Making progress on Washington State Blue Ribbon Panel Recommendations on Ocean Acidification

Adaptation and Remediation

August 2015

Chapter 6 of the Washington State Blue Ribbon Panel on Ocean Acidification (OA) identifies recommendations to increase our ability to adapt to and remediate the impacts of OA. It calls for 12 actions within three strategies:

- **Strategy 6.1** Remediate seawater chemistry
- **Strategy 6.2** Increase the capacity of resource managers and the shellfish industry to adapt to OA
- **Strategy 6.3** Enhance resilience of native and cultivated shellfish populations and ecosystems on which they depend

The following table highlights accomplishments towards implementing these actions.

Notes: [KEA] stands for Key Early Actions.
Italic text indicates priorities identified by MRAC but are not being implemented currently.

Action	Action Title	Accomplishments & Priorities	Partners	Funding
Action 6.1.1	Develop vegetation-based systems of remediation for use in upland habitats and in shellfish areas. *[KEA]*	Established experiments at five sites to assess capacity of submerged aquatic vegetation to ameliorate the local corrosion of low pH waters. Initial experiments determined rate of pH change during daylight and night in eelgrass, bare and shellfish habitat. Results indicate photosynthesizing eelgrass raises pH of water flowing over patch at rate of 0.5 pH units per hour. Areas with eelgrass also retained higher pH through the dark and into dawn. Further research occurring summer 2015: • Collecting ecologically and commercially important larvae (geoduck, Olympia oyster, Pacific oyster, and Manila clam) during daylight and night to investigate the role eelgrass may provide as ocean acidification refugia.	DNR (AAMT), UW	$228,000 IAA with UW $268,000 DNR $80,000 State Legislature

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		• Placing logging sensor packages containing pH, DO, salinity, temperature, depth and chlorophyll and sampling for total alkalinity within large eelgrass meadows, along meadow edge and bare habitat to determine whether the water quality effects from eelgrass can be scaled up spatially • Placing logging sensor packages and sampling for total alkalinity within and outside eelgrass at DNR Aquatic Reserves to assess water quality changes throughout the year. • Constructing 'artificial seagrass units' (ASUs) to deploy with water quality sensor packages and measure fish abundance to compare structural and water quality functions of eelgrass habitat.		
		Conducted field experiments to document potential differences in growth when clams are raised within eelgrass beds or on mud flats.	NOAA NWFSC	
		Beginning a five year project to test the use of planting seaweed and kelp to improve water quality and draw down levels of dissolved CO_2. Project awarded in 2015. Work is underway to start the first year of cultivation and propagation at a site north of the Hood Canal Bridge at Hood Head. *[MRAC priority action]*	PSRF, NOAA, DNR, WDFW, Taylor Shellfish, UW, WOAC, SeaGrant, Anchor QEA	$1.5 million Paul G. Allen Foundation
		Working to use vegetation systems to filter stormwater and reduce land based contributions to OA.		
		Studying the potential for salt marshes to sequester carbon.		
		Investigate current terrestrial nitrogen mitigation efforts as a potential adaptation strategy.	Ian Jefferds	

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Action 6.1.2	Maintain and expand shellfish production to support healthy marine waters.	Included in the Action Agenda and being tracked to increase shellfish production and restore shellfish beds for CO2 mitigation.	Puget Sound Partnership	
		Assess the capacity for existing and expanded shellfish production to mitigate CO2.		
		Relaunch of Washington Shellfish Initiative.	Washington Shellfish Initiative	
Action 6.1.3	Use shells in targeted marine areas to remediate impacts of local acidification on shellfish.	Designing a pilot shell recycling program. A workgroup is being convened including pathologist and WDFW staff to assess risks and identify appropriate next steps. This workgroup will meet prior to the October MRAC meeting.	PSRF, tribes, Shellfish growers, DNR (AAMT)	
Action 6.2.1	Ensure continued water quality monitoring at the six existing shellfish hatcheries and rearing areas to enable real-time management of hatcheries under changing pH conditions. *[KEA]*	Updated monitoring equipment at six sites and providing ongoing technical assistance at multiple shellfish hatcheries. Data is being shared through NANOOS.	WOAC, Taylor Shellfish, Whiskey Creek Shellfish Hatchery, Burke Hales, NOAA, IOOS	$150,000 State Legislature (2013)
		Identify funding for additional OA monitoring sites in Humboldt Bay, Totten Inlet, Hawaii, and other sites that are important to Washington shellfish industry. PCSGA is planning to add five additional monitoring sites (currently undecided on location). A technical expert is also planning to work with hatcheries in each region.	PCSGA	
		Provide information and tools to shellfish growers so they can monitor and respond to changes in OA, including: • A manual for growers to use in operating and maintaining on-site monitoring tools. • Education workshops for shellfish growers. • Tools to share research results with shellfish growers.		
		New pH sensors deployed by King County including a buoy at Point Wells.	King County, NOAA, WOAC	

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Action 6.2.2	Expand the deployment of instruments and chemical monitoring to post-hatchery shellfish facilities and farms.	Monitoring OA at a setting station in Willapa Bay.	PSI	
		OA (TCO_2) sensors installed at Whiskey Creek and Taylor Shellfish facilities. Additional monitoring sites being established in Alaska and California.	Burk Hales, Whiskey Creek Shellfish Hatchery, Taylor Shellfish	
		Competition awarded to Sunburst Sensors for creating a pH sensor technology that accurately measure OA for both scientific and commercial uses.	Wendy Schmidt Ocean Health XPRIZE	$2 million XPRIZE
		Enhance the existing monitoring network and research capacity to investigate the impact of OA exposure on competent, post-set larvae.		
Action 6.2.3	Investigate and develop commercial-scale water treatment methods or hatchery designs to protect larvae from corrosive seawater. *[KEA]*	Working at Taylor Shellfish and Whiskey Creek Shellfish Hatchery to develop hatchery methods that mitigate corrosive conditions. Current work is focused on testing new monitoring equipment and further developing water treatment methods.	WOAC, Taylor Shellfish, Whiskey Creek Shellfish Hatchery	$100,000 State Legislature (2013)
		Continue to support current efforts to investigate and develop commercial-water treatment methods or hatchery designs to protect oyster larvae from corrosive seawater.		
Action 6.2.4	Develop and incorporate acidification indicators and thresholds to guide adaptive action for species & places.	Developed oyster bioassay that measures growth of oysters with slow release buffering ability. Developed bioassay to empirically determine growth rate of settled Pacific oyster larvae through range of pH, alkalinity, and aragonite concentrations. Deployed settled Pacific and Olympia oyster plates within and outside eelgrass beds at several sites in Willapa Bay and Padilla Bay to monitor for growth on a regular basis. Working to develop bioassay for measuring growth rates of native Olympia Oysters along pH, alkalinity and aragonite saturation gradients.	UW, WWU, DNR	$70,000 DNR

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		Trials underway to establish thresholds for gigas oysters.	Whiskey Creek Shellfish Hatchery	
		Provide funding for the development of acidification indicators and thresholds to guide adaptive action for species and places.		
		Developing an assay on shell growth to understand how organisms lay down new shell.	Nina Bednarsek & George Waldbusser	
		Pteropod research and monitoring underway to use as a bio indicator along the outer cost and at eight sites in the Salish Sea.		
Action 6.3.1	Preserve Washington's existing native sea grass and kelp populations and where possible restore these populations.	Developed a Marine Vegetation Atlas and an eelgrass transplant site suitability model to optimize eelgrass restoration throughout Puget Sound. The eelgrass transplant model was employed to restore eelgrass at sites throughout Puget Sound and along the Washington coast. The Marine Vegetation Atlas is posted live at : http://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/washington-marine-vegetation-atlas Locations where eelgrass has been transplanted include: Port Gamble Bay, Quilcene Bay, Dyes Inlet, Eld Inlet, Zangle Cove, Joemma State Park, Anderson Island, McNeil Island, Pickering Passage, Westcott Bay, Port Orchard Bay, Delano Beach, Herron Island, and Stretch Island. Future restoration locations include sites in the vicinity of the Nisqually, Skokomish and Elwha River deltas and other locations in South Puget Sound.	DNR	
		Developing kelp restoration practices and techniques. New kelp culture facility at the Ken Chu Hatchery will add capacity to do restoration and keep these techniques moving forward.	PSRF	Funding needed

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		Operations at shellfish industry facilities already preserve native sea grass and kelp populations. The industry is working on how to measure their contribution.	Shellfish growers	
		Developed a strategy to increase eelgrass in Puget Sound by 20% by 2020.	Puget Sound Partnership, DNR	
		Ongoing monitoring of kelp beds in four counties to understanding how land use practices influence these beds.	MRCs, Northwest Straits Commission	
		Convening of the Kelp Alliance to work in partnership with MRACs to: • Monitor changes in local kelp populations • Foster awareness about the ecological and cultural importance of kelp • Promote citizen science contributions to regional research • Provide a forum for exchanging relevant information and idea	Northwest Straits Commission, MRCs	
Action 6.3.2	Identify, protect and manage refuges for organisms vulnerable to OA and other stressors. *[KEA]*	Deployed logging sensor package and sampling for total alkalinity within and outside eelgrass at DNR Aquatic Reserves to assess water quality changes throughout the year. Snohomish, Island and San Juan MRCs poised to do this through implementation of Marine Stewardship Area plans; effective management somewhat dependent on local political processes.	DNR	$30,500 DNR

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		Aggregated current research and monitoring on the potential for salt marshes to act as refuges for shellfish and seafood. Deploying logging sensor packages at restored saltmarsh/river deltas including Skokomish, Snohomish and Nisqually. Planning to deploy oyster bioassay at restored saltmarshes to measure rate of growth.	DNR	
		A workgroup is being convened to identify criteria to select locations to apply multiple remediation strategies, measure them, and use those results to create refuges. *[MRAC priority action]*	Ecology, WDFW, DNR, PSRF, Tribes, Shellfish growers	
Action 6.3.3	Support restoration and conservation of native oysters.	Restoring 100 acres of native oyster habitat. Since 2010, over 40 acres have been restored. WDFW has identified priority restoration areas and permits are underway but funding is needed for implementation.	PSRF, Tribes, WDFW, Ecology, DNR, NOAA, USDA, Shellfish growers	Funding needed to continue
		Investigate the capacity of native oyster beds to increase OA resilience. *[MRAC priority action]*	*WDFW, PSRF, Pacific Shellfish Institute*	*$660,000 requested from State Legislature in 2015-17, unfunded*
Action 6.3.4	Use conservation hatchery techniques to maintain the genetic diversity of native shellfish species.	Built a new hatchery in Manchester, WA to support seed production for native oyster restoration and research on other native shellfish species and living marine resources. Funding is needed to continue operating a conservation hatchery to support restoration and research of native shellfish species.	NOAA, PSRF, Ecology, DNR, WDFW	$543,000 NOAA $400,000 Ecology $30,000 DNR $100,000 WDFW $19,000 Paul Allen Grant

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Action 6.3.5	Investigate genetic mechanisms and selective breeding approaches for acidification tolerance in shellfish and other vulnerable marine species.	Completed studies on how OA affects gene expression in Manila clams, Dungeness crab, proteomics, and Mediterranean mussels.	NOAA (NWFSC), UW	
		Conducting oyster crossbreeding and selection for resistance to OA in Pacific oysters and hatchery exposures for giga oysters.	Washington Sea Grant, UW Fisheries, NOAA, OSU, Taylor Shellfish, PSI	$253,398 NOAA
		Investigate the capacity for other fishes and invertebrates to adapt to changing OA conditions in Puget Sound and coastal estuaries. Target species might include California sea mussels, Sea stars, urchins, sea cucumbers and other economically important and/or keystone species in the marine environment.		
		Research being conducted on geoduck DNA to understand their likelihood of adapting to OA conditions.	NOAA	
		Looking at molecular mechanisms of the Pacific oyster at the physiological level to understand the OA challenge	NSF	
		Research the capacity for genetic adaptation to OA in keystone and commercially important species within Washington waters. [MRAC priority action]	*PSRF, UW*	*Funding needed to start, estimated at $700,000*