e. anchovies to birds, pinnipeds, etc.). For areas anchovies are left, will they be squeezed into locations where domoic acid is an issue? Modeling approaches for simulating various management strategies - measuring critical inputs to those models. For different types of species, what are the varying climate scenarios you'd want to test? What inputs would you change to model OAH impacts - decrease fecundity of rockfish? Hypoxic impacts to squid egg beds? The predicted fate of anchovies is very concerning for the So. California group (referencing the decline in aerobic volume of habitat) - will have cascading impacts on birds, etc. The oxygen minimum zone will continue to spread.

4. **Species thresholds and indicators of change**

Understanding extreme events and baseline shifts requires that we record climate events – information sharing and story core – anthropology and oral history. Distinguishing climate from different sources of variability. Diel signals of pH fluctuating, but now there's an overall reduction and dipping below critical points more frequently. Then there's diel, interannual, decadal, NGPDO, etc. Developing an index of ecosystem change. We need to put resources into this and science/solutions. Thresholds were discussed in length and prompted the recognition that it is important to think through all of the species responses to multiple variables such as saturation state, temperature, dissolved oxygen, etc. The variables versus less variable environments is important to explore and better understand.

5. HABs and multiple stressors

HABs with pseudo-nitzschia blooms eat up available nutrients and then become toxic. In SoCal you'd not likely get the bloom if there is less nutrient runoff. Can HABs be linked to land runoff? Not likely here in SoCal that's attributable to land/agriculture, but sewage outfalls. Increases in primary production - how much contributes to "blooms" and hypoxia across seasons? Link the source of nitrogen in pseudo-nitzschia blooms to identify what is driving the blooms, anthropogenic or otherwise. Does anthropogenic nutrient input exacerbate domoic acid blooms in SoCal? How is OAH promoting domoic acid blooms?

6. The need for long-term monitoring

We need long-term information and studies. Begin watching what we think we'll need to watch - and when it starts tipping, as fishermen, you start switching catch. However, buying into a new permit may mean excessive debt for those just starting out. There is a great need for long term monitoring. The new normal is abnormal. What does long term change look like? There was a need to identify regions or ecosystems with focus on monitoring that might be a refugee or regions likely to be altered. What is the strength of association between deep-sea corals and fished species, and how is that impacted by OAH? We know that seagrasses are altering chemistry in the bay and making conditions more favorable for shellfish. We are still lacking spatial and temporal, seasonal and interannual datastreams needed to constrain dynamics. Moreover, multiple stressor datastreams and models including nutrients and oxygen can help better constrain estuarine processes. CalCOFI larval data in samples are an underutilized source of info.

7. Fisheries-led observing

How do we build trust and credibility with industry and fishing communities? Collaboration should mean that fishermen are meaningfully included, as well as all interested parties. Begin building trust now - have regular meeting opportunities to have a space for discussion about the latest science and what industries are seeing in the field, or presentations like explaining what happened in AK with Dungeness crab. It's a problem for **everyone** so it should be collaborative in nature - not excluding certain groups. Environmental sensors on traps (SeaFET - but calibration and fouling are issues, but depending on soak times, 7 days or so would still have accurate readings).

Fishing communities want to be involved in the collection of OA and hypoxia information. There was excitement about putting sensors on fishing gear. Issues can arise through trust/concern from the fisherman/data collectors. Awareness that good partnerships can build trust. Working with the next generations of fisherfolk. Collaborations with researchers. Can we incentivize fishermen's cooperation in research and data collection by linking their participation to the ability to get another fishery permit if their primary fishery gets hit/shut down by OAH problems.

V. C-CAN - Where we're headed

Since its onset, C-CAN's mission and membership has grown to encompass both chemical and biological measurements and to serve multiple stakeholder groups including industry, resource managers, tribes, and other interested parties. In the future, C-CAN endeavors to create more engagement opportunities both among researchers and between scientific and other communities and especially including industry and traditionally marginalized and excluded groups. Stronger collaborations can be supported through co-designed engagements and products and, perhaps more importantly, co-implementation of the monitoring network. Improve flexibility

C-CAN brings everyone together. Identifies areas for actions and when to take these actions. Co-produce the priorities. Clarify the current problem statement and purpose – raise the conversation. C-CAN partners well with all partners. Expand the C-CAN message to other groups. All sectors working together. Trust and engagement are key for participants. Stakeholders need to be heard and engaged. A workplan refresh and implementation plan, including bylaws to help instruct membership. Enhanced communications to strengthen community and reestablish a bridge from research to stakeholders including through webinars, in-person meetings, smaller, regional meetings, and annual in-person meetings.

C-CAN aims to increase educational opportunities to expand awareness and resilience to acidified ocean waters. The message on ocean acidification should focus both on people and environment damage and joint messaging and not just one segment. It is important to continue communication with all of the groups involved at the same time. OA information exchange could be utilized better, more activity on the site is needed.C-CAN webinars are important. Communication needs to be taken up and down the chain. Clear message – 1 page story. New tools will need to be developed to reach new audiences.

The role of C-CAN is showing the stories and bringing it to the larger groups. The issue is not a straight line from change to ocean acidification. C-CAN can issue a statement on this. Credibility is an issue, is it also a labeling issue? Focus on the global change issue, the big prize, the unique connections and the various indexes. C-CAN can help with messaging. Highlighting a wide range of issues. The smoking gun level of certainty to message and be more open about uncertainty with the message. There is an opportunity to find new ways to support openness to change and enhance industry engagement.
The emergence of C-CAN 2.0 for the next ten years and reiterating the importance of communication from C-CAN members to the larger groups such as the state, federal and international acidification efforts to improve local enhancements of knowledge, solutions and importance. C-CAN is unique in that it truly engages the aquaculture and fishing communities in it and should continue to be a leader nationally in bringing all sectors to the table to discuss these important issues. A call for additional fishing industry and aquaculture representatives to the C-CAN fold was made to ensure a well-considered and balanced path forward.

To this end, continued and expanded partnerships were identified as a place for additional effort, specifically related to grants with joint government and industry grants where both sides support the research, co-development of the proposals where both sides can provide input and improve the proposals. The groups felt one key question that proposal generators should consider asking "how would you like to be included?"

The creation and use of federal repositories for data is not as advanced as other repositories and have those creating repositories with each other is important. It is important to improve reporting, California is setting standards. There should be a goal and recommendations for data repositories. The group also felt that focusing on youth is important for long-term success.

Marine carbon dioxide removal strategies are important. What are the alkalinity enhancement strategies? What specific locations is this needed? Overall there is a knowledge enhancement opportunity. What are the resulting ecosystem changes that can be measured with marine carbon dioxide removal strategies?

References

California Current Acidification Network (C-CAN) 2013. *Vision for Development of a West Coast Network for Monitoring Marine Acidification and its Linkages to Biological Effects.*

McLaughlin, K., S.B. Weisberg, A. Dickson, G. Hofmann, J. Newton. 2013. *Core Principles for Development of a West Coast Network for Monitoring Marine Acidification and Its Linkage to Biological Effects in the Nearshore Environment*. California Current Acidification Network (C-CAN).

Appendix A. Workshop Participants

Eureka, California
Alex Harper, (Facilitator) Monterey Bay Aquarium Research Institute
John Largier, University of California Davis
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Kim Thompson, Pacific Coast Shellfish Growers Association
George Waldbusser, Oregon State University
Steve Weisburg, Southern California Coastal Water Research Project Authority

Appendix B. Workshop Agenda

November 15, 2022	
7:30	Registration and Coffee
8:00	Welcome and Introductions – Russell Callender, Washington Sea Grant
8:10	C-CAN History, 2010 meeting, goals and objectives, outcomes – Steve Weisberg, Southern California Coastal Water Research Project
8:30	Present knowledge about acidification chemistry in the California Current - Richard Feely, NOAA Pacific Marine Laboratory
9:00	Present knowledge about biological response to acidification in the California Current – Kristy Kroeker, UC Santa Cruz
9:30	Break
10:00	Fishery industry information needs – Mike Conroy, Pacific Coast Federation of Fisherman's Associations and Dick Ogg, F/V Karen Jeanne
10:20	Aquaculture industry information needs – Bill Dewey, Taylor Shellfish
10:40	Fishery management information needs – Julia Coates, California Department of Fish and Wildlife
11:00	Water quality management information needs – Kaegan Scully-Engelmeyer, Oregon Department of Environmental Quality
11:20	Pteropods as excellent indicators for monitoring anthropogenic ocean acidification – Nina Bednarsek, Oregon State Univeristy
11:40	Tribal information needs – Candace Penn, Squaxin Island Tribe
Noon	Lunch – provided
Breakout session	
12:40	Breakout session discussion question: *What are the biological information needs you have in your business/work?*
3:30	Plenary: Breakout group report outs
4:00	Adjourn
November 16, 2022	

7:30	Coffee
8:00	Review Day 1 and Goals for Day 2
OA Collaboration Successes Along the West Coast	
8:20	Models in service of water quality management – California Bight case study – Martha Sutula, Southern California Coastal Water Research Project
8:40	Collaborative information development - Shellfish Industry case study - George Walbusser, Oregon State University and Alan Barton, Whiskey Creek Shellfish Hatchery
9:00	Collaborative information development – Kelp case study – Jan Freiwald, Reef Check
9:20	Collaborative information development – Dungeness Crab fishery case study – Francis Chan, Oregon State University
9:40	Break
9:55	Breakout session discussion questions: *How well are the biological information needs being met currently?* *Is the right data being collected?* *Is it the right quality?* *Is it synchronous?* *Is it collected with supporting chemistry data?* *And to the extent that they are not being met, we need to prioritize what needs to be addressed.*
11:00	Plenary: Breakout group report outs
11:30	Lunch – provided
12:30	Breakout session discussion questions: *How do we improve the current situation and enhance collaboration such that needs are being met.*
2:30	Plenary: Breakout group report outs
3:15	Next steps
4:00	Adjourn

Appendix C. Background materials

Core Principles of the California Current Acidification Network: Linking Chemistry, Physics and Ecological Effects - https://tos.org/oceanography/article/core-principles-of-the-california-current-acidification-network-linking-che

Enhancing California's Ocean Acidification and Hypoxia Monitoring Network - http://westcoastoah.org/wp-content/uploads/2020/06/Enhancing-California's-Ocean-Acidification-and-Hypoxia-Monitoring-Network.pdf

The West Coast Ocean Acidification and Hypoxia Science Panel major findings, recommendations and actions - http://westcoastoah.org/wp-content/uploads/2020/06/Enhancing-California's-Ocean-Acidification-and-Hypoxia-Monitoring-Network.pdf