The Olympic Coast as a Sentinel: *An Integrated Social-Ecological Regional Vulnerability Assessment to Ocean Acidification*

Jan Newton, Melissa Poe, and team

Project Goal

Our overarching goal is to provide an assessment of: **coupled social-ecological vulnerability** to effects from OA that is based **on *new* social science and a synthesis of existing data and model projections** relevant to the Olympic Coast, its biological resources, and its inhabitants (including participating coastal tribes), developed in an actionable interdisciplinary approach that is 1) transferrable to other locations and 2) strengthens capacities for vulnerable place-based communities to adapt.

Project Genesis

- The Olympic Coast National Marine Sanctuary (OCNMS) and NOAA's Ocean Acidification Program recently convened a workshop with regional partners to define the Olympic Coast as an "OA sentinel site."
- Priority needs identified during the workshop include **integration of chemical and biological data and identification of where coupled biological and social vulnerability to OA is highest**, which to date have been generalized or extrapolated from the literature.
- Our project responds directly to this need, building on strong collaborative partnerships to ensure actionable information for response strategies. Together, the University of Washington (WOAC, WSG, JISAO), NOAA (PMEL, OCNMS, NWFSC, IEA), ONP, the Hoh, Makah, Quileute Tribes, Quinault Nation, state agencies, and other collaborators are leaders in conducting regional OA science, primarily with support from NOAA and Washington State.

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- This work will benefit from the rich abundance of long-term observations located in the region. OA risks will be determined using new social science with participating coastal treaty tribes – the Hoh Tribe, the Makah Tribe, and the Quinault Indian Nation – who rely on Olympic Coast resources as fundamental to their way of life. We plan to engage the fourth coastal tribe, the Quileute Tribe, who did not have time to review this work before their Tribal Council at the time of proposal submission.

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- Our proposed assessment is based on original social science research, together with synthesis of existing chemical and biological data from open ocean to intertidal areas, and new model projections, to assess current and projected vulnerabilities associated with OA. Integrating social and natural sciences enables us to identify direct and indirect exposures and sensitivities of OA to key biological resources and coastal communities.

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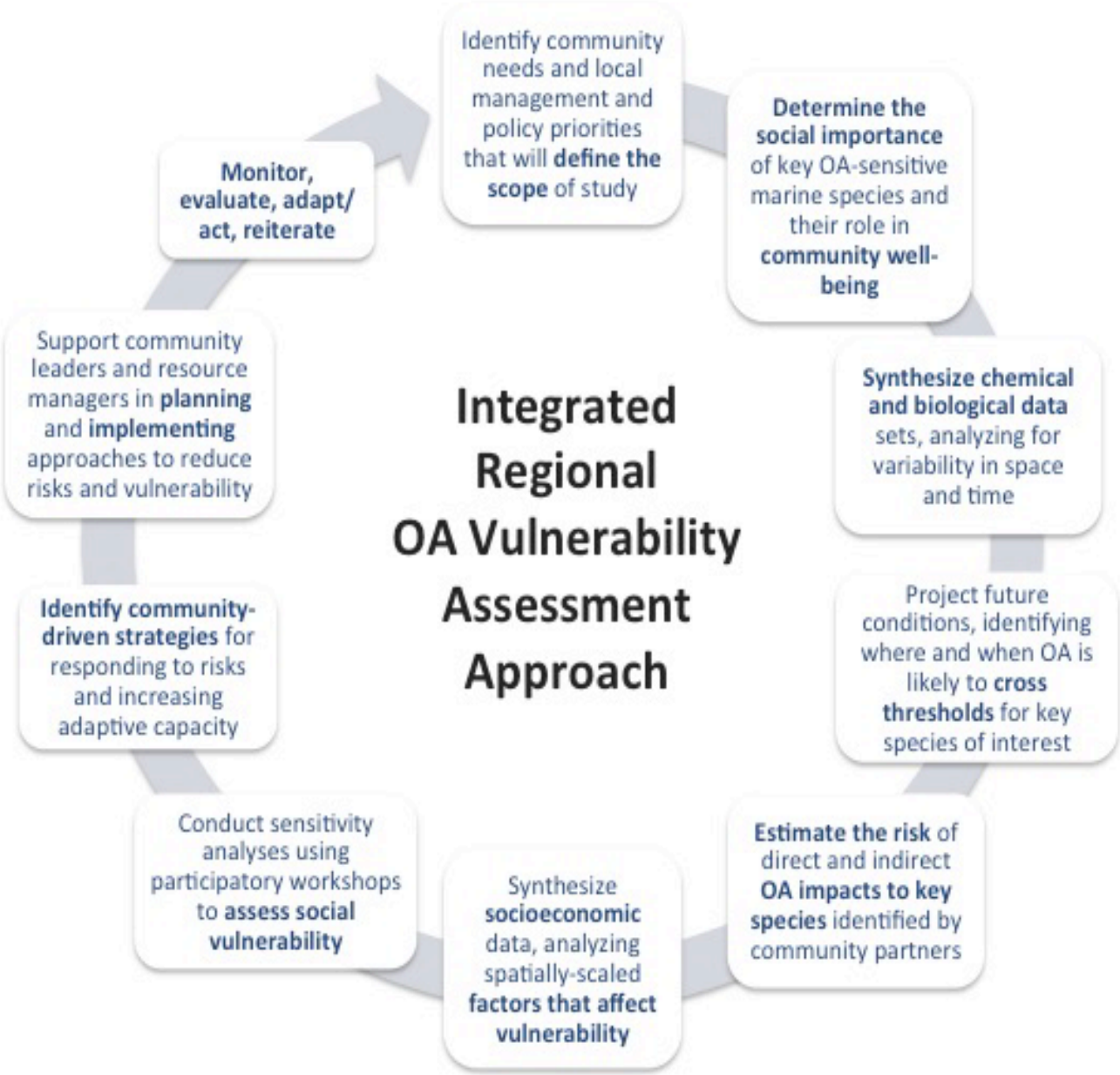
- Our collaborative project is developed in partnership with tribal co-investigators and other regional resource managers from project start to finish and is rooted in a focus on local priorities for social, cultural, and ecological health and adaptive capacity.

Project Objectives

- *Objective 1:* Using new social information co-produced with coastal tribes, **determine the social importance of key OA-sensitive marine species of the PNW Olympic Coast and the role these species play in community well-being**. (Poe, lead)
- *Objective 2*: **Synthesize existing chemical and biological data sets** from Olympic Coast open ocean to intertidal areas, analyzing variability in space and time. (Newton, lead)
- *Objective 3*: Using modeled future projections, **identify regions and timing of where OA conditions will cross thresholds for key species of interest to community partners**. (Siedlecki, lead)
- *Objective 4*: **Estimate the risk of direct and indirect OA impacts to key biological resources** that are important to tribal community partners. (Newton, Siedlecki, and others)
- *Objective 5:* Synthesize existing socioeconomic data, **analyzing spatially-scaled socioeconomic factors that affect social vulnerability and the ability to cope**. (Poe and Watkinson)
- *Objective 6*: **Assess the social dimensions of OA vulnerability** through workshop-based community well-being sensitivity analyses, and **identify community-driven strategies for responding to threats and increasing adaptive capacity**. (Poe)
- *Objective 7*: **Engage with and provide critical information to the area's residents and decision-makers to increase coastal communities' ability** to prepare for and respond to OA vulnerabilities. (Poe, Newton, Chadsey)
- *Objective 8*: **Develop an integrated place-based approach to assess coupled social-ecological vulnerability that is transferrable** to other complex physical and cultural contexts confronting OA and planning responses. (Poe and Newton)


Integrated Regional OA Vulnerability Assessment Approach
Identify community needs and local management and policy priorities that will **define the scope** of study
Determine the social importance of key OA-sensitive marine species and their role in **community well-being**
Synthesize chemical and biological data sets, analyzing for variability in space and time
Project future conditions, identifying where and when OA is likely to **cross thresholds** for key species of interest
Estimate the risk of direct and indirect **OA impacts to key species** identified by community partners
Synthesize **socioeconomic** data, analyzing spatially-scaled **factors that affect vulnerability**
Conduct sensitivity analyses using participatory workshops to **assess social vulnerability**
Identify community-driven strategies for responding to risks and increasing adaptive capacity
Support community leaders and resource managers in **planning** and **implementing** approaches to reduce risks and vulnerability
Monitor, evaluate, adapt/ act, reiterate

Project Team

- *Lead PIs:*
  Jan Newton (Lead PI), UW Applied Physics Lab/Washington Ocean Acidification Center (WOAC)
  Melissa Poe (Co-PI), UW Washington Sea Grant (WSG)/NOAA Northwest Fisheries Science Center (NWFSC)

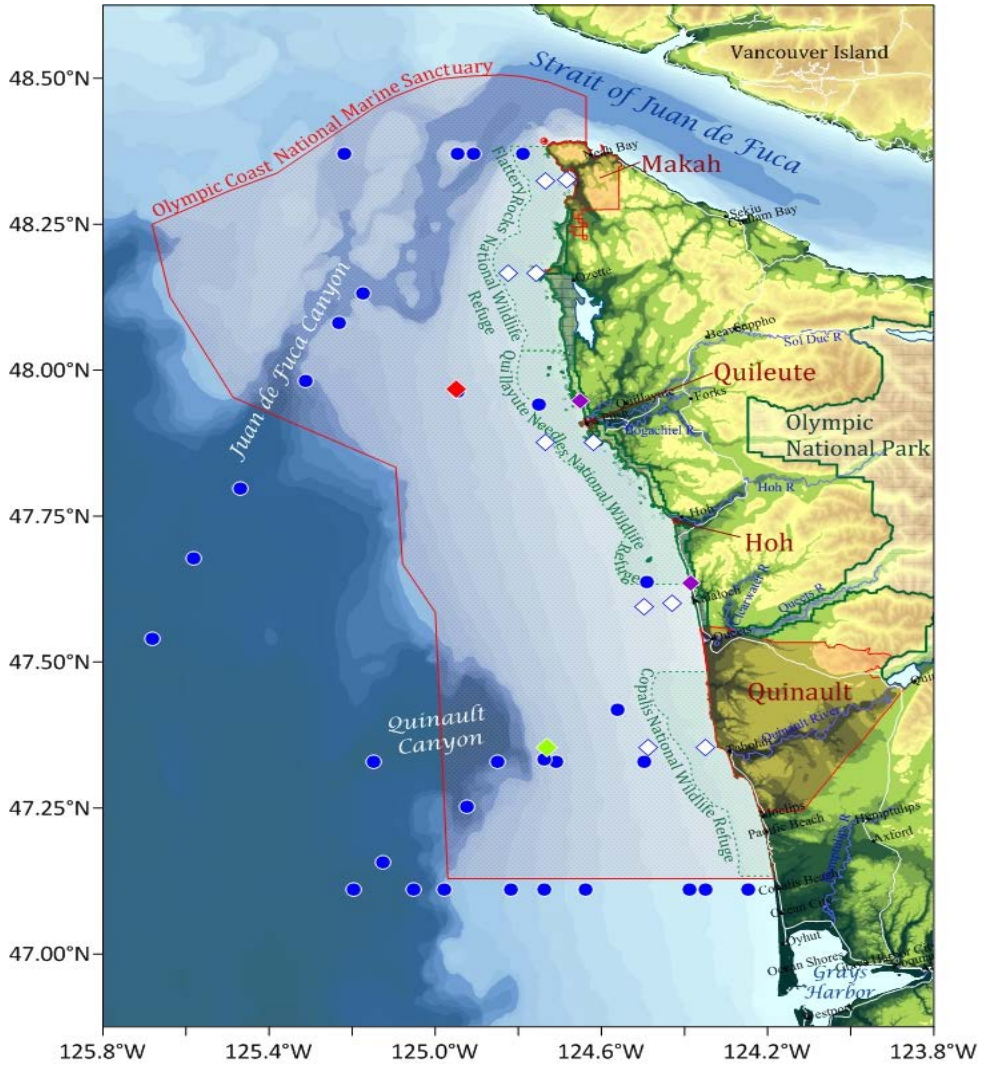
- *Co-PIs:*
  Simone Alin, NOAA Pacific Marine Environmental Lab (PMEL)
  Meg Chadsey, WSG/PMEL
  Richard Feely, PMEL
  Steven Fradkin, Olympic National Park (ONP)
  Khalid Marcus, Hoh Tribe
  Joe Schumacker, Quinault Indian Nation (QIN)
  Samantha Siedlecki, UW Joint Institute for the Study of the Atmosphere and Ocean (JISAO)
  Russell Svec, Makah Tribe
  Jenny Waddell, Olympic Coast National Marine Sanctuary (OCNMS)
  Melissa Watkinson, WSG

- *Partners:*
  Jennifer Hagen, Quileute Tribe
  Adrienne Sutton, (JISAO)

Project Outcomes

- ***Tribal resilience***: Tribal decision-makers can incorporate relevant information about the nature and timing of OA impacts, and community vulnerabilities and strengths, into strategies to protect and maintain traditional and cultural practices associated with marine resources and to strengthen community resilience to change. Tribal fisheries managers can incorporate research findings into decisions about timing, location, effort, and targets of harvest and management to optimize community benefits and improve fisheries management.
- ***Sustainable Fisheries***: Regional non-tribal fisheries managers can incorporate research findings into decisions about timing, location, effort, and targets of harvests to ensure sustainable commercial and recreational harvests, support trust responsibilities with treaty tribes, and optimize community benefits, thus improving ecosystem-based fisheries management.
- ***Science to Management***: National Park Service, OCNMS, and coastal Tribes provided with information about critical areas (OA "hotspots" and potential refugia) to inform co-management and research efforts. Other regional state/federal managers provided with information about OA drivers/impacts to improve ecosystem management/ systems thinking.
- ***Science to Policy***: New published science on OA status and forecasts generated for Olympic region. Regional marine policy advisory bodies (e.g. WA Marine Resources Advisory Council) informed of findings. Study supports Olympic Coast OA Sentinel Site concept.
- ***Increased awareness***: Research findings shared with the public by tribes, NOAA, UW and others, and highlighted in educational curricula.
- ***Transfer***: Approach and methodology (diagrammed on previous page) exported to other regions, and applied to other regional hazard management needs (e.g., HABs, climate change).

Figure 1. Map of Olympic Coast of Washington state, showing the location of the four coastal treaty tribes, other coastal communities, OCNMS (red boundaries offshore), National Wildlife Refuges managed by the U.S. Fish and Wildlife Service (green dashed lines offshore), and coastal portions of ONP (green bounded areas onshore). Superimposed symbols reflect chemical and biological sampling stations for NOAA PMEL cruises (blue circles), Cha'ba NANOOS-NOAA PMEL mooring (2010-2016, red diamond), Cape Elizabeth NDBC-NOAA PMEL mooring (2006-2016, green diamond), OCNMS moorings (2001-2016, white diamonds), and ONP anchored sensors (2010-2016, purple diamonds).



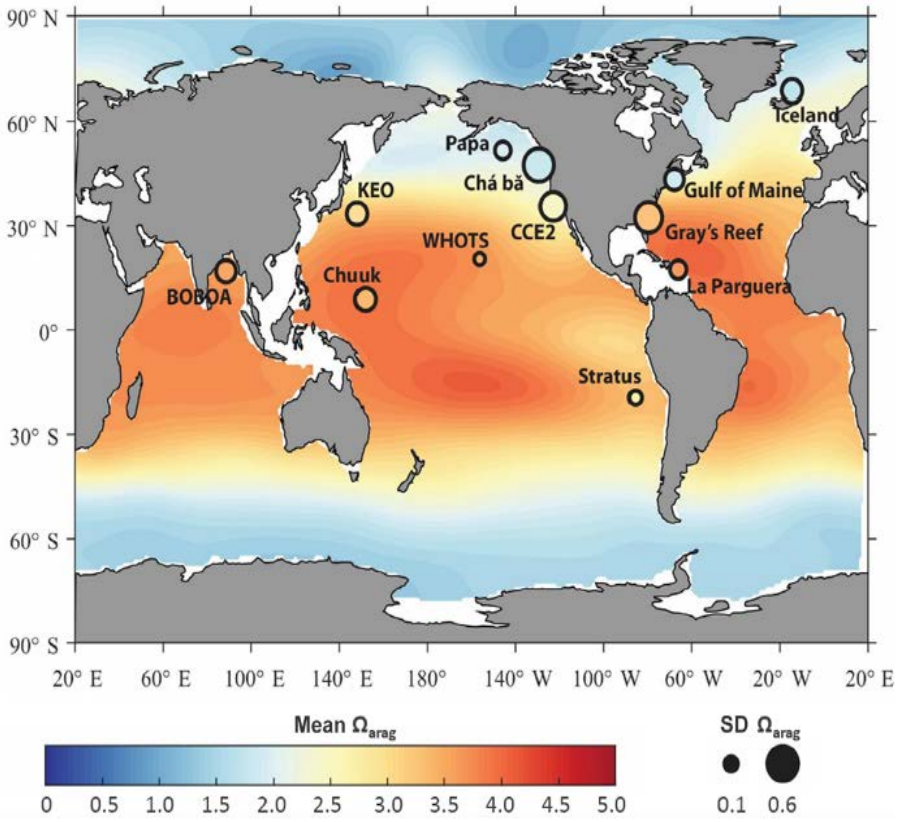


Figure 2. Twelve of the 19 NOAA PMEL/OAP/partner moorings (circles) shown against a backdrop of global ocean mean surface Ωarag from Jiang et al. (2015). The color of each symbol reflects the long-term mean Ωarag value at each site, the diameter its standard deviation. Figure from Sutton et al. (2016).

The Cha'ba mooring has the highest subseasonal variability of all mooring sites in this network (Sutton et al 2016).

Project Context

- ***Problem Statement and Response to Community Partners' Needs:***

The Olympic Coast, located in the Pacific Northwest (PNW) U.S., is already experiencing effects from ocean acidification (OA) (Sutton et al. 2016; Bednarsek et al. 2014), which poses risks to marine resources important to the public, especially local Native American tribes who are rooted in this place and have depended on marine treaty-protected resources since time immemorial.

Harvest and use of Olympic Coast marine species are central to the well-being of coastal tribes for their livelihoods, subsistence and food security, ceremonial and cultural practices.

Thus, OA can create significant, unique and disproportionate social vulnerabilities that must be addressed within appropriate regional and cultural contexts.

To date, **an assessment of the ramifications of OA to tribes in this region is lacking**. "The tribes of the west coast of the U.S. are literally on the frontline of ocean acidification impacts," stated Joe Schumacker, marine scientist for Quinault Nation; adding, "we have a responsibility to know so we can plan for an uncertain future."