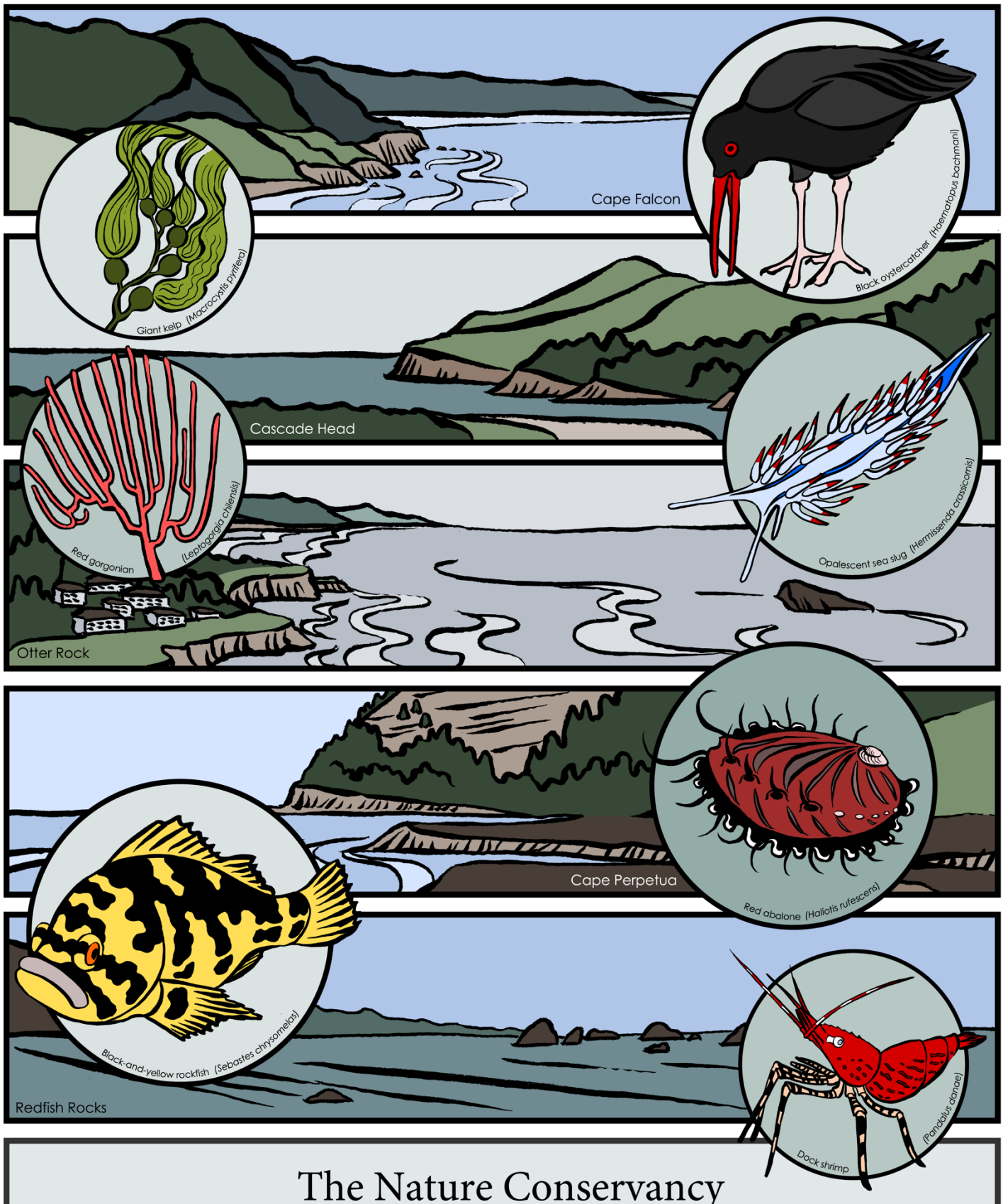

The Nature Conservancy

Oregon Marine Reserves Rocky Intertidal Monitoring Workshop

April 18, 2017 Newport, Oregon

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Executive Summary

On April 18, 2017, a total of 30 people (Appendix A) convened in Newport, Oregon to advance interests in Oregon's marine reserves rocky intertidal monitoring efforts. Specifically, experts from Oregon, Washington, and California met to:

- Share updates on Oregon and Northern California intertidal ecological monitoring interests as well as Oregon's upcoming process to update the Territorial Sea Plan by incorporating a Rocky Tidal Monitoring Network;
- Address key gaps in intertidal monitoring;
- Achieve consensus on the core elements of a long-term sustainable intertidal monitoring network, focusing on two examples—Olympic National Park and the Ocean Acidification and Hypoxia Monitoring Network; and
- Develop strategies to sustain intertidal monitoring long-term.

The agenda for the workshop (Appendix B) included a state-of-the-state session, in which attendees were given an opportunity to briefly share the highlights of their monitoring programs, followed by a networking session, in which they engaged with one another to explore mutual interests, ask questions, and develop a shared understanding of their respective programs.

The networking session was followed by three in-depth presentations on long-term intertidal monitoring at Olympic National Park in Washington, current work underway to revise the designation of Oregon's rocky intertidal sites as part of an amendment to the state's Territorial Sea Plan, and the West Coast Ocean Acidification and Hypoxia Network. All three presentations were intended to set the stage for breakout session discussions, in which attendees addressed questions associated with climate change impacts on rocky intertidal areas, high priority rocky intertidal monitoring issues, and potential additional protections that could be implemented to protect rocky intertidal habitats.

The workshop concluded with a discussion about opportunities for potential collaboration focused on data sharing, outreach and education, policy, and funding categories.

Recommendations:

- Share the results of this workshop with the Oregon Ocean Science Trust. During the 2016 summit, the Ocean Science Trust developed a set of strategies specific to research and monitoring budget levels (https://www.oregon.gov/dsl/OOST/Documents/OOST_summitreport2016EDITED.pdf. Crosswalk the outcomes and recommendations of this report with their recommendations, particularly in the areas of monitoring of physical parameters to determine oceanographic variability and vulnerability to ocean acidification and hypoxia at coastal nodes as well as criteria that should be considered when designing effective monitoring and research programs.

- Support continued climate change monitoring as promoted by the Ocean Acidification and Hypoxia Monitoring Network. Climate change impacts that may affect rocky intertidal areas

include: **Human impacts,** including drone use, waste water, marine debris, national policy associated with climate change and its corresponding effects (and policies in general), human population numbers; **Physical change impacts** including sea level rise, incidence of heat waves, storm frequency, erosion, changes to sand, air and water temperature, harmful algal blooms, ocean acidification, weather changes, changes in ocean circulation patterns, Pacific Decadal Oscillation (PDO), El Niño, and changing ocean currents; and **Biological/ecological impacts** including range extensions/shifts, invasive species, disease, changes in phenology, disease outbreaks associated with temperature changes, loss of macro algae, and changes in inter-specific competition.

- Develop a list of Important criteria to consider for priority rocky intertidal monitoring work. Issues that need to be addressed through research and monitoring include
  1) developing standardized protocols re: how/where data is collected and focusing on obtaining continuous data consistently and sustainably long-term as well as the use of data collected;
  2) designing a monitoring program that uses consistent protocols across sites and is as expansive as possible so that it can accommodate emerging issues;
  3) ensuring it is cost-effective and uses new and existing technologically effectively, matching questions to project design;
  4) focusing on management needs as well as projected/emerging issues;
  5) tracking keystone species and multi-species complexes;
  6) telling compelling stories;
  7) using modeling to evaluate what-if questions in rocky intertidal habitats;
  8) implementing conceptual food web numerical modeling;
  9) clearly articulating ecosystem services;
  10) incorporating and valuing human dimension research to tell the story of how people connect to these places, and identifying refugia.
  11) Priority rocky intertidal monitoring programs include local and relevant meteorological measurements for the rocky intertidal zone as well as beach bird surveys.
  12) Priority rocky intertidal research includes mapping subtidal extent of rocky habitats and quantify existing rocky substrates;
  13) conducting vulnerability assessments, assessing human use and impacts, documenting sand inundation effect, predicting how communities will change,
  14) defining indicators that could be tied to signal change,
  15) determining the level of harvest sustainable within rocky intertidal habitats, and climate change impacts and components.

- Support measures to expand protection of rocky intertidal habitats including additional research that demonstrates the need for additional actions, considerations for tribal sovereign nation rights, connectivity among refugia sites, and vulnerability assessments to prioritize high- and low-risk areas. Articulating ecological goals with any protection strategies is important. The following are specific recommendations for actions:

1) **Identify habitat refugia**, including no take reserves and limited/no access reserves. This could be achieved by designating inaccessible places that are currently inaccessible.
2) **Enhance educational efforts**, including expanded interpretation, incorporating oceans into the Outdoor School, including different language and cultures into outreach, and articulating stewardship messages using species people care about.
3) **Promote new policy**, such as adding a climate change chapter to Oregon's Territorial Sea Plan, enhanced protections for water quality, implementing the precautionary principle, and mandates for state agencies to conducting monitoring in rocky intertidal zones.
4) **Reduce multiple stressors**
5) **Promote the public trust doctrine** and the mandate that natural resource managers are required to ensure long-term sustainability of resources.
6) **Enforce exist regulations.**
7) **Establish intertidal MPAs.**
8) **Define the appropriate use of drones.**
9) **Mitigate visitation impacts** past certain thresholds while positively managing human uses.
10) **Develop low impact access to sites**, or trails, to allow time for recovery/restoration.
11) **Change how we communicate protections**, e.g., chains or ropes versus signs.

Photo credit: Rick McEwan.

Presentations

Oregon Department of Fish and Wildlife (Dave Fox)

Dave Fox presented information on the ShoreZone Survey, Native Littleneck Clam Survey, rocky intertidal collaborations, and unusual findings and sea star wasting information.

- The Oregon portion of the ShoreZone Survey, completed in 2014, is an aerial survey that classified habitat and mapped Oregon's oceans and estuaries as part of a larger effort that includes imagery from 113,000 km of shoreline in Oregon, Washington, British Columbia, and Alaska. The survey delineated along-shore geomorphology and biology, and is an extensive dataset informing a variety of analyses and management needs. Photos, video, and data from the Oregon portion are available at http://oregonshorezone.info/. The entire dataset is available at http://www.shorezone.org.
- Littleneck clams (*Leukoma staminea*) are surveyed in Oregon's rocky intertidal because population-level rapid declines were documented in the late 2000's in Washington and Alaska, and landings and estuary populations in Oregon have both decreased substantially. Oregon seeks to document changes in density through time as well as comparisons of recruitment.
- ODFW is monitoring sea star wasting disease during the summer months in two of Oregon's marine reserve sites. In 2015, Oregon observed disease in 11% of the population compared to 9% in 2016. ODFW also observed an increase in the frequency of *P. ochraceus* across size classes less than 100mm, with the greater increased observed in 10-20mm size classes. The 2016 information demonstrates a 1,060% increase in the number of juveniles (<30mm), which may reflect the episodic pulses in recruitment and the patchy distribution of these recruitment events.
- In Oregon's subtidal rocky reefs, biologists have observed both an explosion in purple sea urchin populations as well as several starved abalones (lab tests confirmed the abalones were not suffering from withering syndrome).

Cape Arago (Alan Shanks, University of Oregon, Oregon Institute of Marine Biology)

Alan Shanks presented on rocky intertidal work being conducted at Cape Arago, a steep rocky shore with a narrow (20m wide) reflective surf zone, and Neptune's Wayside, a rocky shore with a wide (i.e., more dissipative) surf zone (124 m wide).

- Biologists sampled phytoplankton in the surf zones around Cape Arago (median station spacing was only 1 km), therefore variations in offshore phytoplankton concentrations were expected to be minimal, and thus variation in concentration within the surf zone could be caused by surf zone hydrodynamics. Surf zone width was measured from historical *Google Earth* images – reflective and more dissipative surf zones remained reflective and more dissipative through time.
- Biologists also sampled barnacle populations from San Diego to Washington within a range of surf zone widths. They sampled closely spaced sites (4km-130m); if the two surf zones were narrow and reflective, then barnacle density was low and not different. If one surf zone was wide and the other narrow, then there was significantly higher density at the wide surf zone. Weekly recruitment and daily settlements was also higher at the wide surf zone.
- They concluded that surf zone hydrodynamics clearly affect subsidies (e.g., settlers and phytoplankton) to the shore, and that these subsidies clearly affect intertidal populations. This is a variable that has not been included in earlier ecological studies of the rocky intertidal, and should be.

Multi-Agency Rocky Intertidal Network (MARINe) Sites (Melissa Miner)

Melissa Miner discussed the more than 170 MARINe sites that span the Alaska to Mexico coast (pacificrockyintertidal.org). The network is a consortium of federal, state, and local government agencies, universities, and other organizations that conduct long-term, broad-scale monitoring of intertidal marine organisms, using similar approaches. Major partners are the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) (Packard Foundation), National Park Service, Bureau of Ocean Energy Management, California Ocean Protection Council, and the Department of Defense.

The goals of the program are to develop a long-term, spatially extensive, feasible and funded program providing baseline data in areas typically having none; track natural changes within and between communities over a large spatial scale, and assess impacts (e.g. oil spills, El Niño events, public access, harvesting, disease, etc.).

A two-pronged approach includes a) long-term "core" methods using fixed plots that target "key" species that are sampled annually or semi-annually to obtain good temporal resolution and b) Coastal Biodiversity Surveys (SWAT) conducted every 3-5 years that incorporate large grid-style surveys resulting in good spatial resolution. In addition, supplemental methods, such as wave energy, occur at some sites.

Dick Vander Schaaf of The Nature Conservancy conducting monitoring in Oregon's marine reserves. Photo credit: The Nature Conservancy.

In Oregon 5 LT sites have been sampled over 17 years whereas 8 CBS sites were sampled from 2001-2015. In Northern California, from the Oregon border to Pt. Arena, 7 LT sites have been sampled 13-16 years whereas 11 CBS sites were sampled from 2004-2014. Sampling included the use of photo plots and transects using 100 evenly spaced points (grid or transect, including layers recorded) aimed at the following target species: *Chthamalus/Balanus* (barnacles)*, Semibalanus, Mytilus* (mussels)*, Fucus* (rockweed)*, Pelvetiopsis, Endocladia, Mastocarpus, Neorhodomela, Phyllospadix, and Hedophyllum/Saccharina*.

- All static trends can be found at pacificrockyintertidal.org, where user-generated graphs can be created. Long-term trends for Bob Creek have been documented for *Fucus*, *Mytilus*, *Pisaster ochraceus*, and *Katharina tunicata*.
- Coastal biodiversity surveys reveal biogeographic patterns.
- GIS Map and Data Display Goals display physical, individual, population, community and biogeographic metrics in map content. This information informs the health, state, and condition of assessments by GOs and NGOs, provides summary information for stakeholders and the public, and complements current visualization tools.

The Nature Conservancy (Dick Vander Schaaf)

TNC's mission is to conserve the lands and waters on which all life depends. At Cascade Head Marine Reserve, TNC led rocky intertidal monitoring to address sea star wasting disease (2014-current). In 2016, there was an expansion of additional sites, which complemented the MARINe biodiversity survey work. Data was uploaded to a regional database, and local groups were engaged.

- Overall results show an increase in the number of sea stars (all species), from 2014 through 2017, and in particular an increase in juveniles.

Ocean acidification is also being monitoring at Cascade Head Marine Reserve to assess if results correlate in changes to rocky intertidal organisms.

More monitoring will occur at the Roads End Site at Cascade Head Marine Reserve. This includes a bioblitz and effectiveness monitoring with Camp Westwind, studies on algae and ocean acidification, black oystercatchers, intertidal rockfish recruitment, and MARINe biodiversity surveys.

Cape Falcon and Otter Rock Marine Reserve (Chrissy Smith, Karen Driscoll)

Chrissy Smith, Cape Falcon Marine Reserve Coordinator, and Karen Driscoll, volunteer at Otter Rock Marine Reserve, gave a presentation on their reserves.

Currently, the Cape Falcon Marine Reserve is supporting a variety of citizen science projects, including monitoring projects on Pacific brown pelicans, black oystercatchers, and seabirds. The will soon be introducing projects on intertidal and sea star wasting/recovery monitoring and ocean acidification monitoring. Other groups are supporting COASST seabird and marine debris surveys in the reserve.

Otter Rock Marine Reserve is conducting sea star wasting/recovery, oystercatcher, and ocean acidification monitoring as well as bacteria monitoring via the Blue Water Task Force.

For more information:

Friends of Cape Falcon Marine Reserve, Chrissy Smith, 541-231-8041, CapeFalconMR@gmail.com, Nehalemtrust.org/capefalconmr

Otter Rock Marine Reserve, Karen Driscoll, Driscolke@gmail.com

Blue Water Task Force (Charlie Plybon)

Charlie Plybon of Surfrider Foundation discussed the Blue Water Task Force, a water quality monitoring, education and advocacy program that samples Oregon's beaches and freshwater sources for Enterococcus/E. coli bacteria. The program is managed by the Surfrider Foundation chapters.

The Blue Water Task Force is important to public health. There are more than 20,000 beach closures and advisories in the United States annually, 900 billion gallons of untreated sewage spills into U.S. waters annually, and inch of rain falling on the hard surfaces of a city block generates 62,000 gallons of polluted runoff. In addition to health issues, water quality affects our economy. In Oregon, $2.4 billion is expended annually on ocean water recreation. Water quality is important from an ecological standpoint, as well, affecting native fish and wildlife habitats.

Water quality monitoring is conducted on more than 42 sites using 110 volunteers and partners. Seven labs in Oregon analyze the data. Water quality monitoring is conducted on more than 14 sites and seven rocky intertidal areas associated with Oregon's marine reserves.

- Otter Rocky – 17 years, 31 health exceedances
- Seal Rock – 12 years, 56 health exceedances
- Cascade Head – 4 years, 1 health exceedance
- Cape Perpetua – 4 years, 3 health exceedances
- Redfish Rocks – 6 years, 4 health exceedances

Charlie emphasized that limited monitoring reveals that creeks/runoff sites are most impacted, human traffic has impacts, and isolated sites and intact watersheds have higher water quality.

With addition resources, the Blue Water Task Force could collect additional source indicators, such as DNA

and optical brighteners, and pesticide/herbicide information as well as comparative studies.

For more information: www.surfrider.org/blue-water-task-force

oregon.surfrider.org/programs/blue-water-task-force

Charlie Plybon – cplybon@surfrider.org

Long-term Monitoring of Rocky Intertidal Systems for Detection of Climate Impacts (Brittany Poirson, Sarah Graem and Bruce Menge – Integrative Biology – Oregon State University)

PISCO and OSU have been conducting long-term monitoring (community surveys from 1990-2016) in rocky intertidal habitats along the West Coast to quantify change in community structure (abundance, distribution, diversity) through time for assessment of impacts to climate change. Their four primary hypotheses:

- Local community structure is independent of scale of oceanographic variation in ecological subsidies (nutrients, phytoplankton, recruits)
- Local oceanographic variation and subsidies combine with species interactions to drive local community structure.
- Regional (mesoscale) oceanographic variation and subsidies drive local community structure.
- Sub-basin scale (macroscale) oceanographic variation and subsidies drive local community structure.

Their results:

- Null hypothesis rejected: LCS is clearly not independent of oceanographic inputs.
- Local: Although LCS varies locally, and T varies mostly at this scale, site-level inputs explain small amounts (~7 percent) of variation.
- Mesoscale: LCS varies mostly with oceanic inputs, and cape-scale variation is greater than site-scale.

Relative to macroscale, how does climate change impact rocky intertidal communities? Because main factors changing are temperature, and its indirect impact on winds and wave size, used climate patterns as short-term proxy for potential long-term effects on rocky intertidal communities.

Long-term monitoring of rocky intertidal system. Photo credit: Integrative Biology Laboratory at Oregon State University.

Surprisingly, the effects of climate patterns vary by Cape. Even more surprising local scale community structure appears highly sensitive to large, macroscale environmental variation. Next steps are to identify components most sensitive to climate variation and facilitate predication of changes to occur.

Shoreline Citizen Science at Haystack Rock (Melissa Keyser – HRAP Program Coordinator)

The mission of HRAP is to protect, through education, the intertidal and bird ecology of the Marine Garden and Oregon Islands National Wildlife Refuge at Haystack Rock. The program was incorporated by the City of Cannon Beach in 1985. It is a volunteer-based program with 80-200 volunteers. There is a small staff (8-12) that offers free public education 9+ months of the year, on the beach and in the forest.

HRAP participates in citizen science because they are dedicated to protection, anyone can do it, it increases awareness, people have the ability/ capacity to collect data, it provides for the collection of site-specific analytical data and results, it enhances partnership & collaboration, and it's educational and fun. There are four primary citizen science programs: Costal Observation and Seabird Survey Team (COASST): Beached Bird Survey; CoastWatch: Marine Debris Survey, Mile Survey; Audubon Society of Portland,

USFWS, USGS, Friends of Cape Falcon: Black Oystercatcher Survey, Seabird Survey, Pelican Survey; Multi-Agency Rocky Intertidal Network (MARINe): Sea Star Survey.

- The Coastal Observation and Seabird Survey Team (COASST) is a 17-year rigorous citizen science project housed at the University of Washington. COASST trains coastal residents in their communities. The program provides for the collection of high quality data allowing creation of a robust baseline against which change can be measured, regardless of forcing (e.g., natural or anthropogenic).
- The CoastWatch Marine Debris Survey samples 100m once per month, requiring a 2–5 hour time commitment/ month. People record data, collect marine debris, take pictures, send in data.
- The BLOY and seabird monitoring is sponsored by Audubon Society of Portland, USGS, USFWS, Friends of Cape Falcon. It has easy to follow protocols requiring a 1–4 hour commitment total. It includes pre-nesting monitoring, recording behavior at sites, returning for follow up survey, data submission, and follow up with nest surveys if possible.
- The MARINe Sea Star Survey is a partnership of agencies, universities, and private groups committed to determining the health of rocky intertidal habitat. It requires a 1–4 hour commitment every 3 months.

We can improve citizen science with technology (smartphone applications) and more publicity and simplicity.

<u>Oregon's Black Oystercatchers: Using Citizen Science to Help Protect a Species of Conservation Concern</u> (Joe Liebezeit and Amelia O'Connor – Audubon Society of Portland; Dr. Jim Lyons and Elise Elliott-Smith – USGS)

The black oystercatcher is perfect for citizen science projects. The bird is a species of conservation concern and an indicator of intertidal health, there is lack of data on the species, and it is both conspicuous and charismatic.

There are both science/conservation goals and outreach goals associated with the project:

- Science/conservation goals:
  - Estimate population size/trend
  - Breeding success of oystercatchers
  - Baseline in Marine Reserves/MPAs
  - Inform best management: disturbance issues
- Outreach goal:
  - Increase awareness and stewardship of the marine reserves/MPAs & bird conservation

A coast-wide survey was conducted in 2015 and 2016. A total of 57 of 60 survey routes was sampled in 2015 and 74 of 75 routes sampled in 2016. Offshore islands were not sampled. The survey methodology was developed by USGS and allows for comparison with newer data. Three surveys/site are conducted in May to obtain abundance estimates, nest monitoring is conducted

Black oystercatcher. Photo credit: Hayley Crews.

May-August, disturbance information is documented, and outreach is quantified.

Results:

- The estimated population size:
  - 2006 – 311
  - 2015 – 627
  - 2016 – 506
- Outreach accomplishments include thousands of citizens engages about oystercatchers, marine reserves and seabird conservation – 70 survey volunteers, more than 600 people reached directly, more than 20,000 people reached via social media, and more than 500 people reached via presentations and field trips.
- Findings will be used to estimate population size/tend, spatial distribution informs long-term management and conservation planning; novel information on bird use of marine reserves; identify areas of disturbance and outreach to minimize, and build coastal constituents.

Next steps are to continue breeding season monitoring, although in terms of the science, the population estimates seem accurate. Perhaps effort will be shifted to wintering distribution monitoring, where enthusiastic volunteers can transition to collecting information.

Pacific Rocky Intertidal GIS Interactive Map and Data Display (Pete Raimondi, UC Santa Cruz)

Pete Raimondi shard a new online tool, pacificrockyintertidal.org, a GIS interactive map and data display depicting the results of Pacific rocky intertidal monitoring efforts. The map allows the user to choose a metric category (physical characteristics, community characteristics, species cover - % substrate, species density - # per meter squared, and species distribution – presence or absence), along with a specific metric, such as reef slope or the presence of sedimentary rock. The locations where these metrics have been observed on the West Coast are shown on the map. The user can click on each location, and obtain biodiversity survey findings specific to that site and the requested metrics.

Rocky Intertidal Monitoring at Olympic National Park (Steve Fradkin – Coastal Ecologist)

Steve discussed the "Phantom Network" of National Park Service Marine Parks, which are widely spaced. Monitoring strategies are aimed at assessing the vital signs of these places – the physical and chemical attributes, and the biological, and the places where these two intersect. NPS marine resources are biological hotspots – In Olympic NP, there are more than 205 species of intertidal algae, and more than 536 species of intertidal invertebrates. The monitoring goal is to detect trends in rocky intertidal species, community structure, and key physical/chemical environmental parameters.

Monitoring Objectives:

1) Characterize inter-annual trends and variation in **species abundance and community structure**
2) Characterize seasonal and inter-annual trends and variation in **intertidal temperature**
3) Characterize seasonal and inter-annual trends and variation the **intertidal carbonate system (OA)**
4) Assess trends to **formulate management actions, adaptation strategies, or trigger targeted research** to identify causal stressors.
5) **Collaborate and share methods/results** with other monitoring groups (e.g. MARINe, WOAC, NANOOS)

The NPS has a published protocol at: https://irmafiles.nps.gov/reference/holding/462673

The park conducts elevational community monitoring, temperature monitoring, sea star monitoring (frequency dynamics and reproduction), and ocean acidification studies.

Territorial Sea Plan: Rocky Shores Management (Andy Lanier)

Oregon has numerous marine managed areas within the Territorial Sea. The goal of the Territorial Sea Plan (TSP) is to protect the ecological values and coastal biodiversity within and among Oregon's rocky shores while allowing appropriate use.

The Rocky Shore Management Strategy relies on state and federal authorities and programs to implement, includes policies and objectives, is based on scientific data on resources and uses applied to specific sites and situations. Part III of the plan includes the rocky shores management strategy, which describes the rocky shores policy framework, implementing the strategy, existing rocky shores management, the context for management, site analysis and categories, site designations, and rocky shore management at Cape Arago. Classifying Oregon's rocky shores involves describing scale, linkage, and dynamics (environmental considerations), describing shoreline and offshore rocky types, and including descriptions of domains (e.g., ecoregions, segments) to develop an Oregon Shoreline Classification System.

Currently, sites are designated as marine gardens (8) habitat refuge (10), and research reserves (7), however, 9 sites are not yet designated, and 7 sites are priority offshore rocks/reefs. And there are 28 marine shores that are listed but not shown on maps.

Special management or species-use areas allow agencies to tailor management and regulations to address these areas:

Intertidal Marine Gardens

- Marine Gardens are closed to the taking of marine invertebrates, clams (except razor clams at Cape Perpetua), and mussels (except single mussels for bait) and have little or no other site management activities.

Intertidal Research Reserves

- There are areas where permits from the Oregon Department of Fish and Wildlife are required to take intertidal animals. There are numerous rocky shore areas where research is or has been conducted. Some of these are long-term study areas while others are the site for seasonal or special projects.

Habitat Refuge

No take of fish, shellfish and marine invertebrates in all areas of the refuge.

OPACs TSP Part III amendment criteria:

- In Response to more detailed site study and analysis
- Change in circumstances affecting management
- When sites are proposed for designation

ShoreZone includes georeferenced video and aerial photos that provides for geological and biological interpretive analysis.

The Rocky Shores Management Strategy Draft Revision Process and Timeline will begin the Fall of 2017 and will include a 6-9 month scoping process, a 6-9 month plan amendment drafting, and a 6-9 month public review process.

If you have questions:

Andy Lanier, Marine Affairs Coordinator, Oregon Coastal Management Program, Dept. of Land Conservation and Development, Andy.Lanier@state.or.us, (503) 934-0072

Coastal Monitoring in the Age of Ocean Acidification: Integrated Ecosystem Monitoring in the Intertidal (Francis Chan – Department of Integrative Biology, Oregon State University, PISCO)

Francis Chan introduced a key research question: Is the intertidal connected to the global problem of ocean acidification? He referenced the discussion about whether marine protected areas were sited appropriately. MPAs were not sites with ocean acidification in mind, and the progression of ocean acidification threatens to slow, if not upend, gains from MPAs.

The West Coast Ocean Acidification and Hypoxia Science Panel includes 20 scientists from CA, OR, WA, and BC. The charge of the panel is to advance understanding of OAH and develop options for decision makers. It was convened in 2013 by the Ocean Science Trust at the request of the California Ocean Protection Council, in partnership with the Oregon Governor's Office.

Is OAH something that we wait to happen to us, or is it something that we can and should get out in front of? There are essentially two tracts or management options to address OAH:

- Reduce exposure by reducing nutrient and carbon inputs and advancing carbon removal strategies
- Enhance the ability of biota to cope by reducing other stressors and promoting adaptive capacity

Marine reserves can be refuges where other stressors are minimized, reservoirs of demographic and genetic diversity that underlie resilience, and natural "listening posts" to monitor and understand ocean changes.

Two recommendations from the OAH panel are to inventory the distribution of MPAs to OAH vulnerability and define gaps between monitoring efforts and management needs.

Key points:

- The nearshore ocean of the West Coast faces severe exposure to OA stress
- Intertidal communities comprise many taxa that will be affected directly or indirectly by the continued progression of OA
- Intertidal carbonate chemistry is intimately tied to temporal variability in offshore ocean changes
- Exposure to OA stress depends on geography
- How should we monitor changes over time and space into the future even as OA stress intensifies?

MPAs can play multiple roles:

- MPAs can be hotspots for OA engagement: https://oregon.surfrider.org/monitoring-ocean-acidification-in-oregons-marine-reserves/
- New California OAH-MPA initiatives include *MPA Effectiveness and Ecological Responses in the Face of Changing Ocean Conditions*, and *Inventory of Ocean Acidification and Hypoxia Hotspots*.
- In Oregon, Senate Bill 1039 has been introduced in the 2017 regular session. The bill declares a state policy on ocean acidification and hypoxia.
- Movement toward management-relevant monitoring – a regional/federal partnership to inventory monitoring assets, assess gaps, and provide guidance for future efforts.

An Ocean Acidification and Hypoxia Monitoring Network:

- Supports the needs of decision-makers
- Measures and array of physical, chemical, and biology variables
- Builds on ongoing efforts
- Develops and sustains intellectual capacity

The evolving OA monitoring landscape recognizes the intertidal as a hotspot of OA exposure and sensitivity. Earlier iterations of monitoring described integrating ocean changes with ecological changes. The latest iteration integrates ecosystem monitoring through partnerships.

Filling the Knowledge Gaps in Rocky Intertidal Monitoring

Workshop participants participated in two breakout sessions to address three key questions. The groups then reconvened to share the results of their discussions.

What climate change impacts affect rocky intertidal areas beyond those being addressed through the Ocean Acidification and Hypoxia Monitoring Network?

Attendees recommended that the subtidal extent of rocky habitats be mapped and that several criteria be considered when organizing the following list: most significant impact, most feasible to implement, ability to interpret the concepts for use by policymakers, and time scale. In addition, it was recommended the cumulative impacts across the three categories listed below be considered:

- **Human impacts**
  - Drone use (e.g., drone use is not allowed in Oregon state parks)
  - Waste water
  - Marine debris
  - National policy associated with climate change and its corresponding effects (and policies in general)
  - Human population (#s) – there are fewer impacts during bad weather but large numbers of people during warm days affect rocky intertidal areas ("climate migrants" to the coast)
- **Physical changes**
  - Sea level rise (we need to research shifts in distribution along the vertical gradient in intertidal zones – sites with cliffs and very flat benches will experience habitat loss with sea level rise; determining habitat impacts of SLR now could affect monitoring)
  - Incidence of heat waves
  - Storm frequency and erosion and the corresponding impact to native species
  - Changes to sand (e.g., accumulation, scour – we have information about the width, length, and benches where we sample the sand, but we only sample 1-2 times per year – sand is key to certain species – in some places, such as Seal Rock, there are no places for the animals to go)
  - Air and water temperature
  - Harmful algal blooms (frequency and duration of events; more testing of organism tissues versus just the water)
  - Ocean acidification (we focus frequently on calcification, but the byssal threads of mussels are affected and there are olfactory issues)
  - Weather changes (warmer summers, wetter winters, more intense rainfall, fog)
  - Changes in ocean circulation patterns (e.g., upwelling intensity), Pacific Decadal Oscillation (PDO), El Nino, changing ocean currents – we're seeing changes in upwelling intensity and corresponding impacts to food chains)
- **Biological/ecological changes**
  - Range extensions/shifts (rare species require expert and sound experimental design)
  - Invasive species (monitoring efforts often do not include invasive species – prioritize invasive species hotspots or point sources)
  - Disease (generally recognizable only when it becomes catastrophic)
  - Changes in phenology (e.g., migrations – longer, shorter, shifts)
  - Disease outbreaks associated with temperature changes
  - Loss of macro algae

- Changes in inter-specific competition (e.g., major shifts in sea otter populations)
- Home range changes/shifts (e.g., we have observed large jumps in the range of brittle stars in several places on the West Coast; some changes are more predictable than others – explosions in squid populations could have real fishery impacts)

What are the highest priority rocky intertidal monitoring issues that need to be addressed through research and monitoring, and what strategies could advance their implementation?

It was noted that much research was focused on detecting catastrophic change, e.g., oil spill, but very little has been focused on climate change and the associated long-term metrics.

Before articulating a set of priority research and monitoring issues, attendees described a set of criteria to be considered while develop strategies:

- Develop standardized protocols to how/where data is collected
- Design a monitoring program that is as expansive as possible so that it can accommodate emerging issues
- Focus on obtaining continuous data consistently and sustainably long-term
- Ensure it is cost-effective
- Use technology effectively
- Match questions to design
- Focus on management needs
- Focus on projected/emerging issues
- Focus on use of data collected
- Track keystone species and multi-species complexes
- Use consistent protocols across sites
- Consider duration
- Tell compelling stories
- Use new technologies – apps
- Use more modeling to evaluate what-if questions in rocky intertidal habitats
- Implement conceptual food web numerical modeling
- Clearly articulate ecosystem services
- Value human dimensions research to tell the story of how people connect to these places
- Identify refugia (what sites are more resilient?)

Priority Rocky Intertidal Monitoring and Research

- Local and relevant meteorological measurements for rocky intertidal zone – find the most appropriate locations
- Beach bird surveys (indicator of change)
- Weather stations at each marine reserve to capture physical changes
- Map subtidal extent of rocky habitats and quantify existing rocky substrates
- Conduct vulnerability assessments
- Human use and impacts
- Sand inundation
- How communities will change (predator prey, distribution, competition) – functional equivalency
- Phenology – indicators that could be tied to signal change
- What level of harvest is sustainable within rocky intertidal habitats?
- Climate change impacts/components

What, if any, additional protections, beyond those being considered through Oregon's Territorial Sea Process efforts, could be implemented to enhance protection of these important habitats?

Attendees described some overarching concepts that should be considered relative to protections. Research is needed to demonstrate the need for specific enhanced protections. Tribal sovereign nation rights need to be considered in the rocky intertidal zone. Connectivity should be considered among refugia sites, and vulnerability assessments should be conducted to prioritize high- and low-risk areas. Articulate ecological goals with any protection strategies. Have one designation of rocky intertidal areas versus the existing menu of different designations (e.g., marine gardens, marine reserves, marine protected areas), which can be confusing to the public.

- Habitat refugia – no take reserves – limited/no access - designate inaccessible places closed
- Education
    - Include different languages, cultural aspects (supported by social science); use "poster child" animals (e.g., seastar, oystercatchers – species people care about)
    - Expand interpretive services
    - Incorporate oceans into Outdoor School, and make this part of a mandatory 5-day program for all children
- Policy changes – add climate change chapter to TSP; protect water quality; implement precautionary principle action – we need mandates w/in state agencies to conduct monitoring in rocky intertidal zones
- Reduce multiple stressors
- Promote the public trust doctrine-requirement that natural resource managers are required to ensure long-term sustainability of resources
- Enforce existing regulations
- Establish intertidal MPAs
- Define the appropriate use of drones
- Mitigate visitation impacts past certain thresholds (e.g., Yaquina Head) – figure out ways to positively manage human uses
- Rotate access to sites, or trails, to allow time for recovery/restoration
- Change how we communicate protections, e.g., chains or ropes versus signs
- General research should address impacts, resilience, and recovery

Opportunities for Collaboration

Workshop attendees discussed potential additional opportunities for collaboration in the areas of data sharing, outreach and education, policy, funding, and other categories:

Data sharing: A major challenge sharing data is allowing people to find, access, and understand data that is organized in a way that makes sense to users. Attendees discussed collaborating on a shared catalog adapted from Rocky Shores data portal technology that can be organized, viewed, and queried. Such a collaboration would require funds initially, but would grow organically.

Outreach and Education: Attendees discussed ensuring there is collaboration between citizen science projects and researchers to ensure that data is relevant and helpful, but also that the methods are consistent and effective. The HRAP model could replicated, and exported statewide to be used locally.

Policy: Attendees discussed amplifying the message about the importance of the Rocky Shores Amendment process through this group and reach out to a broader group of citizens.

Funding: It was noted that collaborative efforts that blend agencies, NGOs, etc. are necessary to obtain funding, thus the group needs to be proactive and strategic as a nearshore monitoring community. It was recommended group better connect to the ocean observing systems.

Other: The Western Society of Naturalists present an opportunity to discuss rocky intertidal monitoring issues. It was recommended that any collaborative meetings on rocky intertidal habitat conclude with a compilation of upcoming events in the region.

Black oystercatcher in an Oregon rocky intertidal area. Photo credit: Diane Bilderback.

Appendix A. Workshop Attendees

Alan Shanks	Prof Marine Biology	U of Oregon, Oregon Inst of Marine Biology
Amy Ehrhart	PhD Student	Portland State University
Andy Lanier	Marine Affairs Coordinator	Oregon Coastal Management Program
Ashley Knight	Science Integration Fellow	Oregon State University
Brittany Koenker	M.S. Student	Oregon State University
Brittany Poirson	Onshore Research Tech., Menge Laboratory	Oregon State University
Charlie Plybon	Oregon Policy Manager	Surfrider Foundation
Christine L Smith	Coordinator	Friends of Cape Falcon Marine Reserve
David Fox	Resource Assessment Section Leader	ODFW
Dick Vander Schaaf	Associate Director Coast & Marine Program	TNC
Fawn Custer	Volunteer Coordinator	Oregon Shores Conservation Coalition/Coastwatch
Francis Chan	Associate Professor Senior Research	Oregon State University
Graham Klag	Coordinator	Salmon Drift Creek Watershed Council
Gway Kirchner	Marine Fisheries Project Director	The Nature Conservancy in Oregon
Jasmine Osakoda	Volunteer	Oregon Shores Conservation Coalition
Jeff Burright	Graduate Student Intern	Oregon State University (working with DLCD)
Jena Carter	Marine and Coast Director	The Nature Conservancy
Joe Liebezeit	Avian Conservation Program Manager	Audubon Society of Portland
Karen Driscoll	Coordinator ORMR	Otter Rock Marine Reserve
Lindsay Aylesworth	Ecological Research Project Leader	Oregon Department of Fish and Wildlife
Lisa DeBruyckere	President	Creative Resource Strategies, LLC
Lisa Habecker	Education & Volunteer Coordinator	Haystack Rock Awareness Program
Max Beeken	Coordinator	Redfish Rocks Community Team
Melissa Keyser	Program Coordinator	City of Cannon Beach - Haystack Rock Awareness Program
Melissa Miner	Researcher	UC Santa Cruz
Paul Engelmeyer	Manager	Ten Mile Creeks Sanctuary
Peter Raimondi	Professor	UC Santa Cruz
Steve Rumrill	Shellfish biologist	Oregon Department of Fish and Wildlife
Steven Fradkin	Coastal Ecologist	National Park Service

Appendix B. Agenda

Oregon Marine Reserves Rocky Intertidal Monitoring Workshop

April 18, 2017, 9:00am–4:00pm, Oregon Coast Aquarium, Newport, Oregon

Workshop Goals:

- **Share updates on Oregon and Northern California intertidal ecological monitoring interests**
- **Address key gaps in intertidal monitoring**
- **Achieve consensus on the core elements of a long-term sustainable intertidal monitoring network, focusing on two examples—Olympic National Park and the Ocean Acidification and Hypoxia Monitoring Network**
- **Develop strategies to sustain intertidal monitoring long-term**

9:00am – 9:15am	Welcome, introductions, review of agenda **(*L. DeBruyckere, facilitator)*** and introduction to workshop **(*D. Vander Schaaf, The Nature Conservancy*)**
9:15am – 10:15am	Rapid Fire State of the State **— Each organization represented at the workshop will have 5 minutes to present up to 10 PowerPoint slides that describe past and ongoing monitoring efforts for rocky intertidal habitats along the Oregon/Northern California coast to develop a shared understanding of past/existing efforts with an emphasis on speakers highlighting gaps in their programs and gaps between their programs and other programs (*All*)**
10:15am – 10:45am	NETWORKING BREAK **— Workshop participants will have an opportunity to network and discuss the different monitoring programs presented during the last agenda item (*All*)**
10:45am – 11:05am	Long-term Intertidal Monitoring at Olympic National Park **— Staff at Olympic National Park have been conducting long-term intertidal monitoring to assess changes in the nearshore marine ecosystem through time. Staff will discuss the monitoring objectives as well as potential measures of intertidal zone health, intertidal habitat, and water quality (*Steve Fradkin, Olympic National Park*)**
11:05am – 11:30am	**Oregon's Territorial Sea Process and Rocky Intertidal Sites** — Oregon will be assessing the state-designated rocky intertidal sites classified as marine gardens, habitat refuges, and research reserves (*A. Lanier, DLCD*)

11:30am – NOON	Tracking Changing Ocean Chemistry through an Ocean Acidification and Hypoxia Monitoring Network **— A sustained, strategic and adaptive monitoring network that links decision makers with scientific data, such as physical, chemical, biological, and ecological parameters, will be discussed, with an emphasis on successful strategies to fill gaps in monitoring capability and management information needs as well as outreach strategies to improve public/community engagement as well as public awareness, engagement and support (*F. Chan, Oregon State University*)**
NOON – 1:00pm	Working Lunch (provided)
1:00pm – 2:30pm	Filling the Knowledge Gaps in Rocky Intertidal Monitoring **— Workshop participants will work in breakout sessions to address the following issues:** What climate change impacts affect rocky intertidal areas beyond those being addresses through the Ocean Acidification and Hypoxia Monitoring Network? What are the highest priority rocky intertidal monitoring issues that need to be addressed through research and monitoring, and what strategies could advance their implementation? (e.g., Share the outcomes of this workshop with the Oregon Ocean Science Trust, develop a working committee to review priorities and explore funding opportunities) What, if any, additional protections, beyond those being considered through Oregon's Territorial Sea Process efforts, could be implemented to enhance protection of these important habitats?
2:30pm – 2:45pm	BREAK
2:45pm – 3:55pm	Additional Opportunities for Collaboration **— Workshop participants will discuss additional opportunities for collaboration, including, but not limited to, data sharing, outreach and education, policy, and management.**
3:55pm – 4:00pm	Looking Back **— Participants will review what was discussed today, and key next steps to advance the recommendations in today's workshop**
4:00pm	ADJOURN


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