ECOLOGICAL MONITORING REPORT 2012-2013

2015

MARINE RESOURCES PROGRAM
NEWPORT, OREGON

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EXECUTIVE SUMMARY

Oregon Department of Fish and Wildlife's (ODFW) ecological monitoring in Oregon's marine reserves began in 2010. During the first two years (2010-2011), ODFW and partners used a multitude of monitoring tools to survey the marine communities found within the Otter Rock and Redfish Rocks Marine Reserves and their associated comparison areas. The following two year period (2012-2013) surveys were expanded to two additional reserves: Cascade Head and Cape Perpetua. In addition to data collection, the ecological monitoring team was evaluating the utility of using these tools to collect informative data in Oregon's nearshore waters.

At this nascent stage of Oregon's marine reserve system, ODFW's Marine Reserves Program is focused on collecting robust and reliable data that characterize the marine communities present in the reserves and comparison sites at the time of closure. Meeting this goal entails refining sampling methods and tools, evaluating alternative study designs, increasing data collection over space and time, and working with partners to expand monitoring efforts.

These four years of ecological monitoring, method development and habitat exploration have guided the Marine Reserves Program to consider several new approaches to ecological monitoring. Three of these approaches are outlined below and are reflected in the structure and results presented in this report.

FOCUSING ON ODFW'S STRENGTHS

The Ecological Monitoring Program is adopting a two-pronged strategy in order to achieve the ecological monitoring goals. The first component involves narrowing and focusing in-house monitoring efforts to four primary sampling tools: video lander surveys, remotely-operated video (ROV) surveys, fishery-independent hook and line surveys, and subtidal SCUBA surveys. These four core sampling efforts build upon the existing capacity and expertise at ODFW to survey the habitats, fish, invertebrate and macroalgal communities of Oregon's nearshore waters. While these core efforts are sufficient to meet mandates for marine reserve evaluation, ODFW Marine Reserves Program recognizes that other sampling efforts can complement this core work. Hence, the second component of the monitoring strategy is to encourage expanded research and monitoring through partnerships and collaborations. These additional efforts have the potential to enhance our understanding of both Oregon's nearshore environments and marine reserve implementation in this region. Currently, these collaborations include red urchin surveys, intertidal surveys, oceanographic monitoring, and fish recruitment studies. These collaborations allow ODFW to partner with research experts in areas where ODFW's capacity cannot easily reach. We aim to continue to build collaborative partnerships, seek creative funding sources, and consider citizen science efforts as part of a well-rounded, inclusive framework to monitoring the ecological conditions in Oregon's marine reserves.

FIVE UNIQUE RESERVES

The five marine reserves in Oregon are distinct and unique. These reserves vary in size, depth range, habitats encompassed, and past fishing pressure--important attributes that influence reserve performance (Halpern 2003; Claudet et al. 2008; White et al. 2011). As such, there is not a one-size-fits-all monitoring strategy that can be universally applied to Oregon's marine reserves. Rather, the ODFW Marine Reserves Program recognized the need for five individual ecological monitoring plans. These plans will consider the unique habitats, placement, and research potential of each reserve, and develop both the tools and sampling intervals best suited for sampling the marine communities found within that particular reserve. We will also work under a model of an extended time period for baseline data collection. California has set a precedent for considering the first five years post-closure as an adequate time period for taking the initial pulse of the marine communities within their reserves (California Ocean Science Trust and California Department of Fish and Wildlife 2013). Likewise, we will use a similar model in Oregon's reserves. Oregon has the advantage of initiating this sampling two years prior to reserve closure. Hence, baseline conditions in the reserve will include both data collect immediately prior (two years before) and post (three years after) the closure of the reserve. This longer time period will help ensure adequate time to collect robust data with limited personnel and develop the best methods for collecting the data. Marine reserves are a long-term management strategy. Even more so in temperate waters where ecological changes are slow to occur. In light of these realities, coupled with the need to increase our sample sizes in order to sufficiently survey the reserve communities, collecting data within three years of reserve closure is adequate to characterize baseline conditions.

This movement away from a single monitoring plan to five distinct plans serves to highlight the unique attributes of each reserve. By considering each reserve as a unique case-study, we aim to inform stakeholders about how each reserve may respond differently to protection. Where possible, we will look to compare ecological trends across reserves to consider how specific reserves are responding in relation to one another and what unique attributes may be responsible for these trends. By considering each reserve as a unique case-study, we multiply our learning potential about marine reserves by evaluating how reserves may function differently when they are set up in a range of different environments.

LEARNING AND ADAPTING

The marine reserve effort in Oregon is built upon a foundation of adaptive management. Applying this framework to our ecological monitoring efforts allows us to improve, refine, and adapt our existing monitoring methods to produce the best possible data. In this report, we capitalized on the flexibility of an adaptive approach, asking questions about the ability of our existing methods to generate robust, valid, and unbiased data about the marine ecosystems in the reserves. The results section of this report is therefore structured by the individual sampling method. The analyses presented explore whether the sampling tool was used effectively and generated informative data. We also explored what environmental, habitat, or oceanographic features could confound or bias our datasets. These analyses are essential to learning and adapting our methods in the coming field season to yield improved data during this baseline time period. Our goal is to constantly seek to improve our monitoring methods based on the best-available science. At the end of the five year baseline period for each site, we will compile all baseline data into a definitive characterization of the marine communities within reserves and comparison areas from which we will evaluate future change. Ultimately, we aim to develop robust and replicable standards that can and will be used through time to evaluate reserve performance.

A summary of the research and monitoring activities completed by the ODFW Marine Reserves Program and partners in 2012 and 2013 is provided below.

FIELD WORK COMPLETED IN 2012

Oceanography
CTDs collecting temperature, conductivity, dissolved oxygen, and fluorescence were deployed at the Redfish Rocks site throughout 2012. Temperature sensors were used at Redfish Rocks Marine Reserve during the first half of the year and at two of its comparison areas the entire year, and at the Otter Rock site (both marine reserve and comparison area) the entire year. Conductivity sensors were deployed at the Otter Rock and Cascade Head sites in spring 2012. Light sensors were deployed at Redfish Rocks, Otter Rock, and Cascade Head sites in 2012 and retrieved in 2013.

Lander Video
A total of 491 video lander drops were performed in 2012 at the Cascade Head, Otter Rock, Cape Perpetua, and Redfish Rocks sites. Video was reviewed to record data on fish and invertebrate abundance as well as habitat type and biogenic structure. The lander was also used in an exploratory manner while searching for potential rocky habitat suitable for comparison with the deeper (~45 m) reef structure in Cape Perpetua Marine Reserve.

Video Sled
In 2012, the video sled was used to survey unconsolidated sediments and the associated communities. Nine tows were completed in 2012 (surveying ~8 km of habitat) in the Cape Perpetua site, and 31 tows were completed in the Cascade Head site (surveying ~18 km of habitat). Habitat type, fish, and invertebrates were scored from the video. Scoring of the 2012 data revealed substantial weakness of this tool to accurately identify organisms to species level.

ROV
The ODFW-owned ROV, using high-definition cameras and precision acoustic tracking, performed 32 transects at the Cascade Head site and three extended transects (~3.2 km) in Cape Perpetua Marine Reserve, both in the fall. In addition to fish and habitat data, the Cape Perpetua survey also is part of an annual documentation effort of the seasonal hypoxia event in that region. Video was scored for habitat type, fish, and invertebrates.

Red Urchin Surveys
As part of the ongoing ODFW red sea urchin surveys, sampling in 2012 focused on Depoe Bay, and 14 transects were placed in the Otter Rock site. The data will be analyzed in a separate fishery report by Scott Groth (ODFW), which will compare the population structure and abundance between the reserve and the comparison areas, which are still subject to harvest pressure.

SMURFs
Eight moorings, each with a SMURF (Standard Monitoring Units for the Recruitment of Fishes), were placed just offshore of the Otter Rock Marine Reserve and Cape Foulweather Comparison Area, led by Oregon State University. These devices provided an artificial refuge for juvenile fish high in the water column, and bi-weekly monitoring generated data on pelagic juvenile rockfish recruitment rates by species. In 2012, the moorings were in place May through September.

Hook and Line Surveys
In 2012, hook and line surveys were completed in Redfish Rocks Marine Reserve and Humbug Comparison Area as part of the baseline sampling effort. A total of 660 fish were caught on hook-and-line over 10 sampling days. We successfully measured the lengths of 645 of these fish, with 15 escaping before they could be brought on board. We caught an average of 5.17 fish/angler hour (+/- 2.86, 95% CI) at Redfish Rocks and 5.5 fish/angler hour (+/- 1.53, 95% CI) at Humbug comparison area. From these data, catch per unit effort, size frequency distribution, and mean length per species will be determined.

FIELD WORK COMPLETED IN 2013

Oceanography
CTDs were deployed in Redfish Rocks Marine Reserve in early 2013 and relocated to Cascade Head Marine Reserve mid-year. Temperature loggers were deployed in Otter Rock and Redfish Rocks at various sites and times throughout the year. Conductivity sensors in Redfish Rocks were recalled for erroneous readings; data were unusable.

Lander Video
In 2013, we completed 82 lander, high-definition video surveys (~4-6 min. in duration) in the Cascade Head site in rocky reef habitats, from which fish and invertebrate community composition was quantified. Data from the underwater lander surveys were generated for fish and invertebrate diversity and abundance, as well as habitat features that might influence observed abundances.

Video Sled
A towed video sled was used to survey soft bottom habitats and associated communities in the Cape Perpetua and Cascade Head sites. Forty-one tows were completed in 2013 (surveying ~38 km of habitat) in Cape Perpetua. Cursory examination of the 2013 video data showed no improvement over 2012. Due to poor species-level resolution in the sled data at large, this sample tool was deemed uninformative to address our monitoring questions in soft sediment habitats and is being discontinued until better methods can be developed.

ROV
A remotely operated vehicle (ROV) equipped with high-definition video was used to survey deep rocky reef communities in the Cascade Head site (~10 km of reef habitat surveyed). Data are currently being processed from this effort by ODFW's Habitat Program (under Scott Marion).

SCUBA Surveys
Subtidal SCUBA surveys quantifying the macroalgal, invertebrate, and fish communities were initiated in the Cascade Head site in 2013 involving the training of an Oregon-based team of volunteer scientific divers. Both the diver training and official surveys are ongoing, including

refinement of the survey protocol to adapt a PISCO California Kelp Survey methodology to Oregon nearshore habitats.

SMURFs
SMURFS were successfully used to sample juvenile fishes recruiting to the nearshore in 2013 through a collaborative effort betwen Oregon State University (OSU), Oregon Coast Aquarium, and ODFW. Eight moorings were sampled throughout the summer at the Otter Rock Marine Reserve and Cape Foulweather Comparison Area. Data are being processed by Dr. Kirsten Grorud-Colvert and colleagues at OSU.

Hook and Line Surveys
In 2013, hook and line surveys were completed in Cascade Head and Cape Perpetua sites as part of the baseline sampling effort. The third year of hook and line survey was completed in Redfish Rocks site in accord with long-term monitoring plans. These hook and line surveys involved 75 volunteer anglers, 26 survey days and over 384 total angler hours. Over 3000 fishes representing 27 nearshore species were caught, weighed and total length recorded. From these data, catch per unit effort, size frequency distribution, and mean length per species will be determined.

Benthic Extraction
A benthic biodiversity study in subtidal hard-bottom habitats at Cascade Head was conducted to sample the diversity and abundance of macroinvertebrates and macroalgae not readily captured by our visual survey methods. This sampling approach allowed us to resolve species-specific taxonomy for both the algal community and sponge community through collaborative partnership with Dr. Gayle Hansen, a phycologist with OSU and Dr. David Elvin, a sponge taxonomist and lead of the Oregon Porifera Project.

CONTRACTED VESSELS

Three local commercial fishing vessels were contracted in 2012 to assist with the monitoring efforts.

Five local fishing vessels (including both charter and commercial vessels) were contracted in 2013 to assist with the monitoring efforts.

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INTRODUCTION

In 2008, the state of Oregon began a process to establish a limited system of marine reserve sites within state waters. The Oregon Department of Fish and Wildlife (ODFW) is the designated lead agency responsible for implementing Oregon's system of marine reserve sites. To that effect, in 2009, ODFW established a program comprised of staff responsible for marine reserves implementation, including the design and execution of an ecological monitoring program to provide information for marine reserves evaluation and to support nearshore resource management.

The ecological monitoring program has been developed by ODFW program staff, with assistance and collaboration from external scientists and marine reserve community members, and is designed for the long-term monitoring of Oregon's marine reserve system. The *Oregon Marine Reserves Ecological Monitoring Plan* (ODFW2012) documents and describes the objectives, monitoring design, metrics, sampling activities, and data analyses that are all a part of the marine reserves ecological monitoring program. Detailed methods, analyses, and results are to be presented in biennial monitoring reports.

This report serves as the second biennial monitoring report covering the first two years of baseline data (2012-13) collected at the Cape Perpetua and Cascade Head Marine Reserves. In addition, research and monitoring has continued post-closure on January 1, 2012 at the Redfish Rocks and Otter Rock Marine Reserve and their associated comparison areas where extractive activities are not prohibited, and is also reported here. Hereafter, we use the term **site** to refer to both a **marine reserve** and its associated **comparison areas**. This report characterizes the oceanographic conditions and marine habitats present at the sites as well as the algal, invertebrate, and fish community structure within the marine reserve sites.

MONITORING DESIGN

Monitoring design and sampling methods were previously laid out in our *Oregon Marine Reserves Ecological Monitoring Plan* (ODFW2012). Our research questions, metrics, field sampling activities, and data analyses have all been designed to provide the information needed to meet the goal and objectives of marine reserves evaluation. In this chapter, we provide an overview of the monitoring design implemented for the Cape Perpetua and Cascade Head sites in 2012-13, as well as continued monitoring in the Redfish Rocks and Otter Rock sites.

A. Research Questions

The following overarching questions provide general guidance for how we focus and structure our initial monitoring efforts. For the Cascade Head and Cape Perpetua sites, we attempted to address each question for the baseline conditions of both the marine reserves and the comparison areas. We then evaluated any differences in baseline conditions between a reserve and its associated comparison areas.

- What is the oceanographic condition of each site?
- What habitats exist within each site?
- What algal, invertebrate, and fish community structure exists at each site?
- What are the species-specific size structures of fishes at each site?
- What are the species-habitat correlations at each site?

As the marine reserve program continues, we will evaluate how these baseline conditions change through time and compare these rates of change in the marine reserve to the comparison areas.

B. Before, After, Control, Impact (BACI)

Two of the core components of marine reserve monitoring are separating natural changes in species and habitats from human-caused changes, and determining if marine reserves are effective in conserving certain species and habitats. To accomplish this, the marine reserve needs to be compared before and after protective measures are put in place, and with areas that do not have marine reserve protections. To this effect, each marine reserve was paired to other areas that we refer to as **comparison areas** (i.e. scientific controls). Ideally, we paired multiple comparison areas to each of the marine reserves. Given our limited monitoring resources, we assigned one area that most closely resembled a given marine reserve with respect to habitats present, oceanographic conditions, and depth as the **priority comparison area** in which the most detailed sampling would occur. Additional comparison areas were sampled to the extent possible.

We designed our monitoring studies to measure the same variables in the marine reserves as in their associated comparison areas. Observing the rates of change in these variables over time, both inside the reserve and in the fished comparison areas, will help us understand if marine reserve management has been effective in meeting conservation goals.

C. Sampling Design

This monitoring design requires that sampling account for:

- Differences in habitat and depth (and other environmental factors that could confound our response variables);
- Differences over time; and
- Differences between reserves and comparison areas

To meet these criteria, we employ a stratified random sampling design for biological variables that consists of comparing the marine reserve and comparison areas within specified habitat and depth strata, and repeating these comparisons over time.

D. Selecting Comparison Areas

It is nearly impossible to identify truly independent comparison sites for monitoring the effects of marine reserves (Halpern et al. 2004). Reserves can affect neighboring areas both negatively, through displaced fishing effort, and positively, through spillover benefits. Furthermore, no true replica exists for a given marine reserve site with respect to abiotic environment, oceanography, and habitat. Despite these limitations careful measures were taken to choose comparison areas as similar as possible to their corresponding marine reserve. We selected comparison areas to be of comparable size to the marine reserve and of similar geological habitat type, depth ranges, oceanographic conditions, and fishing pressure. We also considered spacing between the marine reserve and potential comparison areas. Comparison areas require some degree of spatial separation from the reserve to favor statistical independence yet also must be close enough to the reserve to experience similar oceanographic conditions.

To identify comparison areas for Cascade Head and Cape Perpetua, we met with members of the local fishing fleet and recreational users to acquire site specific information on habitat, ocean conditions, and fishing pressure. We also examined available seafloor maps and any existing datasets that would be helpful in site selection. Where needed, field reconnaissance was used to explore potential sites for presence of rocky reef habitat.

CAPE PERPETUA COMPARISON AREA SELECTION

Cape Perpetua Marine Reserve is south of the town of Yachats and north of Florence. The site includes a no-take marine reserve adjacent to shore, a seabird protection area to the south, and two MPAs to the north and south of the marine reserve that allow limited take.

Habitats and Depths

We sought to find comparison areas with similar characteristics to the marine reserve. The marine reserve component of Cape Perpetua is 36.5 km^2 and extends west from the shoreline to the boundary of Oregon's territorial sea at a depth of ~50 m (Figure 1). Within the shallow reaches of the marine reserve adjacent to shore, the area is predominately comprised of unconsolidated sediment in the form of gravel and sand. Seaward, at deeper depths of 42-48 m, there is a narrow, rocky reef habitat. The shoreline alternates between rocky intertidal and sandy beaches along the length of the reserve.

Oceanography

The waters in area of Cape Perpetua have experienced episodic hypoxic conditions generally associated with strong upwelling activity and cooler water temperatures during summer months. The fall period through winter to the spring transition (typically April or early May) is characterized by a relaxation of upwelling, a well-mixed water mass, and warmer water temperatures.

Fishing Pressure

Fishing pressure within the limited rocky reef habitat within the reserve is sporadic but focused on a small geographic area (as the rock reef is small), with charter vessels making occasional groundfish trips there. The reserve also had regular commercial crab and salmon fishing pressure (soft bottom and pelagic habitats). Indeed, the marine reserve and associated MPA encompasses some of the highest crab fishing activity in the state. Lastly, moderate recreational angling for groundfish and surfperch species occurs along the shore within the reserve.

Comparison Area Selection

The main challenge for identifying a suitable comparison area lay in finding rocky habitat in a similar depth range as that found inside the reserve, and that is fished occasionally by the charter and recreational fleet. Discussions with local crabbers suggested many areas of hard bottom, but we were unable to locate any suitable rocky reefs at a similar depth range to the reserve. A small patch of reef off Yaquina Head had been known, but our efforts to place the lander on it had limited success, and past ROV attempts had not proved successful due repeated limited visibility. The Yaquina Reef was also far from the reserve itself with fishing pressure is light. Therefore, Yaquina Reef was not considered a reasonable comparison area. Gridded lander drops were made in an area referred to as San Marine just south of Waldport, but no rock habitats were found and it was dismissed as a comparison area. Just north of the mouth of Alsea Bay lay several small rocky pinnacles variously known to local fishers as “the Postage Stamp”. We investigated that area and found isolated rocky patches, but in shallower depths than the reserve. Due to the proximity to the reserve, the occasional fishing pressure, and the isolated nature of the rocky habitats, Postage Stamp was selected as a comparison area for the reserve despite the incongruent depths of the rocky reefs. The comparison area boundary also included the south end of Seal Rock Reef at depths of approximately 40 m.

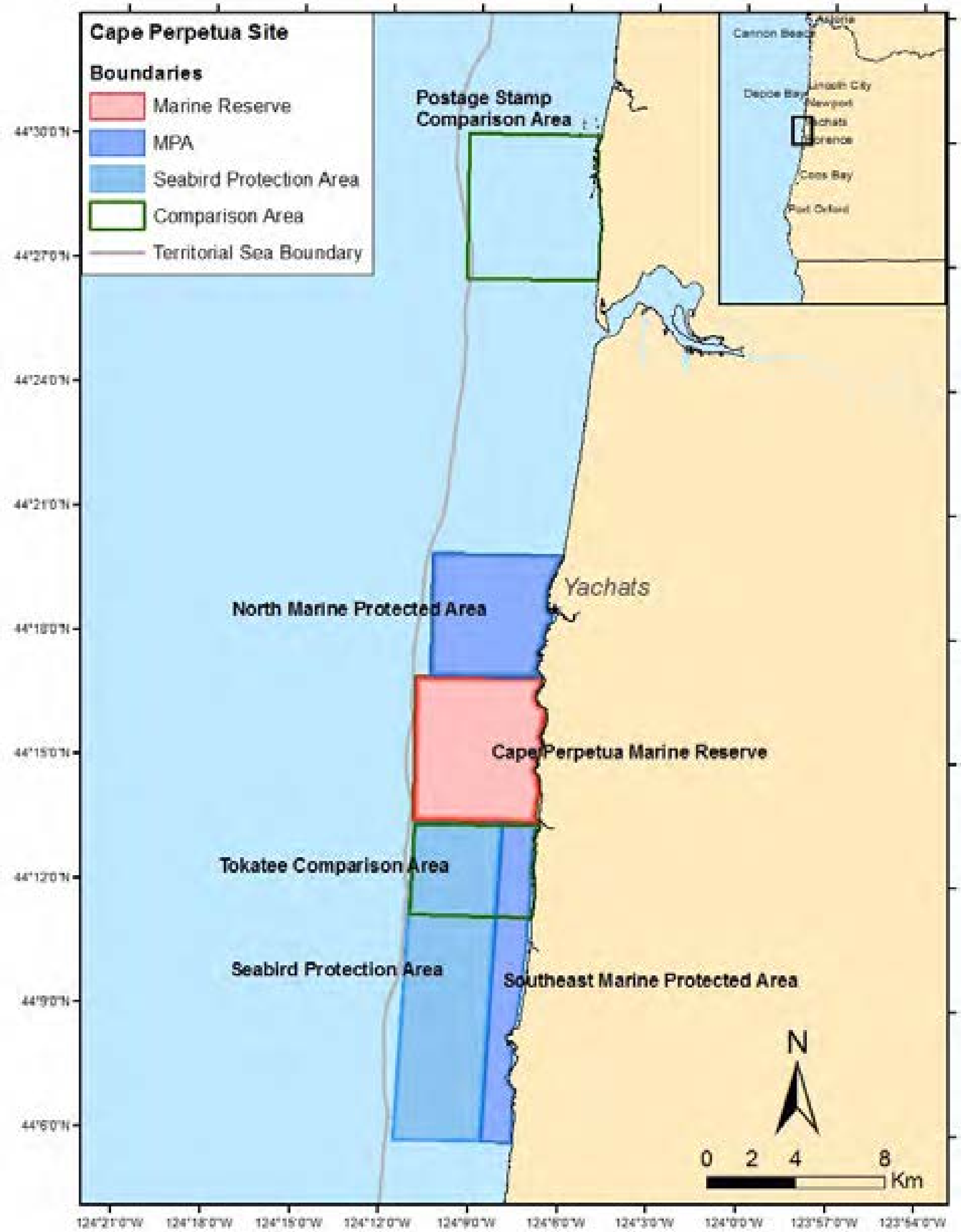


Figure 1. Cape Perpetua Marine Reserve, marine protected areas (MPA), and associated comparison areas.

CASCADE HEAD COMPARISON AREA SELECTION

Cascade Head Marine Reserve is north of the town of Depoe Bay and west of Lincoln City. The site includes a no-take marine reserve adjacent to shore and three MPAs to the west, north, and south of the marine reserve that allow limited take.

Habitats& Depths

Cascade Head Marine Reserve is 25.0 km^2 and extends west from the shoreline out to a depth of approximately 50 m. The reserve has one large emergent rock (Polly Rock), with submerged large boulders and flat bedrock extending outward from it. The northern section of Siletz Reef is enclosed within the marine reserve and additional patchy reefs exist though rarely in depths shallower than 20 m. The Siletz Reef primarily occupies depths between 20-35 m. The shallower depths are dominated by sandy bottom.

Oceanography

The waters in area of Cascade Head generally experience strong upwelling activity and cooler water temperatures during summer months. The fall period through winter to the spring transition (typically April or early May) is characterized by a relaxation of upwelling, a well-mixed water mass, and warmer water temperatures.

Fishing Pressure

The area encompassed by Cascade Head Marine Reserve experienced steady fishing pressure from recreational and charter fishing vessels departing primarily out of Depoe Bay. Occasional boats fished out of the Salmon River mouth immediately to the north of the reserve though shallow bar passage at the river limits this activity to smaller vessels. The reserve also had regular commercial crab and salmon fishing pressure (soft bottom and pelagic habitats) primarily in the northern portion and close along the beach. Occasional shore fishing did occur in the area just south of the Salmon River mouth.

Comparison Area Selection

We initially explored areas encompassing the central Siletz Reef (Schooner Creek comparison area) and the southern Siletz Reef (Cavalier comparison area) as potential reference sites as both these areas contained similar proportions of rocky reef and unconsolidated habitats in similar depths to the reserve. The Schooner Creek comparison area was created to be of similar size to the reserve and experienced similar fishing pressure as the reserve. As with the reserve, it is bounded to the east by a sandy beach shoreline and extends westward to depths of 50 m. Cavalier comparison area was also created to be of similar size to Schooner Creek and the marine reserve. Despite being closer to the port of Depoe Bay, this area has lower fishing pressure than either the reserve or Schooner Creek comparison area. In addition, Cavalier comparison area is bounded to the east by rocky coast and cliffs. Water clarity/visibility was found to be poor in this area during baseline sampling compromising our ability to conduct visual surveys successfully. Likewise, hook and line sampling yielded low catch per unit effort. As a result, we are currently exploring replacing Cavalier comparison area with an additional comparison off of Cape Foulweather to the south for the remained of the baseline sampling period.

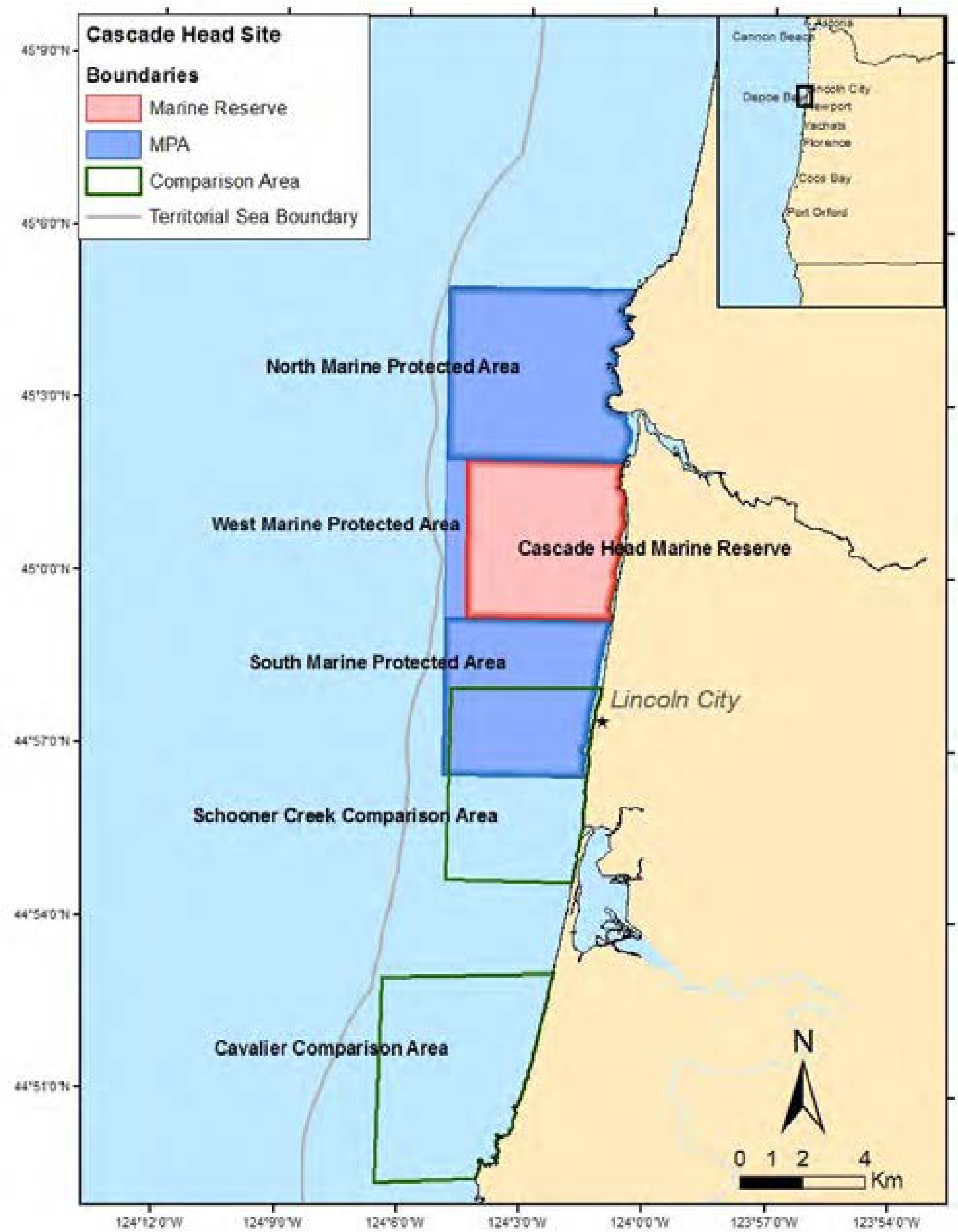


Figure 2. Cascade Head Marine Reserve, marine protected area (MPA), and associated comparison areas.

E. Baseline Site Characterization

Baseline ecological data is collected within each of the marine reserves and their associated comparison area(s) for three primary purposes. The first purpose is to provide a general characterization of the site. Second, we use baseline data to assess whether we have selected appropriate comparison area(s) to use as reference sites (i.e. scientific controls) for evaluating reserve effects through time. Lastly, baseline ecological data needs to provide a robust starting point from which we will assess future changes.

Oregon's nearshore marine environments are a relatively new area for research and exploration. Due to a combination of factors including limited accessibility, rough sea states, cold waters and poor underwater visibility, the research and monitoring efforts in subtidal habitats off the Oregon coast have been somewhat limited. Hence, the first component of baseline data collection in the marine reserve and comparison area(s) is to begin with characterizing the nearshore habitats. Our goal is to review any existing data on habitat distributions, bathymetry, oceanographic condition, fishing/extractive pressure and biological communities so that we can inform systematic monitoring (e.g. target rocky habitats between specific depth strata to sample with video lander). For specific reserve sites where existing data is limited, ODFW's Marine Reserves Program undertook some of the pioneering ecological characterizations of the site (see sections using Video Lander and Benthic Extraction). By understanding what habitats and environments are present within the boundaries of the reserves, our long-term monitoring strategy can be best tailored to surveying those specific habitats and communities through time.

During the baseline data collection period, comparison areas are delineated and evaluated. Based on our information gathered during site characterization, we select comparison areas with as many similar attributes to the reserve as possible, including habitat types, oceanographic regime, depth range, and fishing pressure. We then gathered data on each of these metrics to compare whether the comparison area(s), that are remaining open to extractive activities, are an appropriate reference area to compare through time to the marine reserve. Our goal is to finalize the delineation and evaluation of comparison area(s) for each reserve during the baseline data collection period.

Lastly, baseline data collection also entails initiating robust long-term ecological monitoring. This dataset will serve as the starting point from which we will evaluate changes in the reserve and comparison area(s) through time. Long-term monitoring of the marine community will be conducted identically in both the reserve and comparison areas to tease out changes due to environmental variation from changes caused by marine reserve protection. To evaluate reserve performance in the future, our analyses will compare the magnitude of change from this initial starting point between the reserve and comparison area(s) for response variables such as fish and invertebrate diversity, size, and abundance.

Based on meta-analyses of reserve performance worldwide (Lester et al. 2009) and the cold, temperate environment of Oregon's marine reserves in which biological changes occur slowly and species are long-lived (Willis et al. 2003; Ballantine 2014), we anticipate reserve effects will not begin to be detectable for a minimum of 10-15 years. At this nascent stage in the timeline of Oregon's Marine Reserves system, our reporting focuses on methods used and sampling conducted rather than analysis of reserve effects. In all likelihood, the initial two years of data collected prior to the closure of the reserves will be insufficient statistically to offer a robust starting point from which to evaluate change in the reserves over time. Rather, the baseline period would benefit from being extended to the first five years of reserve implementation (2 years pre-closure coupled with 3 years post-closure). This extension will allow ODFW the crucial time needed to characterize the sites, select appropriate comparison areas, refine sampling methods to nearshore environments, and collect larger, more robust datasets. Indeed, the state of California has set a precedent for this 5 year baseline (all of which occurred post-closure) in their reserve monitoring efforts. Hence, we will use a modified baseline of two years or pre-closure data pooled with 3 years of post-closure data.

Baseline ecological data is collected by ODFW staff in collaboration with scientific research partners at Oregon State University and Oregon Coast Aquarium. Site characterization and comparison area selection was conducted in 2012 and 2013 for the Cape Perpetua and Cascade Head sites, before harvest restrictions took effect, to provide a general description of the habitats, oceanographic condition, and species present. In addition, long-term monitoring was continued in Redfish Rocks and Otter Rocks Marine Reserves.

In 2012-13, ODFW Marine Reserves Program's ecological monitoring team focused on three types of surveys: (1) oceanographic sampling, (2) visual surveys, and (3) extractive surveys (Table 1). These surveys occurred in the four marine reserve sites currently active: Redfish Rocks (implemented 2010), Otter Rock (implemented 2010), Cascade Head (implemented 2012) and Cape Perpetua (implemented 2012). No surveys were completed in Cape Falcon as implementation begins at this site in 2014.

Table 1. List of the specific survey techniques employed by ODFW in the marine reserves between 2012-13. The techniques are grouped under headings of oceanographic, visual, or extractive survey modes.

Oceanographic	Visual	Extractive
PISCO moorings	Video lander	Fish Recruitment (SMURF)
ODFW benthic plates	Video sled	Hook and Line
	Remotely Operated Vehicle (ROV)	Benthic Extraction
	SCUBA surveys	
	Urchin surveys	

Many of these survey techniques are being refined and/or adapted to improve their applicability to Oregon's reserves goals (OPAC 2008). Hence, these sampling techniques will be refined, reevaluated and in some cases ceased to ensure that the most relevant and information ecological data is being collected.

Looking forward, it is worth noting that the sampling tools and periodicity of sampling will differ between reserves. Each survey tool will not be used each in each reserve as the habitats, depth and communities found within the reserves differ from one another. Each reserve is unique and merits a unique monitoring strategy. Hence, the Ecological Monitoring team at ODFW's Marine Reserves Program is currently working to develop five, site-specific monitoring plans that will establish and explain the sampling tools and their sampling intervals for the initial monitoring period up until the year 2023.

METHODS AND SAMPLING

In this chapter, we provide further details on the methods employed and the sampling conducted for the Cape Perpetua, Cascade Head, Redfish Rocks, and Otter Rock sites in 2012 and 2013.

Throughout this report, the term **site** refers to a **marine reserve** and its associated **comparison areas**. Below we present our monitoring activities in three general categories: oceanography, visual surveys, and extractive surveys.

A. Oceanography

METRICS ASSESSED: Temperature, salinity, and dissolved oxygen

INTRODUCTION

In order to control for the effects of oceanographic conditions on possible indicators of marine reserve effects, we need to understand the oceanographic conditions of Oregon's marine reserve sites. Oceanographic parameters such as water temperature affect the growth rate of fish species such as rockfish (Black 2009). So, quantifying any potential differences in oceanographic conditions between our reserves and associated comparison areas will help us isolate reserve effects, such as increase in fish size (Halpern 2003), from oceanographic effects.

Oceanographic data were collected at marine reserves and their associated comparison areas by ODFW staff and research collaborators from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) at Oregon State University.

QUESTIONS

- What are the general oceanographic conditions of the sites over time?
- Are the reserve and its associated comparison areas experiencing similar water masses?

Our baseline objectives are to: characterize the general oceanographic conditions of the sites, and determine if the reserve and its associated comparison areas experience different water masses.

Looking forward, we plan to partner monitoring efforts with oceanographers at OSU to see if large scale oceanographic phenomena (e.g. increasing sea surface temperatures, declining pH, and hypoxia events) known to influence the biological community are detectable within select reserve sites. For example, long-term monitoring of oxygen and pH in Cape Perpetua Marine Reserve will be a priority as this area is known to have a history of hypoxic events).

METHODS

ODFW Data Collection

Oceanographic data were collected from Benthic Oceanographic Platforms (BOPs) and CTD cages bolted to rock substrate on the seafloor in depths of ~15 m of water. Our equipment configurations have been designed to withstand Oregon's high energy coastal waters and therefore allow us to conduct year round oceanographic sampling.

BOPs: BOPs are a stainless steel plate with mounting brackets for oceanographic sensors, designed to be anchored to rock substrate on the seafloor. We mounted our BOPs with temperature, light, or conductivity (salinity and temperature) sensors. Temperature sensors used were Onset HoboTemps U22-001 temperature loggers. Light sensors used were Wildlife Computers TDR-Mk9 Archival Tags. Onset Hobo U24-002 Conductivity Sensors were used to collect conductivity and temperature data. Onset recalled the Hobo U24-002 in 2013 due to inaccurate readings of conductivity, therefore only temperature data collected that year were analyzed.

CTD cages: CTD instruments were also mounted onto metal plates then bolted into rock on the seafloor, but with an additional frame built around the plate to protect the CTD instrument. We used SeaBird Electronics 16 Plus CTs that measured temperature, conductivity, dissolved oxygen, and fluorescence.

BOPs and CTD cages were installed and serviced by divers using SCUBA or surface-supplied air. For further details and images of BOPs and CTD cages please see *Oregon Marine Reserves Ecological Monitoring Report 2010-2011* (ODFW 2014).

PISCO Collaboration

Deployment of BOPs and CTD cages is limited to rocky habitat that is accessible to divers. Rocky reef habitat in the Cape Perpetua Marine Reserve (MR) is too deep to be accessed by divers, prohibiting oceanographic sampling with BOPs or CTD cages. PISCO researchers have deployed oceanographic moorings in the area now designated as the Cape Perpetua MR every summer since 2002. Additionally, PISCO had deployed oceanographic moorings in the locale of the Postage Stamp comparison area (CA) during the summer months from 2002-2009. To the north, PISCO moorings were deployed in the Cascade Head Marine Reserve and two locations in the Cavalier Comparison Area. These moorings provided us with years of data that can be used to establish oceanographic conditions in the reserve prior to implementation. Pending continued funding for PISCO's research, this collaboration will provide continued oceanographic data from the Cape Perpetua MR into the future.

SAMPLING CONDUCTED

An overview of the sampling conducted in the four marine reserve sites can be found in Table 2. Details for each site are provided below.

Monitoring Activity	Site	2012												2013											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
CTD - Temperature, Conductivity, Oxygen, Fluorescence	RR MR			S				S	S				S			R									
	RR Humbug					D		S	S	S			S			R									
	RR Humbug (Island Rock)																								
	RR Orford Reef																								
	OR MR																								
	OR Cape Foulweather																								
	CH MR																				D		R/D		R/D
	CH Cavalier																								
	CP MR					D	PISCO Data			R								D	PISCO Data			R			
	CP Postage Stamp																								
Temperature Sensor	RR MR																								
	RR Humbug					R																			
	RR Humbug (Island Rock)															R/D									
	RR Orford Reef															R/D									
	OR MR					S								R/D											
	OR Cape Foulweather					D													R/D						
	CH MR													D											
	CH Cavalier																						D		
	CP MR					D	PISCO Data			R								D	PISCO Data			R			
	CP Postage Stamp																								
Conductivity (Salinity) +Temperature Sensor	RR MR															D									
	RR Humbug															D									
	RR Humbug (Island Rock)																								
	RR Orford Reef																								
	OR MR					D								R											
	OR Cape Foulweather					D													R						
	CH MR						D							R											
	CH Cavalier						D																R		
	CP MR																								
	CP Postage Stamp																								
Light Sensor	RR MR															R									
	RR Humbug																								
	RR Humbug (Island Rock)																								
	RR Orford Reef																								
	OR MR					S								R											
	OR Cape Foulweather																								
	CH MR						D							R											
	CH Cavalier						D																R		
	CP MR																								
	CP Postage Stamp																								

Table 2. Oceanographic data collected in marine reserve sites for 2012-2013. "D" denotes when an instrument was deployed, "R" denotes when an instrument was retrieved, "S" denotes that the same instrument was serviced and replaced. "PISCO Data" indicates a dataset collected from PISCO moorings.

Redfish Rocks

A CTD, light meter, and temperature sensor were installed in the reserve in October 2011 (Figure **3**) and was in place for all of 2012 (with the exception of the temperature sensor) with periodic sampling and servicing, approximately every 2-3 months. A CTD cage was installed in the Humbug CA in May 2012, replacing a BOP with a temperature sensor that had been in place since September 2011. The CTD in the Humbug CA stayed in place for the remainder of 2012 with periodic sampling every 2-3 months. Both CTDs in the Redfish Rocks site were removed and replaced with BOPs carrying conductivity sensors on March 28, 2013. To aid in relocating BOPs, a 50 foot segment of galvanized chain was attached to the BOP plates and stretched out to create a larger search target for SCUBA divers. Additional BOPs were placed in the Humbug CA, near Island Rock, and Orford Reef CA in December of 2011. These two BOPs were mounted with temperature sensors and deployed for all of 2012 and 2013.

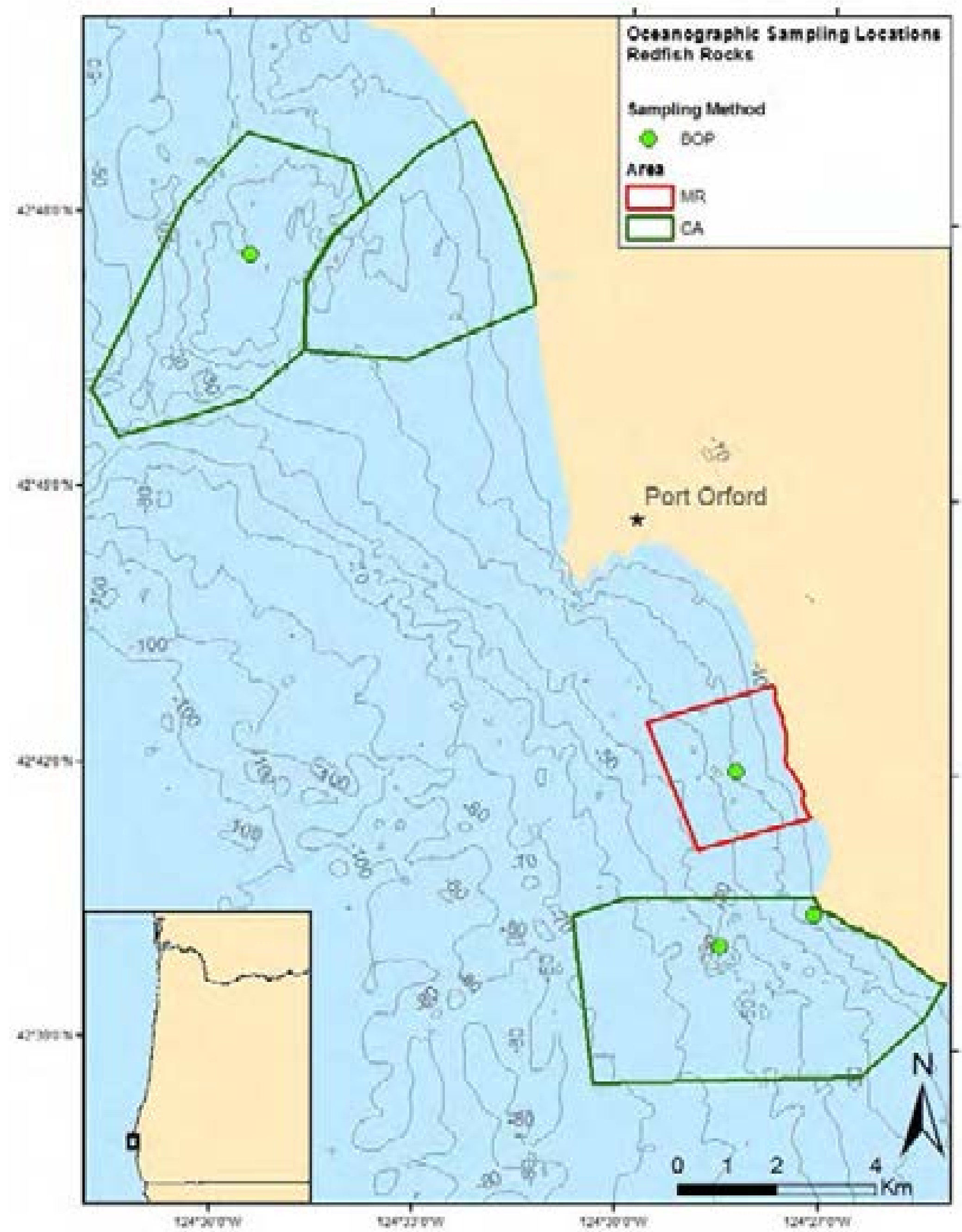


Figure 3. Oceanographic sampling locations for 2012-2013 for the Redfish Rocks site.

Otter Rock

A new BOP with temperature and conductivity sensors was installed in the Cape Foulweather CA in May 2012 to complement the existing BOP in the reserve. Temperature, light, and conductivity sensors were maintained in both the reserve and the comparison area (Figure 4). No CTDs were used in this site during 2012-13.

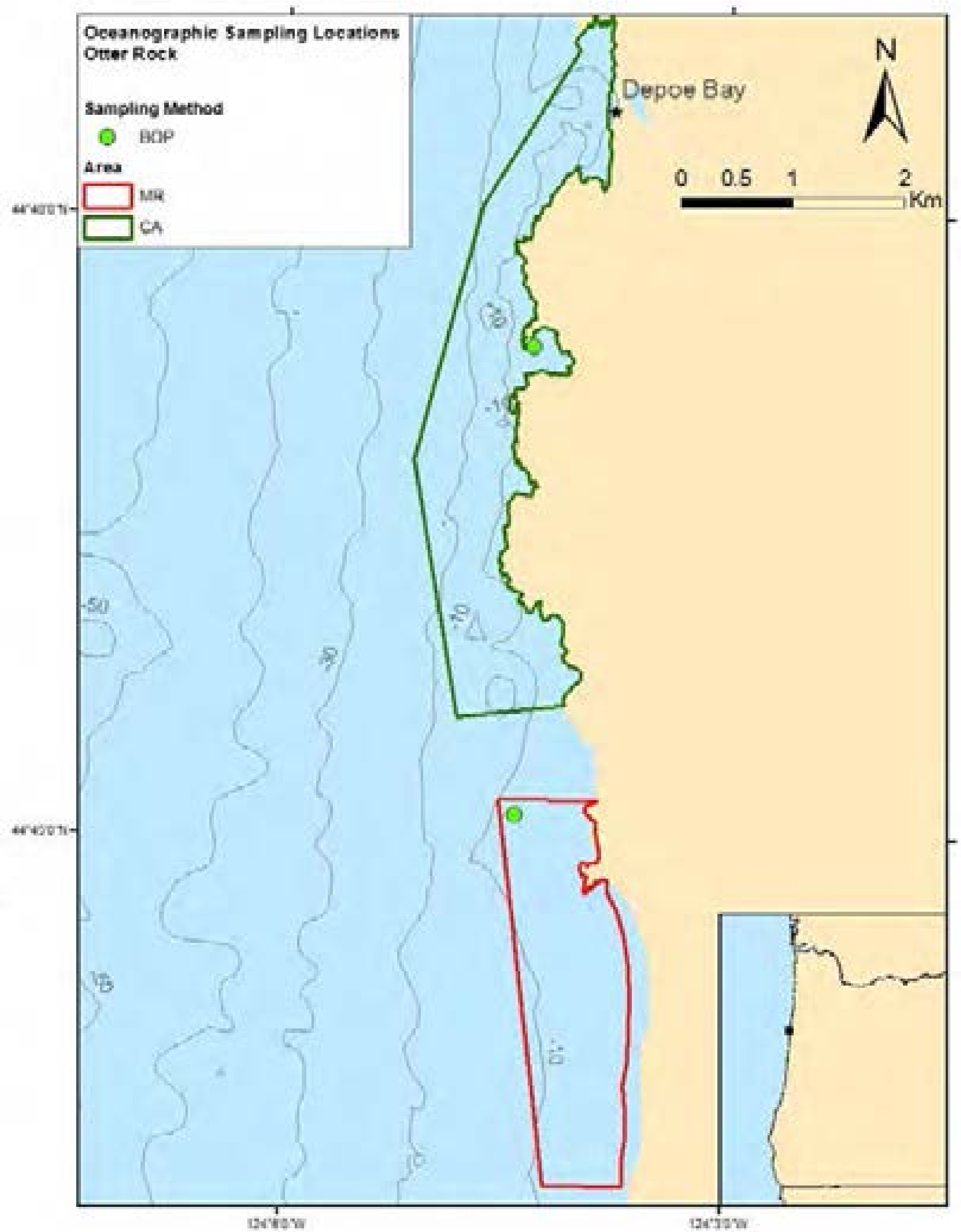


Figure 4. Oceanographic sampling locations for 2012-2013 for Otter Rock site.

Cascade Head

BOP plates with conductivity and light sensors were installed in Cascade Head MR and the Cavalier CA (Figure 5) on June 27, 2012 to begin collection of baseline data. A CTD cage was installed in the reserve near the BOP location on August 5, 2013 (Figure 5). To aid in relocating the CTD one end of a 50 ftgalvanized chain, with short sections of floating line spliced into the chain along its length, was attached to the seafloor near the CTD and stretched out to create a larger search target for the SCUBA divers. The BOP deployed in the reserve has not been successfully located since January 16, 2013, and is presumed to be permanently lost. The conductivity and light sensors were retrieved from the BOP in the comparison area and replaced with a temperature sensor on October 18, 2013.

PISCO moorings were used for additional data. We accessed data from PISCO's online data portal for the "Cascade Head" mooring, located in the reserve, and "Fogarty Creek" mooring, located in the Cavalier comparison area. Both moorings were anchored at 15 m water depths (Figure 5) for summer of 2001. Additionally, we requested CTD data from PISCO for their "Lincoln Beach" mooring, also in the Cavalier CA at 15 m depth for summer of 2013 to compare to our CTD data in the reserve. We used PISCO temperature data from the deepest temperature sensor available on the mooring line at each site to maximize comparable with our benthic mounted gear.

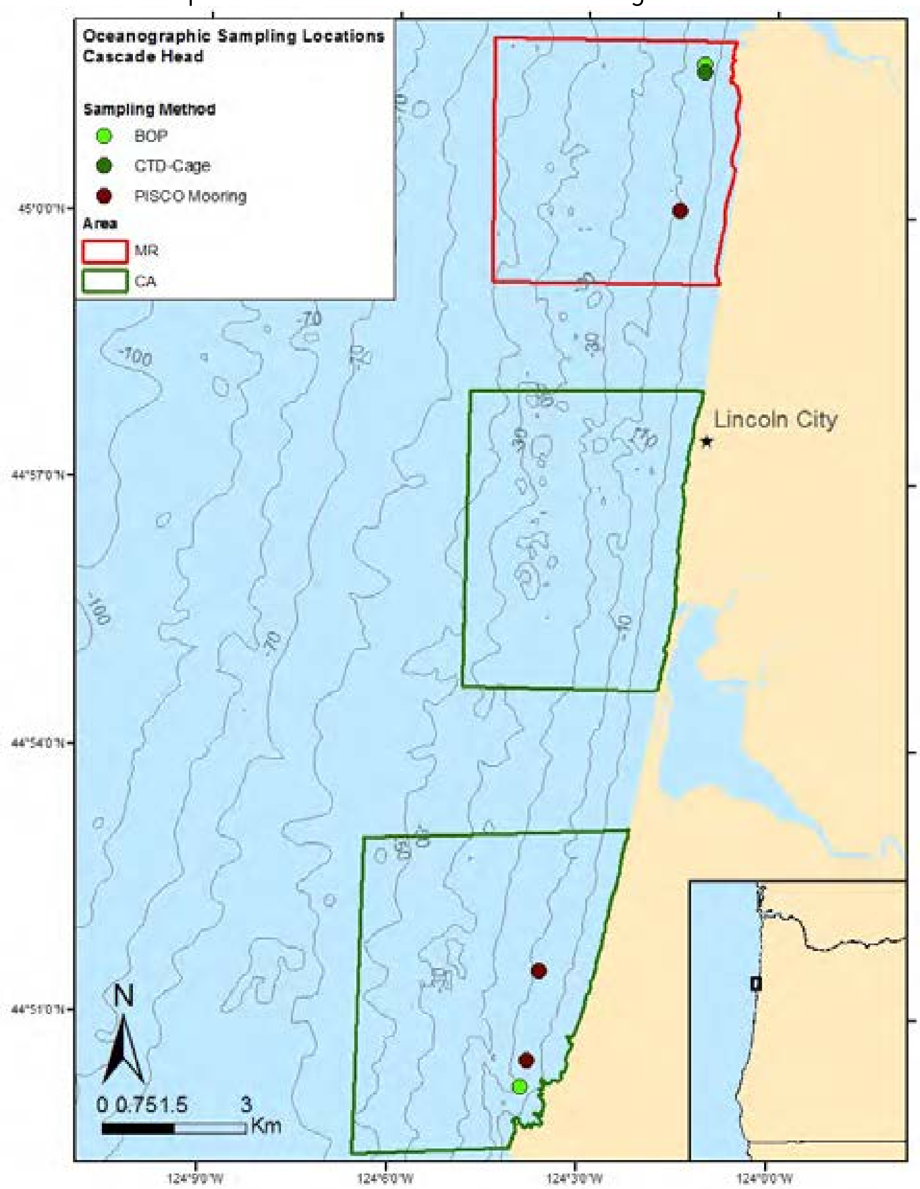


Figure 5. Oceanographic sampling locations for 2012-2013 for Cascade Head site.

Cape Perpetua

Oceanographic data for the Cape Perpetua site has been entirely provided by PISCO. We accessed data from PISCO's online data portal for the "Strawberry Hill" mooring, in the reserve, and the "Seal Rock" mooring, located in the Postage Stamp CA). Moorings were anchored at 15 m water depths (
Figure 6) during the summer months from 2002-2009. We used PISCO temperature data from the deepest temperature sensor available on the mooring line at each site to maximize comparable with our benthic mounted gear at other sites. Additionally, we acquired 2012 and 2013 data from the "Strawberry Hill" mooring anchored at 15m water depth.

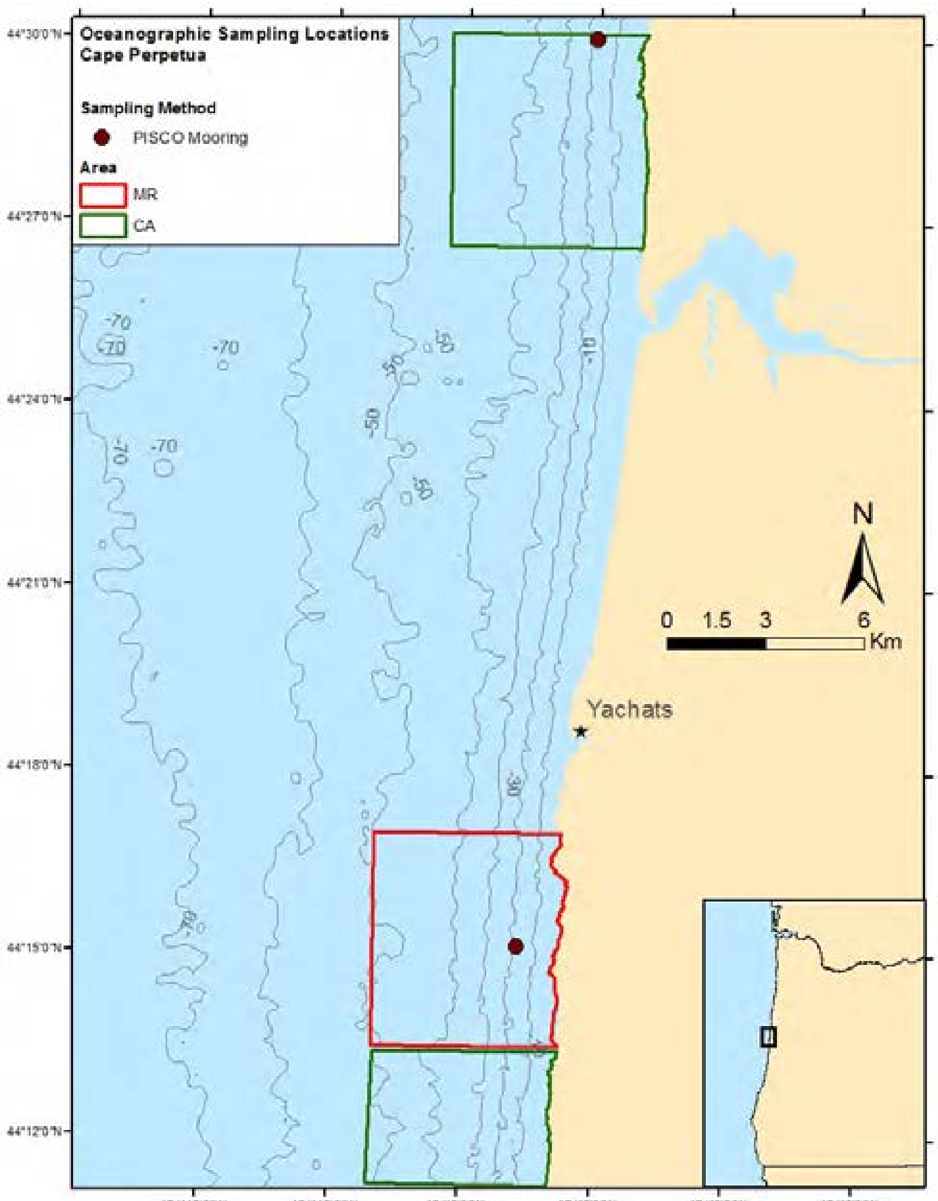


Figure 6. Oceanographic sampling locations for 2012-2013 for the Cape Perpetua site.

DATA ANALYSES

Oceanographic data were downloaded from the sensors and exported into Excel. Data from adjacent time periods were stitched together; and data was checked for instrument dropouts, erroneous readings, and other errors in Excel. The daily running mean and the weekly running mean were calculated from the hourly (raw) data. Data from both the marine reserve and comparison area(s) were plotted in SigmaPlot, and trends in data were visually analyzed for differences between the sampling areas.

B. Visual Assessments

METRICS ASSESSED: Algal, invertebrate and fish community structure and distribution
Substrate type and relief
Urchin population structure and abundance

I. LANDER

Video landers have been used in a variety of ways to explore habitats, characterize fish populations, and observe fish behaviors (Priede et al. 1994; Kaimmer 1999; Cappo et al. 2003). ODFW's Marine Reserves Program chose to use a video lander for several reasons. First, it can be dropped onto a variety of substrate types and reliefs and be successfully retrieved. Second, it can be used in nearly any depth we would encounter in the marine reserve sites, up against emergent rock, and in high-energy areas such as the outer surf zone. Lastly, a lander is relatively inexpensive.

ODFW's video lander consists of an aluminum frame, with a breakaway mild steel base section in case of snagging (Figure 7). For the 2012 season, the video system consisted of a Deep Sea Power and Light (DSPL) 2060 low-light color camera, paired with an LED light in a DSPL Rite-light housing. A DSPL parallel laser with 10 cm spacing was used to estimate scale in the image. A cable harness custom-made by Teledyne-Impulse connected the camera, light, and lasers to an aluminum pressure tube containing a micro-controller card, a set of batteries powering the system and a standard definition Sony camcorder recording onto mini-DV tape. A pressure switch, externally located on the pressure tube, provided the means to manually activate the system and start recording. An appropriate length of floating buoy-line and three crab floats were attached to the lander for location and retrieval.

For the 2013 field season we switched from a standard definition to a high definition (HD) camera system (Figure 8). The video system consisted of a Canon Vixia HF G10 camcorder housed in a 4.5" aluminum pressure tube. High definition video was collected at 30 frames per second in progressive mode, recorded onto an SD card. The camcorder was fitted with a 0.5x wide-angle adaptor to enhance the field of view. The pressure tube was fitted with a clear acrylic dome port. A pair of DSPL SeaLite Six LED lights were mounted high in the lander frame well separated from the camera tube to minimize backscatter from debris in the water column. The lander framework was slightly modified to fit the new pressure tube, but

Figure 7. Video lander suspended by buoy line. At top is breakaway link; at bottom is breakaway base. Camera, lasers, light, and pressure tube are mounted within the aluminum frame.

otherwise unchanged.

Figure 8. Video lander, showing the camera pressure tube, lasers, lights, and battery pressure tube mounted within the aluminum frame.

Study Design

Sampling was conducted over the course of the summer and fall months to take advantage of good weather and vessel availability. Sampling days were chosen based on reports of good water visibility, and multi-day trips were preferred to minimize temporal variation in the data. Locations for lander deployment (hereafter termed "drops") were determined using a stratified random design targeting areas of rock substrate. Hard bottom habitats were selected using the available bathymetry and habitat maps primarily provided by Dr. Chris Goldfinger's Active Tectonics and Seafloor Mapping Lab at Oregon State University. Drop location stratified by depth bins of 0-10m, 10-20m, 20-30m, 30-40m, 40-50m, and 50-60m and then restricted to hard bottom habitats within each bin. Random points were then generated in these stratified habitats using ArcGIS.

In 2012, lander sampling occurred in four marine reserve sites: Cascade Head, Otter Rock, Cape Perpetua, and Redfish Rocks (Table 3). Cascade Head (Figure 9) and Cape Perpetua (Figure 10) were more intensively sampled to provide us with a robust general characterization of the sites, as part of our ecological baseline work. In 2013, lander sampling occurred in the Cavalier and Schooner Creek comparison areas (CAs) at Cascade Head, where sample sizes of drops encountering rock were low. A potential confounding factor, however, is that we changed from standard definition video to high definition (HD) between 2012 and 2013. Hence, the two comparison areas sampled with

HD in 2013 may not be directly comparable to the lander sampling of the reserve in standard definition from 2012. Sampling at Otter Rock in 2012 (Figure 10) was conducted to boost sample numbers in rocky areas. At Redfish Rocks (Figure 12), we dropped the lander in areas of high-relief bottom at Orford Reef to begin exploration of this area for use as a comparison area to the reserve.

The Cavalier CA for Cascade Head was sampled in both 2012 and 2013 with the lander and sled. However, the difficulty with this area is chronic poor visibility, which affects the abilities of visual surveys to collect data of adequate quality. Hence, the decision was made at the end of the 2013 field season to suspend monitoring efforts in this comparison area unless superb conditions for water clarity and sea state could be achieved.

Table 3. Number of lander drops completed in each marine reserve and comparison area (CA) by year.

Site	2012	2013	Total
Cascade Head:			
Marine Reserve	100		100
Schooner Creek CA	91	71	162
Cavalier CA	87	11	98
Otter Rock:			
Marine Reserve	12		12
Cape Foulweather CA	11		11
Cape Perpetua:			
Marine Reserve	45		45
Postage Stamp	29		29
Tokatee	30		30
Redfish Rocks:			
Marine Reserve	29		29
Humbug CA	19		19
McKenzie Reef CA	18		18
Orford Reef CA	20		20

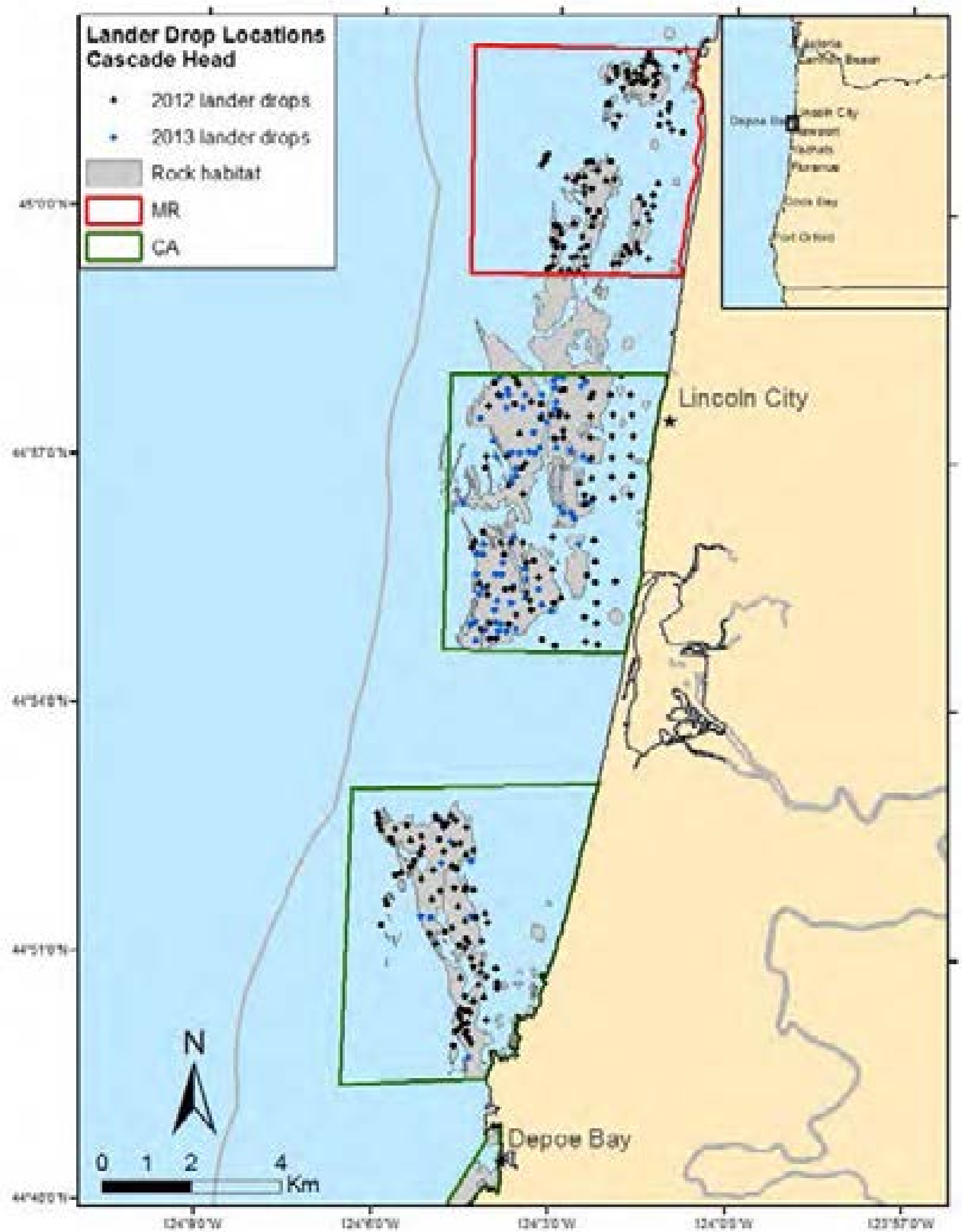


Figure 9. Lander sampling locations in Cascade Head Marine Reserve and comparison areas in 2012-13.

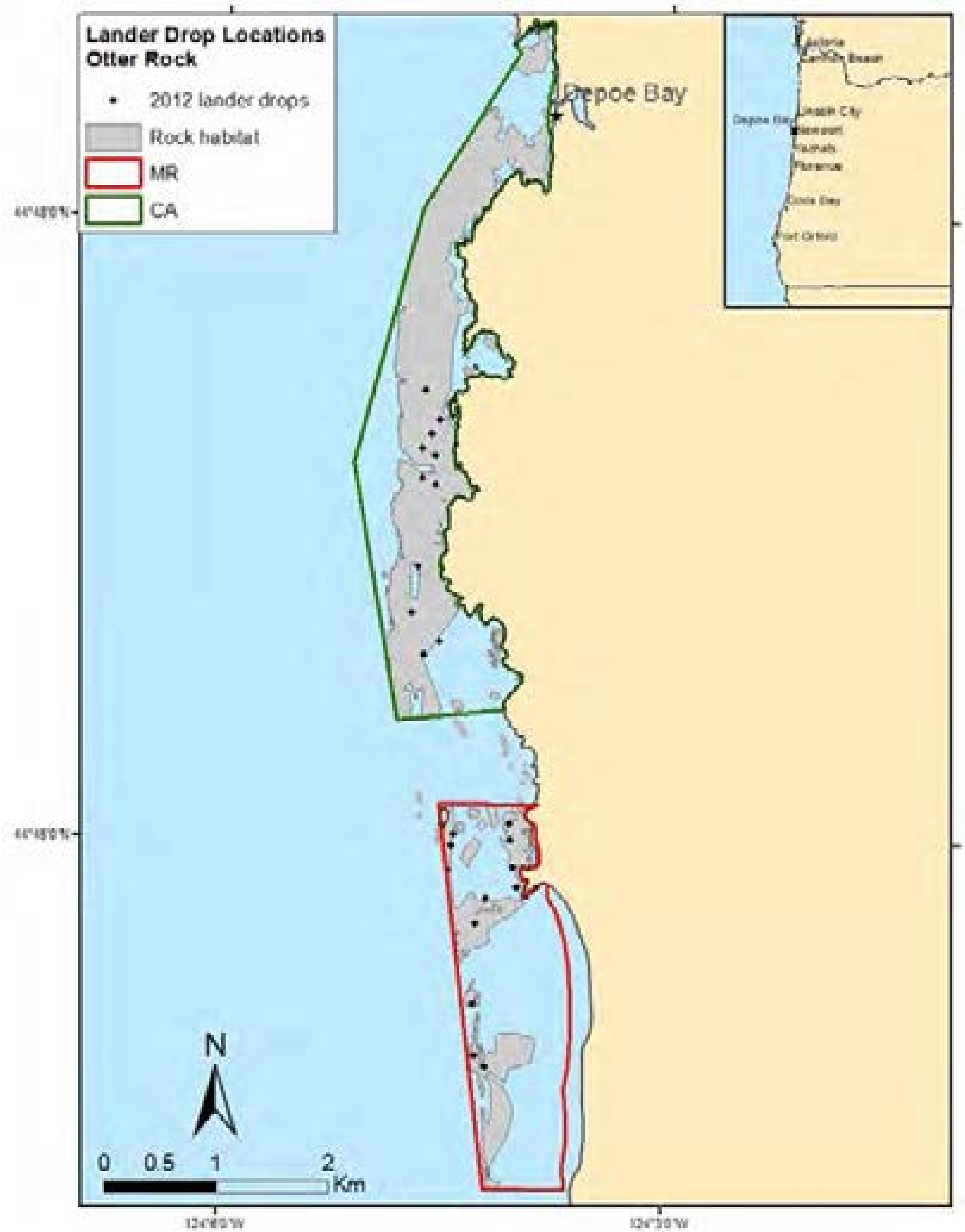


Figure 10. Lander sampling locations at Otter Rock Marine Reserve and comparison areas in 2012.

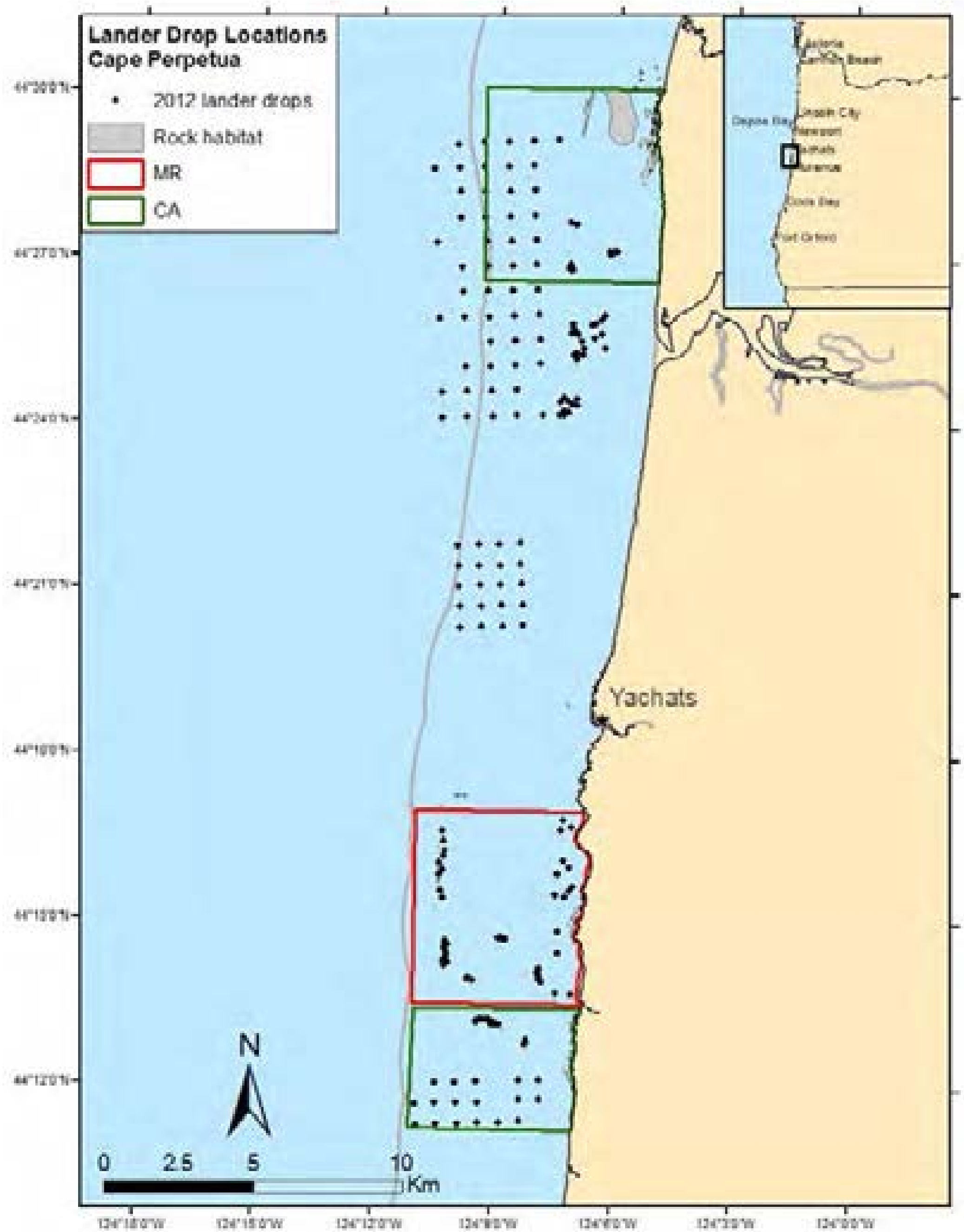


Figure 11. Lander sampling locations at Cape Perpetua Marine Reserve and comparison areas in 2012.

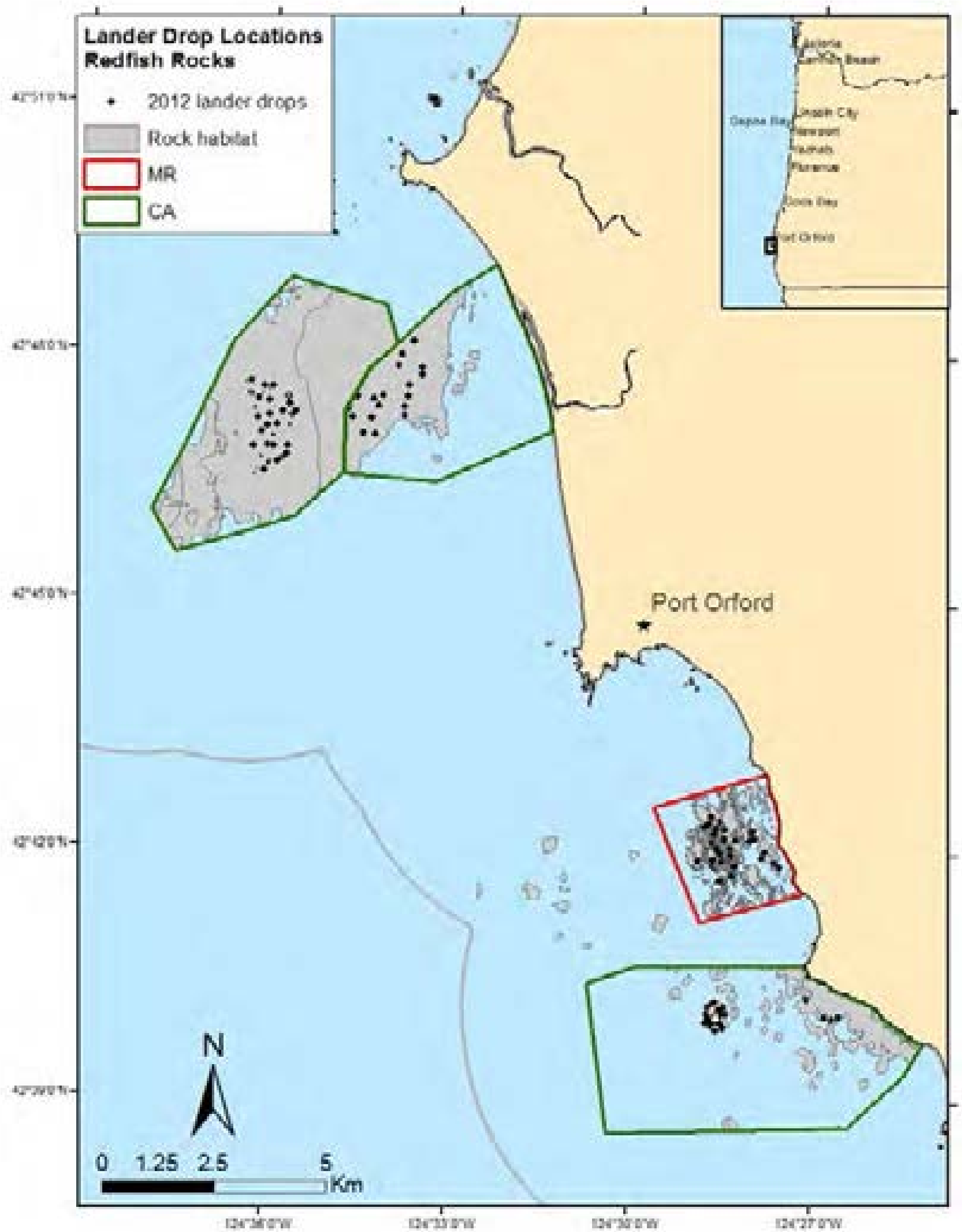


Figure 12. Sampling locations at Redfish Rocks Marine Reserve and comparison areas in 2012.

Field Methods

Once the boat was maneuvered over a sampling station, the camera was turned on via the pressure switch and "drop point" data were taken including date, target grid point, tape/memory card number, and drop number. An estimated benthic position of the lander was based off a waypoint taken of the vessel position at time of deployment. The lander was then launched overboard, and an estimated latitude and longitude were recorded as a GPS waypoint from the vessel. No attempt was made to account for lander horizontal drift as it descended as it was assumed to be minimal with the weighting used. The buoy line was rapidly fed out so that the line remained slack and the lander would free-fall. The time from when the lander hit the water until the lander came out of the water was noted, to estimate on-bottom time. The buoy line and buoys were released, leaving the lander to sit on the bottom undisturbed by any influence from the boat. Once the appropriate on-bottom time had elapsed, the lander was retrieved and hauled aboard using a crab block.

Based on previous lander studies off the Oregon coast (as recommended by Hannah and Blume 2012), we targeted an on bottom-time of four minutes allowing enough time for stirred up sediment to clear and to observe the maximum number of fish (MaxN) on an unbaited drop. All video "drops" occurred during daylight hours, being confined to one hour after sunrise until one hour before sunset. This avoided confounding our data with imagery collected during crepuscular periods and the possible change of animal behavior and visibility.

Video files were stored on an external hard drive and imported into Adobe Premiere for review on an HD monitor at full resolution. Initial scoring of the video was for visibility and view. Visibility was scored as an index from 0-3, with zero (0) being complete lack of visibility, one (1) being poor, with ID ability comprised, two (2) being moderate, with view limited by variable turbidity and/or marine snow, but ID of fish still possible, and three (3) being the ability to see far out in the water column, and fish can be identified to species readily. View was scored as 0 for completely obstructed by a rock or wall less than 1m from the camera, 1 for partial obstruction of view, and 2 was a completely unobstructed view. Lander drops with a visibility score of 0 or a view score of 0 were not reviewed any further, nor were they entered into the database.

Video was scored for primary and secondary habitat type in one of ten categories (Table 4). Primary habitat was defined as the dominant substrate type in view with at least 50% of the view. Secondary habitat was the second most dominant substrate with at least 20% of the view.

Table 4. Geologic substrate classes and definitions used for scoring 2012-13 lander video.

Substrate classes	Description
Bedrock	Substrate with mostly continuous formations of bedrock
Bedrock Outcrop	Individual rocks or outcrops of bedrock with sizes greater than or equal to 4.0 meters in any dimension
Large Boulder	median Gravel size of 1 m to ← 4.0 m, including angular and rounded blocks
Small boulder	median Gravel size of 25 cm to ← 1 m
Cobble	median Gravel size of 64 mm to ← 25cm
Gravel Pebble	median Gravel size of 2 mm to ← 64 mm

Sand	particles 0.0625 mm to ← 2 mm in diameter
Mud	particles less than 0.0625 mm in diameter
Shell substrate	primarily composed of shells or shell particles; shell particles have a median size from 2 mm to 64 mm (though larger is acceptable); if particles are small than 2mm, score as sand
Worm substrate	primarily composed of the cemented or conglomerated calcareous or sandy tubes of polychaetes or other worm-like fauna

Biogenic habitat was grouped into five categories based on size and shape: canopy (stipes or holdfasts visible), midstory (→ 25 cm in height), understory (5-25 cm in height), turf/crust (← 5 cm in height), and seagrass. Each category was given a score of 0-5, with 0 being not present; 1 = ←5%; 2 = 5-25%; 3 = 26-50%; 4 = 51-75%; 5 = 76-100%.

Fish and invertebrate relative abundance were scored as MaxN per species. MaxN was determined as the greatest number of individuals observed within a single frame of the video to minimize the risk of repeat sampling the same mobile individuals. Only a subset of invertebrates was scored (Table 5). These conspicuous and largely mobile invertebrates mirror the species list used in the PISCO subtidal SCUBA surveys and are considered target invertebrate species for the ecosystem. At the point when the maximum number of fish of a given species was seen in the video, that instantaneous count was recorded as the MaxN for that species. A MaxN was recorded for each species observed. Organisms were scored to the lowest taxonomic resolution possible. Organisms that could not be confidently identified to the species level were recorded to the next higher taxonomic level, such as "unidentified rockfish" or "unidentified sea star". Additionally, fish seen as the lander was descending were counted, totaled, and recorded separately in the Access database created for the lander dataset.

To ensure quality control for the database, a random subset (20% of all lander drops) were re-reviewed by a second reviewer. Any discrepancies were resolved and the database corrected. The rate of errors was very low and no further QC review for this dataset was performed. Quality control for lander drops done in 2013 was performed on a higher number of drops representing 29% of the total drops. Again, the error rate was very low. Data entry was checked for 100% of drops to ensure accurate data was entered into the database.

Table 5. List of invertebrates considered target species for recording from lander video data.

Common Name	Genus	Species
Bat Star	*Patiria*	*miniata*
Blood Star	*Henricia*	*spp.*
Christmas Anemone	*Urticina*	*crassicornis*
False Ochre Star	*Evasterias*	*troschellii*
Fish-Eating Anemone	*Urticina*	*piscivora*
Giant Acorn Barnacle	*Balanus*	*nubilus*
Giant California Sea Cucumber	*Parastichopus*	*californicus*
Giant Green Anemone	*Anthopleura*	*xanthogrammica*
Giant White Plumed Anemone	*Metridium*	*spp.*
Giant-spined Star	*Pisaster*	*giganteus*
Gumboot Chiton	*Cryptochiton*	*stelleri*
Leather Star	*Dermasterias*	*imbricata*
Morning Sun Star	*Solaster*	*dawsoni*
Ochre Star	*Pisaster*	*ochraceus*
Orange Sea Cucumber	*Cucumaria*	*miniata*
Pink or Short-spined Star	*Pisaster*	*brevispinus*
Purple Urchin	*Strongylocentrotus*	*purpuratus*
Rainbow Star	*Orthasterias*	*koehleri*
Red Urchin	*Stongylocentrotus*	*franciscanus*
Red, Flat or Pinto Abalone	*Haliotis*	*spp.*
Rock Scallop	*Crassadoma*	*gigantea*
Rough Keyhole Limpet	*Diodora*	*aspera*
Starburst Anemone	*Anthopleura*	*sola*
Stimpson's Sun Star	*Solaster*	*stimpsoni*
Stubby Rose Anemone	*Urticina*	*coriacea*
Sunflower Star	*Pycnopodia*	*helianthoides*
Velcro Star	*Stylasterias*	*forreri*
White-spotted Rose Anemone	*Urticina*	*lofotensis*
Dungeness Crab	*Metacarcinus*	*magister*
Basket Star	*Gorgonocephalus*	*eucnemis*
Weathervane Scallop	*Patinopecten*	*caurinus*
Giant Pacific Octopus	*Enteroctopus*	*dolfleini*

Data Analyses

Numerous lander drops were conducted during the 2012-2013 field seasons (n=514). Drops were excluded from analysis if the visibility and view scores equaled zero indicating that our ability to observe fishes in these drops was compromised by poor visibility and/or an obstructed or upward facing view from the lander. Only fishes and invertebrates that were observed during the bottom time (i.e. not on deployment or retrieval) were analyzed. Unidentified species were not included in the main analyses;

however unidentified (UNID) juvenile rockfish were included since these individuals demonstrate potential ontogenetic differences from their adult counterparts.

In total, 203 drops (39.5%) yielded fish data for the 2012-2013 effort. Of these, 92 of the 203 (45%) consisted of a single fish observation. 148 drops (29%) yielded mobile invertebrate data for the 2012-2013 effort. Of these, 130 (94%) consisted of a single mobile invertebrate observation. Lastly, 53 drops (10%) yielded sessile invertebrate data for the 2012-2013 effort. Of these, 130 (92%) consisted of a single sessile invertebrate observation.

The goal of the analyses presented in this report was not to compare fish and invertebrate communities in a reserve versus comparison area. As we are still collecting baseline data, the reserve-comparison area analysis will wait until baseline data collection has completed. Rather, we focused this analysis on several confounding factors within our current dataset that could influence our response variables for the fish and invertebrate communities observed. These confounding variables include: lander configuration, visibility, view, drop duration, depth, habitat relief, and substrate type. We aim to explore which, if any, of these variables significantly influence our response variables and explore what method refinements we can put into play for future sampling to collect more robust and unconfounded data using the video lander.

Univariate response variables consisted of MaxN, aggregate MaxN ($MaxN_a$) and species richness. MaxN is a relative abundance estimate per species. $MaxN_a$ is therefore the sum of all the MaxN values for all species in a given drop. Species richness is calculated as the total number of species that were observed during a drop. These response variables failed to meet the assumptions of normality so several transformations were conducted. Since the transformations did not result in the meeting the parametric assumptions of normality, the equivalent non-parametric tests were performed.

II. SLED

As broad areas of unconsolidated substrate make up significant portions of the marine reserves and comparison areas, we chose an inexpensive video sled with a customizable design to survey unconsolidated substrate to survey for fish and invertebrates and classify substrate type. Also, while a video sled may require large amounts of post-survey analysis and processing time, and have a high initial equipment and video software cost, the video sled is very responsive logistically, requiring less than one day to mobilize, and only two people aboard to operate the equipment.

The video sled consisted of an aluminum 3-rail sled frame, 85cm wide and 160cm overall length, constructed of 2.5cm inside diameter aluminum pipe frame (
Figure 13). The video camera was located centrally, looking forward and down at a 30-degree angle. The lights were placed 35cm to the side of the camera, one light on the right in 2012, and two lights, one to either side in 2013. Ten-centimeter parallel lasers were fitted directly above the camera. The pressure tube for the batteries and controller electronics was hung under the spine of the sled, keeping mass centrally concentrated. Chains were hung from the four corners of the sled frame, balanced by flotation attached

to the sled frame. The result was that the sled frame floated a few inches off the bottom, allowing transects to be sampled with minimal stalling due to friction on the bottom.

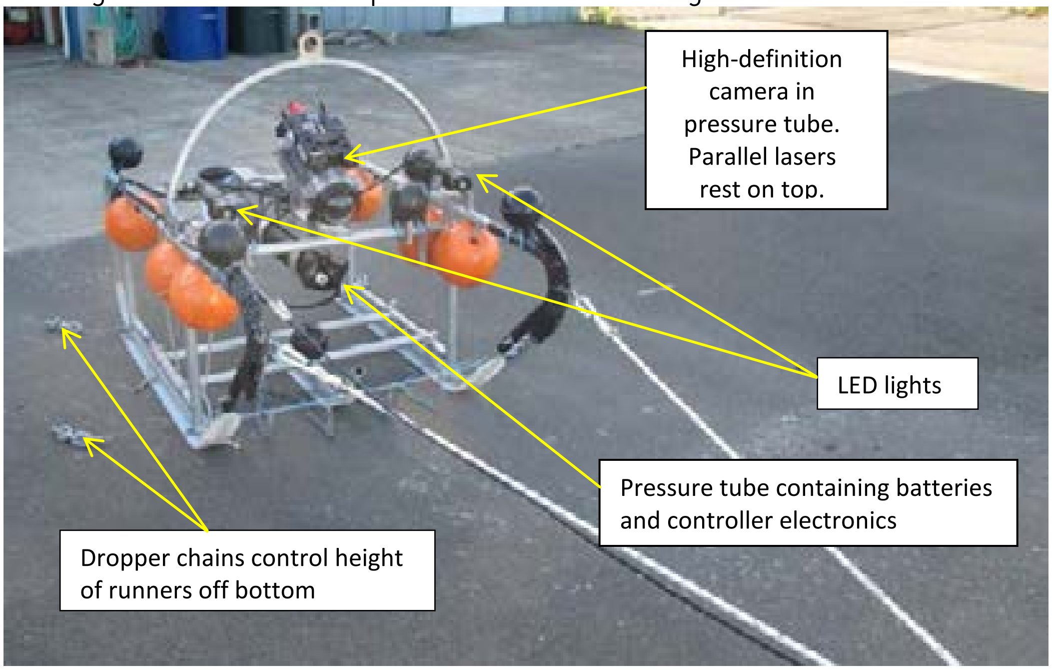


Figure 13. Photograph of the video sled as configured in 2013.

For 2012, video was sent from a Deep Sea Power & Light (DSPL) 2060 low-light color camera to a Sony MiniDV camcorder, and lighting provided by one DSPL Rite-Lite fitted with a 5-watt LED flood. In 2013, we changed the main video system to a high-definition Canon Vixia HF G10, with lighting by two DSPL SeaLite Six LED lights. A Horita PG-2100 time-code generator synced to GPS time was connected to the camcorder and laid an analog time-code signal onto the audio track.

The towline was constructed from 7/16" 3-strand poly-dacron line. A depressor weight of approximately 70 kg was clipped into a becket eye spliced 18.3m above the sled on the towline. For both years, a remote GPS antenna was placed as closely as possible over the crab block of the vessel used to deploy the sled and the GPS recorded a track of vessel location once per second.

Study Design

Sampling in 2012-13 occurred at the Cascade Head (Figure 14) and Cape Perpetua (Figure 15) sites over the course of the summer and fall months to take advantage of good weather and vessel availability (
Table 6). Locations for sled transects were determined using a stratified random design targeting areas of unconsolidated substrate, stratified by depth, divided into 10 m strata. Sampling was confined to deeper than 10 m due to turbidity and visibility restrictions, out to depths of 60 m at the outer boundaries. The area of unconsolidated substrate within each depth stratum was calculated. A sampling goal of a 500m sled transect per square km of unconsolidated substrate per stratum was determined based on cost and sampling

speed. Multiple transects of shorter length can yield, when distributed throughout the depth stratums, spatially independent replicate samples. Transect starting locations were selected randomly within a depth stratum. The target transect length was 600-800 meters. Each transect was constrained to a single 10m depth stratum and followed the depth contour. To avoid behavioral biases, we restricted sampling to daylight hours, one hour after official sunrise until one hour before official sunset.

Table 6. Summary of sled transects sampled in 2012-13 by area (listed north to south). Total area of unconsolidated substrate for each area is shown, as well as mean transect length (m). For each given area, the percentage of the targeted transect length (500m/km2) is shown.

Area	Unconsolidated Area (km^2)	Number of Transects	Mean Transect Length (m)	% Sampling Goal Surveyed (m)
Cascade Head MR	21.8	14	606	77.8
Schooner Creek CA	16.6	6	472	34.1
Cavalier CA	25.1	11	639	56.0
Postage Stamp CA	35.7	20	801	90.5
Cape Perpetua MR	36.1	18	1,051	104.8
Tokatee CA	22.1	12	994	107.9

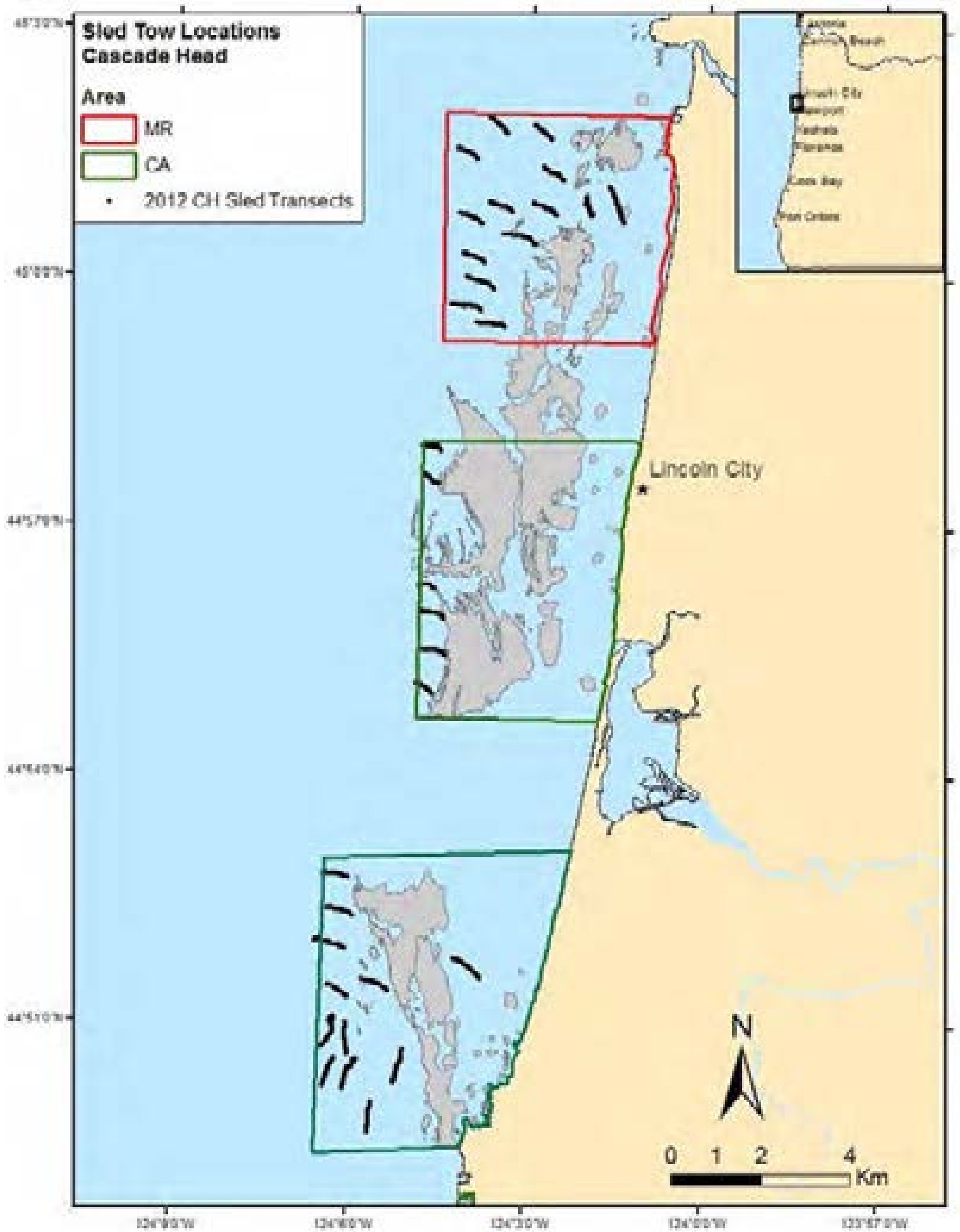


Figure 14. Sled sampling locations at Cascade Head Marine Reserve and comparison areas in 2012.

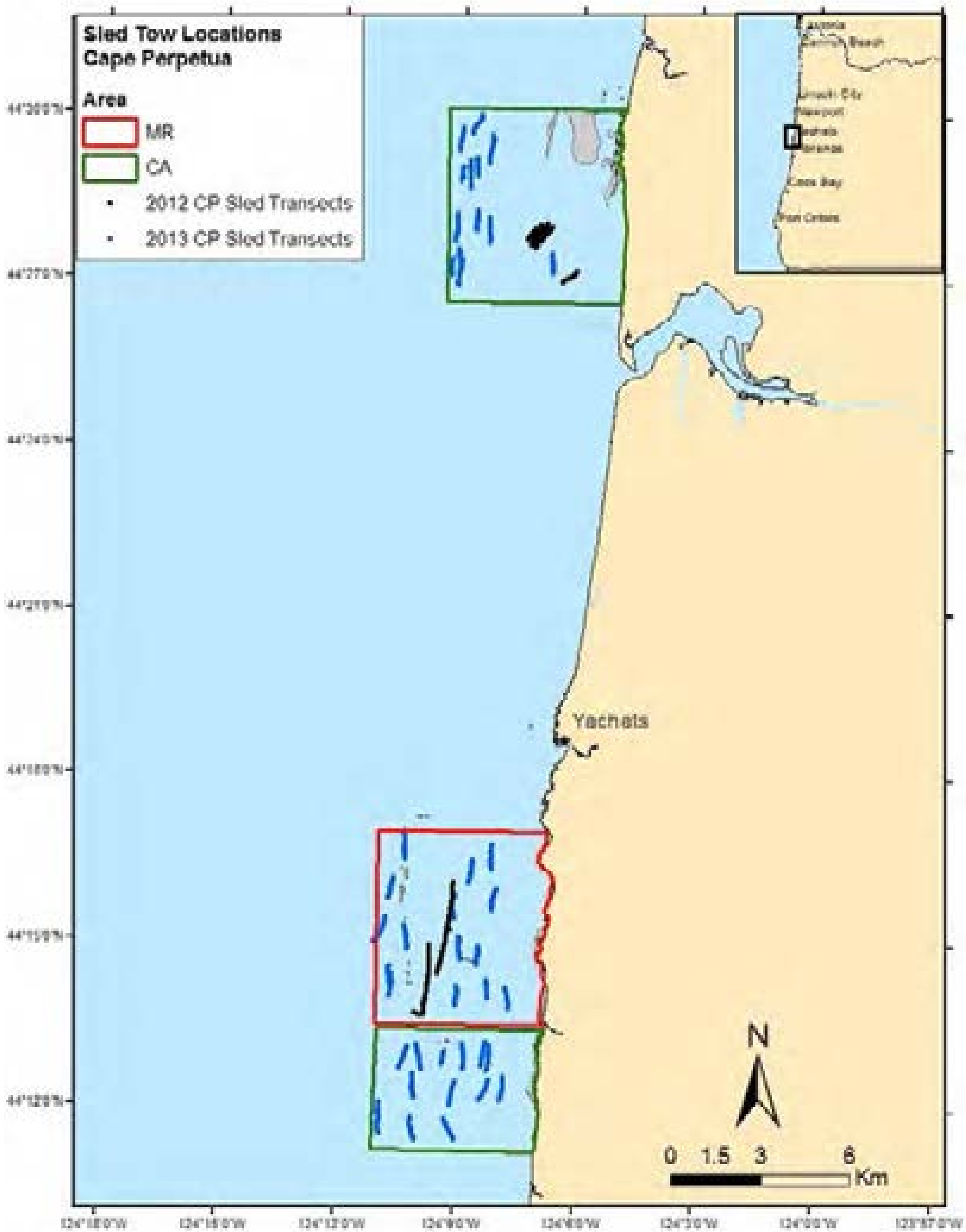


Figure 15. Sled sampling locations at Cape Perpetua Marine Reserves and comparison areas in 2012-13.

Field Methods

The vessel was positioned over the selected starting point and transect data were recorded including date, time, target point, depth, location, tape/memory card number, and tow number. The sled was placed overboard, depressor weight attached, and then lowered to the seafloor. The depressor weight was hung 1.5-3.5 m off-bottom allowing the sled to be towed from straight ahead.

Depth was recorded every two minutes from the vessel. For optimal video quality, a slow vessel speed of 1 knot was targeted, and the vessel maintained a course to follow the depth contour, or, if necessary, towing into the wind and/or current to maintain a 1 knot speed while keeping the sled within the desired depth range. If the sled came off the bottom, the vessel was temporarily slowed to allow the sled to sink and regain a stable attitude along the bottom, and/or the height of the depressor weight off-bottom was adjusted.

Data Analyses

Video from each sled transect was viewed for analysis with Adobe Premier. Using Premier, we overlaid masks on-screen, with superimposed horizontal lines at points corresponding to 80% of the vertical distance from the bottom of the screen, and another at 50%, roughly the level where the lasers struck the substrate.

Four categories of information were recorded for each video transect: sled status, habitat, organism, and in 2013 biogenic habitat. Within a sled transect, each habitat or organism classification was paired with an observation time using a Horita TCW-50 time code wedge, TR-100 timeclock, and a programmable X-keys keyboard, allowing the reviewer to enter the time with a keystroke. Each classification event was entered in the database to the nearest second.

Sled status was first assessed for video quality, visibility, and other factors. Observations were made for when the sled was operating normally, off-bottom, obstructed by kelp or rock, malfunctioning, or stopped. An entry was also made for the time that the sled touched down at the beginning of the tow and began the on-bottom transect, as well as the time that the sled lifted off the bottom and the transect ended.

Habitat was classified as it passed through the bottom of the screen. Characteristics recorded included substrate type (same classifications as with video lander), vertical relief, composition, surface pattern, and limited structural classifications. Primary habitat was defined as comprising →50% of the video screen from the 50% line to the bottom of the screen; secondary habitat comprised 20-50% of the same area. Vertical relief was classified as "high" or "low" for bedrock, with the criteria being a change of 50cm over a 1m lateral distance. Surface patterns in unconsolidated substrate were recorded as flat, dimpled, ripples, waves, or mounds. If the sled was towing in an area where unconsolidated substrate adjoined the edge of a rock structure, "edge/transition" was recorded. Biogenic habitat was classified in an identical manner to the video lander.

Fish and select invertebrates were counted only when they passed below the 80%-line (any part of the fish), constraining the survey to a fixed width and accounting for the practical limits of underwater visibility. Invertebrates and macroalgae were counted as they passed below the 50%-line. The transect width was calculated at the 50% line, which extends horizontally across the monitor image at the vertical midpoint. The width of the laser reflection points was measured repeatedly in each of 10 randomly selected transects, and a mean width of the video image calculated as 166 cm. Fish passing were identified to species or lowest taxonomic grouping possible and enumerated. Select sessile and mobile macroinvertebrates were identified to species or lowest possible taxonomic grouping and either relative abundance or counts were determined. In 2012, the video analysis was done without reference to a restricted list of species that were intended for analysis. All organisms observed were recorded in the database.

For 2012, eight of the 39 tows were randomly selected for quality control review by a second reviewer. Any discrepancies were resolved and corrected in the database. Upon viewing the 2012 database, we questioned the utility of the sled sampling tool to generate species-specific abundances for soft sediment fishes and invertebrates. The motion of the sled makes clear stop-frame images difficult to obtain which limits species-level identification. As a result, in the 2012 sled video data, 99.0% of the fish observed in Cascade Head Marine Reserve (MR) were classified as either unidentified flatfish or unidentified fish, and 94.9% and 97.9% in Schooner Creek and Cavalier comparison areas CAs respectively. The Cape Perpetua video showed a similar quality. Without species-specific resolution, counts of unidentifiable fishes are of very little use. Some additional issues included questionable taxonomic ID based on common names that could not be related to specific species (e.g. fish eating star) and encounter rates with consolidated rock substrates that resulted in scoring organisms not found in soft substrates.

With high-definition video in 2013, cursory examination of the video showed no significant improvement in the identification rate, and the video was not scored in detail.

Data Analyses

For data analysis, we queried the 2012 database to limit organism observations to sand habitats only, where both primary and secondary habitats were sand. We then restricted our organism analysis to species or species groups who would be found within soft sediments and/or were commercially important (Table 7). Sea stars were retained due to the wasting syndrome that impacted subtidal waters after this survey was completed. Sea pens were retained as a biogenic component of soft sediment habitats.

Table 7 Organisms or organismal groups retained from the sled 2012 data base for analysis.

Fish	Mobile Invertebrate	Sessile Invertebrate
UNID Flatfish	Basket Star	Sea Pen
Big Skate	Leather Star	
Dover Sole	Mottled Sea Star	
Pacific Sanddab	Pink Sea Star	
Skate	Sand Star	
	Sunflower Star	
	UNID Sea star	
	Dungeness Crab	

Density of these species were estimated per transect by dividing the total count by the transect length. Note that this transect length does not account for the section of the total transect that may have encountered consolidated substrates such a small boulders or bedrock habitat. While these organisms were excluded from the organism count we did not modify the transect length to exclude these small patches of hard bottom habitats. Hence, this density data should be viewed as slightly conservative underestimates of true density.

III. ROV

Primary Investigator: Scott Marion

Introduction

Visual surveys of habitat and biota in targeted rocky reef areas at depths greater than 20 meters were conducted using ODFW's remote operated vehicle (ROV), a Deep Ocean Engineering Phantom HD2+2. A high definition video camera (Sony HDR CX550V) housed in a custom pressure tube with a dome port was mounted on the front of the ROV at an angle of 30° below horizontal, and a pair of parallel red lasers (Deep Sea Power & Light SeaLaser 100) spaced 10 cm apart were mounted on the housing to provide a scale reference. Time data from a Horita PG2100 time code generator located within the video housing was recorded onto the camera's audio track for later synchronization of video observations with ROV position data. Altitude above the seafloor was tracked with the aid of two ranging altimeters, one mounted on the forward-looking camera housing and one mounted vertically at the rear of the ROV. Two Nuytco 200-watt HMI lights provided illumination for the forward-looking camera. The ROV was navigated using an acoustic tracking system (ORE Offshore Trackpoint III), high-precision GPS heading sensor (Hemisphere VS100), motion reference unit (ORE Offshore), and Hypack software. Raw ROV positions were determined at 1 s intervals and subsequently smoothed using a 7-point moving average to minimize any positional artifacts. This equipment and processing typically yielded a positional accuracy of ± 4 m.

Study Design

A stratified random sampling design was used to target transects within two depth strata, 20-30 m ("shallow") and 30-40 m ("deep"). Potential transects approximately 500 m in length intersecting hard-bottom reef habitats and following depth contours were delineated using ArcGIS. Subsequently, equal numbers of shallow and deep transects were randomly selected for surveying. Video transects were conducted with the ROV less than 1 m above the bottom at a target speed of 0.5–1 knot, though speed varied as wind and seas affected the survey vessel. The resulting view angles produced a transect width of 1-4 m as the ROV navigated bottom features. A transect was considered valid if its video quality was sufficient to identify fish along at least 40% of its length.

In 2012, ROV transects were conducted at Cascade Head Marine Reserve (MR) and Cavalier comparison area (CA) on September 20-22 aboard the R/V Pacific Surveyor (map of transects provided in the results section). A total of 32 transects were conducted, 16 at each site. Visibility conditions required replacement of some targeted transects, and as a result the depth distribution of completed transects differed from the initial targets. At Cascade Head MR, ten (10) shallow, five (5) deep, and one (1) intermediate (approximately 30 m deep) transects were completed. At Cavalier CA, six (6) shallow, eight (8) deep, and two (2) intermediate transects were completed.

Also in 2012, three extended ROV transects totaling approximately 3.2 km in length were conducted at Cape Perpetua Marine Reserve on October 7. These transects are surveyed each year as part of a 12-year time series documenting impacts of hypoxic episodes during upwelling events. Unlike the Cascade Head region where transects targeted a small subsample of the region's rock, the Cape Perpetua transects were designed to efficiently sample much of the area's limited rock substrate.

In 2013, ROV transects were conducted at Cascade Head MR, Schooner Creek CA, and Cavalier CA on October 24-26 aboard the F/V Timmy Boy.   A total of 30 transects were targeted, five (5) from each depth stratum at each site. Poor visibility encountered on the first day of sampling resulted in no valid transects completed in the Cavalier CA, but at Cascade Head MR and Schooner Creek CA both depth strata were successfully sampled with five (5) transects each, for a total of 20 valid transects.

Video Review

Digital video files were reviewed using Adobe Premier Pro CS6. The audio track containing time stamp data was directed to a Horita TCW-50 time code wedge which provided text input to an Xkeys programmable data entry keyboard. This allowed reviewers to use single keystrokes to enter species codes, substrate codes, or other information along with associated times of observation into a Microsoft Access database. The times of observation were later merged with time-stamped ROV navigation files to geolocate each observation along a transect at 1 s intervals.

A trapezoidal screen overlay was used to define the review frame, an area of usable video extending from the full width at the bottom of the screen to a line at 80% of screen height, tapering toward the top. This overlay excluded areas too distant or marginal to allow reliable species identification. Within the review frame, six individual data types were each interpreted from video in separate passes:

1. ROV Status review applied a threshold criterion to exclude problematic sections of video with respect to identifying fish. Segments were defined as a Fish Gap if the reviewer estimated that a 20 cm fish could be obscured in more than 20% of the review frame for any reason, including poor visibility, terrain obstructions, or ROV maneuvering. Fish Gaps were also invoked if the ROV was not making relatively linear forward progress (e.g. during stops or rapid turns). Fish Gap segments were excluded from later quantitative analyses of fish abundance, though other data from Fish Gaps such as substrate type were used where appropriate.
2. Transect width was calculated at 30 s intervals by measuring the on-screen distance between scaling laser contact points with the sea floor. Camera calibration

measurements conducted prior to the survey were used to relate measured laser width to review frame width. The total surveyed area was calculated as the total transect length (excluding Fish Gaps) times the mean transect width.

3. Primary and secondary substrates were assessed continuously along the transect as they intersected the bottom of the review frame. Substrate types classified were bedrock (including outcrops → 4 m diameter), large boulder (1 – 4 m), small boulder (0.25 – 1 m), cobble (64 – 250 mm), gravel (2 – 64 mm), sand (0.06 – 2 mm), and shell hash. Any substrate type recorded was required to constitute → 20% of the assessed area, and a Substrate Gap was recorded if more than 20% of the substrate was not viewable. Where primary and secondary substrates each comprised half of the assessed area, the type with the larger grain size was recorded as primary. Substrate codes were entered during review at points where substrate proportions or grain sizes transitioned to new categories, and the database was subsequently interpolated to assign a primary and secondary substrate (or Substrate Gap) for each second along the transect.
4. Fish were identified to species where possible for 26 target species (Table 8), and otherwise were recorded in higher level taxonomic groupings (Table 9). Size of individual fish was estimated where possible (broadside near lasers) within the following categories: ← 10 cm, 10 – 30 cm, 30 – 60 cm, → 60 cm. Sex was recorded for Kelp Greenling, which exhibit distinct coloration by sex. Schooling behavior was also recorded.
5. Invertebrates belonging to the list in Table 10 were enumerated. Size of individual invertebrates was estimated where possible within the following categories: ← 5 cm, 5 – 15 cm, 15 – 30 cm, 30 – 50 cm, → 50 cm. Sizes were estimated following the dimensions in Table 11.

Data Analyses

ROV position, substrate type, ROV Status, and fish and invertebrate observations were merged into a single data file based on timestamps associated with each record using R statistical software. ROV positions were used to calculate a total transect length associated with each substrate class for each transect. For the current analysis, only primary substrate classes were used. Total fish and invertebrates counts for each transect were divided by transect length to generate a mean abundance per linear meter. Total counts of fish found in association with each substrate type were calculated. Fish distributions were also qualitatively examined by plotting transect data on maps showing bathymetric relief and habitat distributions derived from previous multibeam surveys.

Fish and invertebrate taxa were ranked by total abundance. Quantitative data analyses were conducted only for those taxa sufficiently numerous to constitute at least 1% of total abundance. Mean abundance of each taxon at Cascade Head MR and Cavalier Reef CA was compared using Welch's t-tests on square root transformed data. Shannon Diversity and Pielou's Evenness Indices were calculated for fish and invertebrate communities at each area.

Table 8. Fish targeted for species-level identification.

Scientific Name	Common Name
Anarrhichthys ocellatus	Wolf-eel
Embiotoca lateralis	Striped Surfperch
Hemilepidotus hemilepidotus	Red Irish Lord
Hexagrammos decagrammus	Kelp Greenling
Hippoglossus stenolepis	Pacific Halibut
Hydrolagus colliei	Ratfish
Ophiodon elongatus	Lingcod
Oxylebius pictus	Painted Greenling
Platichthys stellatus	Starry Flounder
Rhacochilus vacca	Pile Surfperch
Scorpaenichthys marmoratus	Cabezon
Sebastes auriculatus	Brown Rockfish
Sebastes caurinus	Copper Rockfish
Sebastes entomelas	Widow Rockfish
Sebastes flavidus	Yellowtail Rockfish
Sebastes helvomaculatus	Rosethorn Rockfish
Sebastes maliger	Quillback Rockfish
Sebastes melanops	Black Rockfish
Sebastes miniatus	Vermilion Rockfish
Sebastes mystinus	Blue Rockfish
Sebastes nebulosus	China Rockfish
Sebastes nigrocinctus	Tiger Rockfish
Sebastes pinniger	Canary Rockfish
Sebastes ruberrimus	Yelloweye Rockfish

Table 9. Fish species groupings for unidentified and non-targeted fish.

Groupings
Eelpout (Zoarcidae and other elongated unidentified fish)
Unidentified fish
Unidentified flatfish
Unidentified left-eyed flatfish (Bothidae)
Unidentified right-eyed flatfish (Pleuronectidae)
Unidentified rockfish (Sebastes sp.)
Unidentified sculpin (Cottidae)
Unidentified skate (Rajidae)
Unidentified surfperch (Embiotocidae)

Table 10. Invertebrates targeted for enumeration.

Scientific Name	Common Name
Aphrocallistes vastus	Cloud sponge
Armina californica	Striped nudibranch
Ascidia sp.	Glassy tunicate
Cancer magister	Dungeness crab
Craniella sp.	Tennis ball sponge
Cucumaria sp.	Burrowing cucumber
Dermasterias imbricata	Leather star
Doridae	Dorid nudibranch
Enteroctopus dofleini	Pacific giant octopus
Gorgonocehphalus sp.	Basket star
Henricia sp.	Blood star
Loligo opalescens	California Market Squid
Luidia foliolata	Sand star
Metridium farcimen	Giant white plumose anemone
N/A	Unidentified anemone
N/A	Unidentified crab
N/A	Unidentified nudibranch
N/A	Unidentified star
Octopus dofleini	Pacific Giant Octopus
Octopus rubescens	Red octopus
Orthasterias koehleri	Rainbow star
Pachycerianthus fimbriatus	Tube anemone
Pachycerianthus sp.	Tube anemone
Parastichopus californicus	Giant cucumber
Pectinidae	Scallop
Pisaster brevispinus	Pink pisaster star
Polymastia pachymastia	Aggregated nipple sponge
Pteraster tesselatus	Pincushion star
Ptilosarcus gurneyi	Orange sea pen
Pycnopodia helianthoides	Sunflower star
Solaster sp.	Sun stars
Styela monteryensis	Stalked tunicate
Stylasterias forreri	Fish eating star
Stylissa sp.	Trumpet sponge
Suberites sp.	Peach ball sponge
Swiftia spauldingi	Gorgonian
Tethya sp.	Rough ball sponge
Urticina columbiana	Columbia sand anemone
Urticina coriacea	Stubby rose anemone
Urticina crassicornis	Painted anemone
Urticina lofotensis	White spotted rose anemone
Urticina piscivora	Fish eating anemone
Urticina spp.	Unidentified Urticinid anemone

Table 11. Dimensions used to estimate invertebrate size.

Organism	Size metric
Anemone	Columnar diameter
Basket star	Oral disk diameter
Crab	Carapace width
Crinoid	Arm length
Cucumber	Length
Finger sponge	Height
Gorgonian	Height
Nudibranch	Length
Sea star	Diameter
Tunicate	Height

IV. SCUBA

Survey Collaborators: Oregon Coast Aquarium and Oregon State University

Introduction

Subtidal SCUBA surveys for Oregon's Marine Reserves are patterned off the PISCO subtidal kelp forest surveys used along the California Coast (http://www.piscoweb.org/research/science-by-discipline/ecosystem-monitoring/kelp-forest-monitoring). These surveys consist of fish, invertebrate, and macroalgal belt transect and point intercept sampling of rocky reef habitats. Replicate transect surveys are completed within each sampling cell at established depth contours. Survey cells are selected to encompass rocky reef habitats from and span depths from 10-20m depth. The specific dimensions of each cells are not fixed as the depth contours dictate how far off shore a cell will extend to obtain depths of 20m. In general, the cells are ~200m wide (parallel to depth contour). Replicate survey cells sampled within each marine reserve and corresponding comparison areas.

Sampling Conducted

As Cape Perpetua has extremely limited rocky reef habitat between 10-20m depths, SCUBA surveys were only conducted in the Cascade Head site between 2012-13. Surveys were initiated in fall 2013 to establish ecological baselines prior to the reserve closure on January 1, 2014. However ODFW's lack of a scientific diving program coupled with limited numbers of scientifically trained Oregon-based divers has hindered rapid collection of subtidal baseline data. Baseline monitoring for Cascade Head using volunteer scientific divers trained in partnership with Oregon Coast Aquarium and Oregon State University (OSU) continued into 2014. For this report, basic summary statistics of the surveys completed in Cascade Head Marine Reserve (MR) (Table 12) will be provided.

More extensive comparisons between the reserve and comparison area will occur in 2014 once the dataset has been completed.

The distribution of survey cells within the Cascade Head MR and the Schooner Creek comparison area (CA) reflect areas of both rocky habitat and depths of 10-20m. The shallow depth of 5m employed by PISCO surveys in California was deemed too difficult to sample in Oregon nearshore conditions and removed from the sample planning. While baseline surveys in both Otter Rock and Redfish Rocks reserves in 2010-11identified emergent rocks and forests of the bull kelp, *Nereocystis luetkeana,* these habitats were not prevalent in the Cascade Head site. Rather, sampling cells were selected first by prevalence of rocky reef structure based on the Active Tectonics and Seafloor Mapping Lab's (Oregon State University) benthic habitat maps and then further stratified by depth. We aimed to establish four sample cells in each area (Cascade Head MR and Schooner Creek CA). However, limited shallow rock habitat in Schooner Creek limited our sampling to only three cells in this area (Figure 16). Within each cell, a depth stratified sampling design was used that differed between fish and benthic surveys.

Fish belt transects (2m wide x 2m tall x 30m long) were conducted at 20, 15, and 10m depths. All fish encountered within the $120m^3$ transect were identified to species and fork length (cm) was estimated. For invertebrate and macroalgal sampling, within a sampling cell, a single waypoint was generated at 20m and 12.5m (using ArcGIS bathymetry layers). Two benthic transects were completed at each point. Invertebrate transects included uniform-point count (UPC) 30m transects with data describing relief, substrate and cover recorded every meter, and invertebrate swath (2m x 30m belt transects) censusing the abundance of a specific, conspicuous invertebrates. If conspicuous brown macroalgae was present at the site, a macroalgal swath surveys was completed.

At Cascade Head MR, a total of 32 benthic survey transects were completed in October 2013; 16 UPC and 16 invertebrate swath transects (Table 12).

Data Analyses

Surveys initiated in 2013 were continued into 2014 in the Cascade Head site as limited weather windows and diver availability prevented a complete subtidal sampling prior to the closure of the reserve on January 1, 2014. Hence, data from the fall 2013 sampling will be pooled with 2014 data to represent baseline subtidal condition for the reserve and comparison area. Results and analysis will be compiled for the 2014-15 monitoring report.

Table 12. Cascade Head Marine Reserve SCUBA surveys completed in 2013. Only invertebrate surveys were completed in 2013.

Site	Area	Cell	Date	Lat	Long	Depth (m)	Survey	Transects
CH	MR	1	10/17/2013	45.02957	124.02439	20	UPC	2
CH	MR	1	10/17/2013	45.02957	124.02439	20	Invert swath	2
CH	MR	1	10/17/2013	45.02709	124.01894	12	UPC	2
CH	MR	1	10/17/2013	45.02709	124.01894	12	Invert swath	2
CH	MR	2	10/17/2013	45.02211	124.02399	20	UPC	2
CH	MR	2	10/17/2013	45.02211	124.02399	20	Invert swath	2
CH	MR	2	10/17/2013	45.02484	124.02206	12	UPC	2
CH	MR	2	10/17/2013	45.02484	124.02206	12	Invert swath	2
CH	MR	3	10/18/2013	44.99430	124.02791	20	UPC	2
CH	MR	3	10/18/2013	44.99430	124.02791	20	Invert swath	2
CH	MR	4	10/18/2013	44.99947	124.02735	20	UPC	2
CH	MR	4	10/18/2013	44.99947	124.02735	20	Invert swath	2
CH	MR	1	10/18/2013	45.02642	124.02193	12	UPC	2
CH	MR	1	10/18/2013	45.02642	124.02193	12	Invert swath	2
CH	MR	2	10/18/2013	45.02802	124.01935	12	UPC	2
CH	MR	2	10/18/2013	45.02802	124.01935	12	Invert swath	2

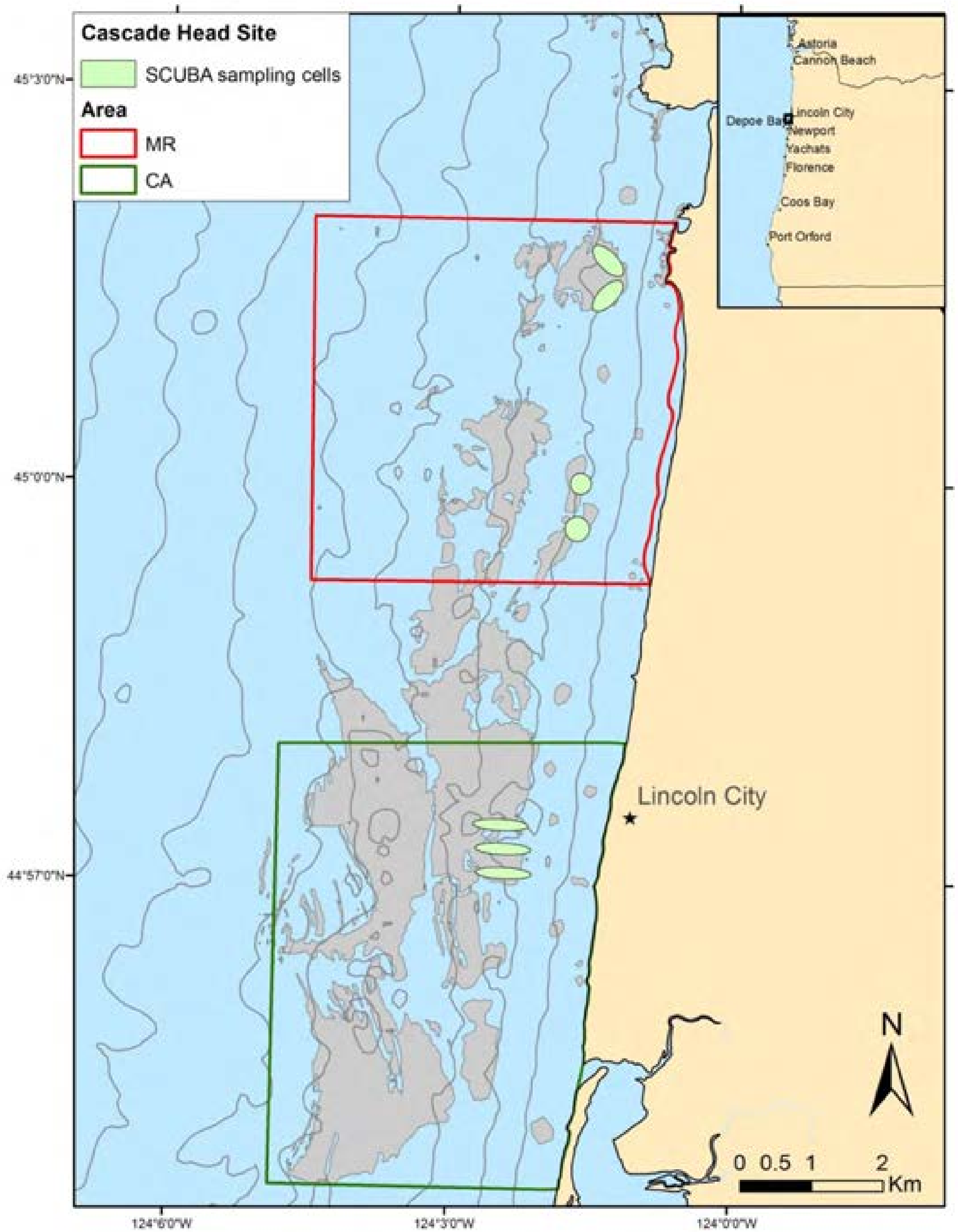


Figure 16. Sampling cells for SCUBA subtidal surveys. Gray polygons represent rock habitat based on benthic habitat maps. Grey lines reflect raster bathymetry (10 meter depth increments). Locations for transects sampled within the green cells can be found in Table 12.

V. RED URCHIN SURVEYS

Primary Investigator: Scott Groth

Introduction

In 2012-2103 the ODFW Shellfish Program continued long term monitoring of red sea urchin populations (*Strongylocentrotus franciscanus*). Sampling took place at index sites located in harvest areas, historic protected areas, and at new marine reserves.

Redfish Rocks and Otter Rock reserve sites have been historically important to the commercial red sea urchin fishery. Sampling was implemented to understand changes in population structure and abundance between these new reserve sites relative to nearby control sites, which are subject to ongoing fishery pressure. Comparing measures of abundance and size structure between reserve and control areas allows an understanding of harvest refugia on sea urchins and the function of reserves as a potential management tool for the sea urchin fishery.

Sites were selected within areas of the extents of bull kelp, *Nereocystis luetkeana*, beds and of depths 5-20 meters. Historic sampling (1990's) targeted sites where commercial densities of red sea urchins were expected, these sites were prioritized in recent work to allow temporal comparison.

Standard sea urchin belt transect sampling was employed. Samples began at anchorage nearest planned coordinates. A 40 meter transect line was laid out using a dive spool marked at 5m increments. Transects were divided into sixteen (5x1m) quadrats, at each 5m increment and laterally 1 meter away from the transect line. Divers counted and collected emergent red sea urchins within each quadrat, then a biologist measured test diameter of each red sea urchin. Emergent purple sea urchins, *Strongylocentrotus purpuratus*, and flat abalone, *Halitotis walallensis*, were also counted; however, few were seen. In surveys since 2011, *Pycnopodia helianthoides,* were also enumerated.

Sampling Conducted

In 2012, red sea urchin surveys focused on areas in the vicinity of Depoe Bay, Oregon. Thirty three transects were completed in four days (Table **13**). Four transects were completed in Otter Rock Marine Reserve and ten in the Cape Foulweather Comparison Area (Figure 17). Additional transects were performed throughout the Depoe Bay area, including Whale Cove Habitat Refuge (6) and Pirate Cove Research Reserve (4).

Data are currently being compiled and analyzed by Scott Groth (ODFW) for a fishery report to be used for ongoing management considerations.

Table 13. Urchin surveys completed around the Otter Rock Marine Reserve sites in 2012. Survey coordinates, sampling dates and depths (m) are given.

Survey ID	Zone	Date	Lat	Long	Depth (ft)
2012001	Depoe North	8/7/2012	44.828953	124.071094	13.1
2012002	Depoe North	8/7/2012	44.826371	124.070564	9.1
2012003	Depoe North	8/7/2012	44.822739	124.069408	missing
2012004	Depoe North	8/7/2012	44.818509	124.073428	15.2
2012005	Depoe North	8/7/2012	44.805143	124.071312	10.1
2012006	Depoe North	8/7/2012	44.799785	124.076542	10.2
2012007	Depoe North	8/7/2012	44.795802	124.077607	13.7
2012008	Depoe North	8/7/2012	44.792305	124.076119	14.3
2012009	Pirates Cove RR	8/7/2012	44.818549	124.065951	5.5
2012011	Depoe North	8/8/2012	44.781572	124.07965	17.7
2012012	Depoe South	8/8/2012	44.763947	124.072303	14.6
2012013	Depoe South	8/8/2012	44.758483	124.070982	12.6
2012014	Depoe South	8/8/2012	44.757416	124.0742	11.7
2012015	Depoe South	8/8/2012	44.753952	124.07313	11.0
2012016	Otter Rock MR	8/8/2012	44.750445	124.073994	7.0
2012017	Otter Rock MR	8/8/2012	44.747681	124.074102	10.4
2012018	Otter Rock MR	8/8/2012	44.741566	124.071907	10.7
2012019	Otter Rock MR	8/8/2012	44.743602	124.069052	10.7
2012020	Pirates Cove RR	8/8/2012	44.818655	124.065953	4.6
2012021	Pirates Cove RR	8/8/2012	44.818634	124.06599	5.5
2012022	Pirates Cove RR	8/8/2012	44.818735	124.066878	6.1
2012023	Depoe North	8/9/2012	44.78525	124.077972	13.7
2012024	Depoe North	8/9/2012	44.775248	124.080272	15.2
2012025	Depoe North	8/9/2012	44.772069	124.079422	18.3
2012026	Depoe Bay Shallow	8/9/2012	44.796401	124.075684	7.9
2012027	Gov't Point Shallow	8/9/2012	44.821667	124.069518	9.1
2012028	Whale Cove HR	9/18/2012	44.788786	124.071814	6.7
2012029	Whale Cove HR	9/18/2012	44.788331	124.071461	5.9
2012030	Whale Cove HR	9/18/2012	44.7893	124.071985	5.3
2012031	Whale Cove HR	9/18/2012	44.789309	124.071986	4.6
2012032	Whale Cove HR	9/18/2012	44.789238	124.070926	5.5
2012033	Whale Cove HR	9/18/2012	44.789238	124.070926	4.6
2012034	Whale Cove Shallow	9/18/2012	44.787822	124.074598	12.2

Data Analyses

Sites were pooled into areas (Depoe North, Depoe South, Otter rock MR, Pirates Cove RR, and Whale Cove HR) based on latitudinal position or harvest restriction and mean density (and 95% CI) calculated per m^2. Size frequency distributions and mean urchin size were also compared among sites.

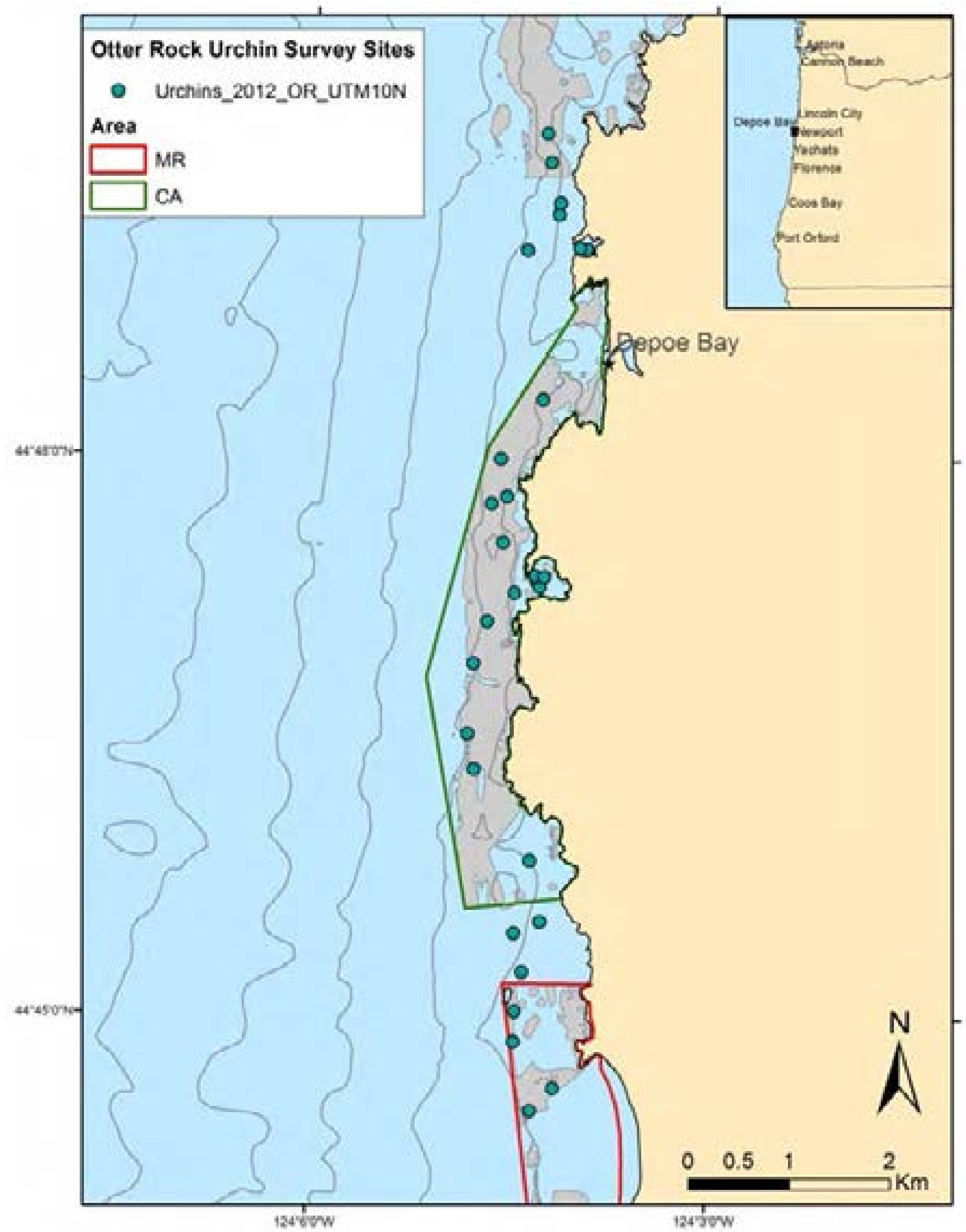


Figure 17. Map of red urchin surveys completed in Otter Rock Marine Reserve (red polygon) and Cape Foulweather Comparison Area (green polygon) in 2012.

C. Extractive Assessments

METRICS DERIVED: Focal fish population, sex, and age structure
Community composition of invertebrate and macroalgal communities on rock habitat

I. SMURFs

Primary Investigator: Dr. Kirsten Grorud-Colvert

Introduction

This research aims to quantify the community composition and abundance of recruiting temperate reef fishes to determine the value of designated MR habitats to protect early stages of fish ontogeny. In two previous years (2011, 2012) at the Otter Rock site, pilot efforts by Dr. Grorud-Colvert used Standard Monitoring Units for the Recruitment of Fishes--SMURFs (Ammann 2004) to successfully sample the relative abundance of settlement-stage fish recruiting to the reserve and adjacent comparison area. This same approach was used in 2013 in collaboration with OSU, PISCO, and the Oregon Coast Aquarium.

Sampling Conducted

Stationary SMURF units attached one meter below the surface to a fixed mooring were sampled every two weeks through the sampling season. Moorings were deployed in 15m of water (hence why moorings were placed outside the eastern boundary of Otter Rock MR). Moorings possess a surface expression consisting of a large crab float, a radar reflector, and halibut flag attached to a bamboo pole (Figure 18). Eight SMURF moorings were deployed between May 16-21, 2013 (Table 14); four in Cape Foulweather CA and four just outside Otter Rock MR. The two northernmost moorings were deployed from the R/V Elakha by OSU-PISCO's oceanography team. The remaining six moorings were deployed from the R/V Kalipi by PISCO and ODFW. Moorings were deployed with SMURFs attached. SMURFs were sampled via snorkeling every two weeks from one of three vessels: R/V Kalipi (OSU/PISCO), R/V Gracie Lynn (OCAQ), or R/V Shearwater (ODFW). The first snorkel sampling was on June 6th and the last SMURF sampling was September 11th at which point all the SMURFs were removed from the moorings. One of the Cape Foulweather moorings (CF06) was missing as of the sampling on August 27th, so only seven SMURFs were in operation for the last two week sampling period. The remaining seven SMURF moorings were retrieved on September 16th by PISCO's oceanography team.

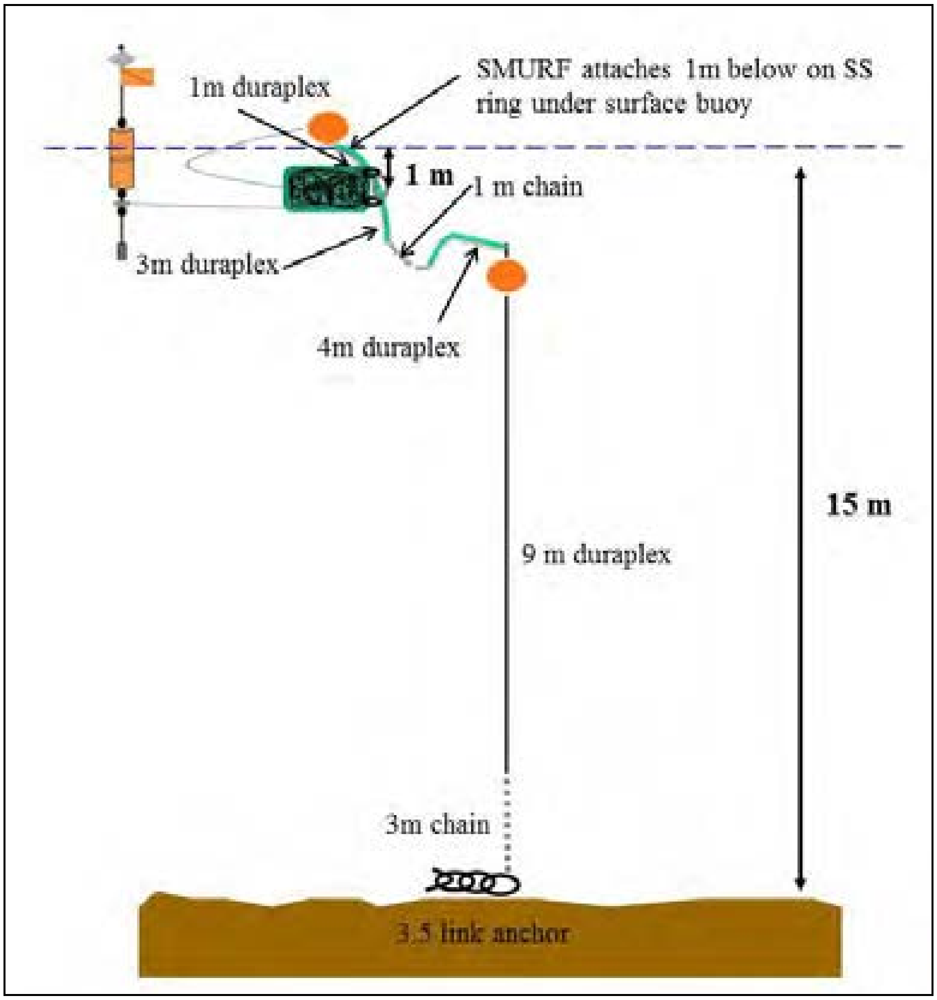


Figure 18. Schematic of a SMURF Mooring. SMURF attached to a stainless steel (SS) ring one 1m below the surface of the water.

A SMURFing team consisted of a minimum of four people: two people to retrieve the SMURFs in the water, one person topside to assist with gear and communications, and one to captain the vessel. SMURFs were retrieved via surface snorkeling, without the aid of SCUBA, due to their relatively shallow fishing depth (1 m). The two snorkelers worked to retrieve each SMURF and simultaneously deploy a second SMURF in its place for the next two week sampling window. Once onboard, the team members quickly extracted sampled fishes from the SMURFs and preserved them via Oregon State University Institutional Animal Care and Use Committee (IACUC) approved methods, as described in the section that follows.

Once fishes were free of the SMURF and collected in the BINCKE (Benthic Ichthyofauna Net for Coral/Kelp Environments) net, they were quickly euthanized via a lethal dose of MS-222 (Tricaine methanesulfonate), stored in a dark polypropylene jar at 500 mg/L buffered to 7.0 pH. Fish were left in solution for up to 10 minutes until cessation of opercular movement confirmed death. The samples were then stored in individually labeled Ziploc bags, preserved on ice, and transported to the lab at OSU in Corvallis.

Sampled fish were identified to species or species complex, total length measured, and stored in the -80° freezer for future genetic species identification and otolith extraction.

Meristics and analysis of data were led by Dr. Kirsten Grorud-Colvert at OSU.

Table 14. Mooring locations for SMURFS at Otter Rock site in 2013.

Mooring Code	Area	Latitude (DD)	Longitude (DD)
CF03	Cape Foulweather	44.7838	124.0793
CF06	Cape Foulweather	44.7792	124.0793
CF04	Cape Foulweather	44.7755	124.0807
CF05	Cape Foulweather	44.7668	124.0813
OR06	Otter Rock	44.7567	124.0815
OR02	Otter Rock	44.7517	124.0803
OR01	Otter Rock	44.7464	124.0791
OR05	Otter Rock	44.7426	124.0796

Data Analysis

Data were analyzed by Dr. Kirsten Grorud-Colvert (OSU) using Excel and R. Fish species assemblages were evaluated by year and by site. Recruitment rates by species, complex, and overall were calculated by dividing the number of fish per SMURF by the number of days between samplings. Mean recruitment rates and variance were calculated for each species, complex, and overall throughout the sampling season for the two areas and examined for temporal and spatial trends.

II. HOOK AND LINE

Introduction

The Oregon Department of Fish and Wildlife's monitoring of Oregon's Marine Reserves uses a suite of visual survey tools including video lander, sled, ROV, and SCUBA to monitor various marine habitats and their associated organisms. However, these tools have a limited capacity to accurately estimate fish lengths, a metrics that protected areas have been shown to increase in certain species (Claudet et al. 2010). In response to these limitations and to reduce uncertainty, fishery-independent hook-and-line surveys were used to obtain precise size structure data for fishes inside the marine reserves and the associated comparison areas (Harms et al. 2010). Fishery-independent sampling methods are preferable to fishery-dependent methods because regulations often forbid harvest of small size classes (Bohnsack 1999). Hook-and-line surveys were conducted at marine reserve and comparison area sites to establish baseline during the first 5 years of reserve implementation. No hook and line surveys were conducted at Otter Rock due to the limited rock habitat, shallow depths and small overall size of the reserve. Fish length and weight distributions as well as catch per unit effort (CPUE) rates for the most commonly caught species will be established for the baseline period. Fish responses to reserve protection will differ based on individual ecological traits as well as attributes unique to each individual reserve (e.g. size, habitats present, extractive pressure, etc.), hence the analysis for this survey tool will focus on the individual fish species within a single reserve rather than species assemblages or pooling data across multiple reserves (Haggarty and King 2006; Kleiber and Maunder 2008; Claudet et al. 2010). The timescale for detecting significant changes has been found to exceed 10 years for most species (Molloy et al. 2009; Babcock et al. 2010; Fung et al. 2013; Kelaher et al. 2014). Therefore, ODFW will continue to conduct hook-and-line surveys at certain sites over regular intervals in the marine reserves to detect any changes in fish richness, size and/ or catch rate that may occur as a result of this management strategy.

Study Questions and Rationale

This study aimed to answer the following questions comparing (1) baseline conditions in the reserve to the comparison area, and (2) reserve performance through time using a Before-After-Control-Impact (BACI) approach (Francini-Filho and Moura 2008).

Baseline comparisons:
- For a given fish species, does mean fork length, mean weight differ between the comparison area(s) and marine reserves before closure?
- Are species length-weight relationships similar between the comparison area(s) and the reserves before closure?
- Is fish community composition, based on CPUE and biomass per unit effort (BPUE), similar between the comparison area(s) and the reserves before closure? If not, what species are driving those differences?

Reserve response over time:
- For a given fish species, does rate of change in mean fork length, mean weight, CPUE or BPUE differ between the comparison area(s) and marine reserves?
- Has the species composition changed within the reserve since closure? Has it changed between the reserve and the comparison area?

Without fishing pressures, we anticipate lower mortality rates in fishes which can lead to older, larger individuals. However, variable environmental conditions can confound our ability to detect changes in fish physical characteristics due to marine reserve protection. By sampling in both the reserve and comparison area, we can separate environmental influences from management influences on fish response characteristics. Ideally, comparison areas will be as similar as possible to the marine reserve. For this reason, comparison areas were chosen to have similar geographic size, oceanographic condition, depth range, habitat types and fishing pressure to the reserve.

Study Design

Within any area, catch-per-unit effort and species assemblages can vary significantly within a given year (Karnauskas and Babcock 2012). To improve consistency, the hook-and-line survey was conducted over several months during the summer (June -October), a period displaying less variability in CPUE than other parts of the year (Fox and Starr 1996; Karnauskas and Babcock 2012), to maximize statistical reliability. Surveys targeted rocky reef habitats where much of the nearshore groundfish fishing effort is focused. All species caught were measured (FL, cm) and weighed (0.1 kg) before being released. During 2013, baseline data collection included lethal hook-and-line sampling of Black Rockfish of different lengths (20-55 cm) to gather otoliths for ageing from Cape Perpetua (n = 328) and Cascade Head Marine Reserves (MRs) (n = 202). Otoliths were aged by ODFW age reader and stored in ODFW otolith collection. Age estimates from otoliths are a more precise estimate of age than non-lethal length measurements. To avoid extensive lethal sampling in marine reserves sites, lethal surveys were limited to the year prior to reserve closure to establish a baseline age-frequency distribution. Lethal extraction was re-assessed using population models for Black Rockfish provided by Mr. Robert Hannah (ODFW) and Dr. David Sampson (OSU). According to these models, the magnitude of change in age expected once fishing pressure ceases would be small (0.6 years) and undetectable with these sample sizes. Lethal extraction was deemed uninformative and has been discontinued in future ODFW marine reserve hook-and-line surveys. No age data will be presented in this report.

Sampling Conducted

2012

Non-lethal hook-and-line sampling surveys were conducted at Redfish Rocks MR and Humbug comparison area (CA) in 2012.

To limit variation between samples and increase the likelihood of detecting a reserve effect over time, index areas were chosen in both the reserve and comparison areas. In 2011, index areas were delineated around patches of rocky reef substrate (identified from multibeam habitat maps provided by the Active Tectonics and Seafloor Mapping Lab, OSU) within four depth strata (11.9-18.3 m, 18.6-24.4 m, 24.7-30.5 m, and 30.8-36.6 m) in the reserve and comparison area. In 2012, the index areas used in 2011 were expanded to include shallower waters to improve catch rates. Fishing effort was equally allocated across the reserve and the comparison area during a sampling day. Drift times varied in duration from 2-45 minutes, depending on fishing success in an area.

In 2012, five volunteer anglers were used to catch fish aboard the F/V Mach 1 during sampling. Each angler used a Danielson 6 oz. Jeopardizer jig (chrome plated diamond jig) with a 2/0 barbless double hook. This gear type was recommended by local charter vessel captains and was selected after conducting a pilot study (2011) that compared the size distributions of fish caught on shrimp flies, rubber worms, and diamond jigs. Diamond jigs caught a large diversity of groundfish species and had the most variable size range of fish. Anglers kept track of their total fishing time with a stopwatch. The total time the “bait” was available to fish was recorded. The watch was paused when an angler hooked a fish, was hung up, reeled up for any reason, or when the boat was moving. The time at which each fish was caught was recorded and later matched with a GPS track to obtain a precise geographic location. Each fish was identified to species, measured (FL; cm), weighed (0.1kg) and released. Fish were released at the surface into a bottomless releasing pool or, if a fish exhibited barotrauma symptoms, released at depth using weighted cages.

2013

Hook-and-line surveys were conducted at Redfish Rocks, Cape Perpetua and Cascade Head sites. This was the third set of surveys for Redfish Rocks (1 pre-closure and 2 post-closure) and consisted only of non-lethal sampling. Pre-closure surveys for Cape Perpetua and Cascade Head involved both non-lethal and lethal sampling for otolith collections. Sampling was re-designed in 2013 using a stratified random approach. Each area was mapped for depth (m), rocky reef habitats (Goldfinger 2010), and local knowledge of areas previously fished. Using ArcGIS; 500 m X 500 m grid cells were created to target specific depth ranges. Grid cells were then stratified by habitat type to exclude those cells that did not contain rocky substrate. These remaining cells were then stratified to only include areas that had been fished historically (coordinates obtained from local charter captains). Mean depth was calculated for each of the grid cells based on bathymetric raster data. This grid cell selection process resulted in 10 grid cells each for Redfish Rocks MR and Humbug CA. Cascade Head MR and Schooner Creek CAs each contained 9 grid cells (Table 15). Initially both the Cavalier and Schooner Creek CAs were sampled. After the third sampling trip, the Cavalier CA was discontinued due to low catch rates.

Within Cape Perpetua MR rocky substrates are rare and located in depths greater than 17 meters (Table 15). Grid cells were placed on the available rocky substrate disregarding depth and coincided with local fishing knowledge supplied by a charter boat captain.

Table 15: Average and range of depths and percent rock of grid cells sampled in 2013.

Site	Avg. Depth (m)	Depth Range (m)	Avg. % Rock	Range of % Rock
Redfish Rocks MR	25.73	15.76 - 36.43	46.81	19.07 - 70.44
Humbug CA	24.71	6.97 - 37.11	47.89	12.42 - 92.77
Cape Perpetua MR	43.34	32.63 - 48.89	4.97	0 - 8.51
Postage Stamp CA	28.02	19.82 - 36.17	10.79	4.77 - 20.71
Cascade Head MR	26.35	20.76 - 35.0	46.98	22.72 - 67.05
Schooner Creek CA	34.33	19.20 - 38.88	73.32	37.03 - 100

Paired sampling was conducted each month from July – October 2013, with one day in the reserve and one day in the corresponding comparison area. To the extent possible, these two sampling dates occurred within a 48 hour time span. During each day of sampling, five cells were randomly selected for fishing (except at Cape Perpetua MR where four cells were chosen due to time constraints). The captain was provided the cell coordinates and asked to fish in each cell in places where he thought he could successfully catch fish. The objective was to fish in three distinct locations within each grid cell for 15 minutes each. The captain would position the vessel within the sampling cell to maximize fishing opportunity based on experiential knowledge. If a single 15 minute drift was not possible before the vessel exited the cell (i.e. due to high currents), the captain could chose to make several drifts in the same location for a combined total of ~15 minutes.

Local commercial and charter fishing vessels were contracted by ODFW for each site. Each chartered vessel carried five (5) anglers, two (2) ODFW scientists, a deck hand, and the captain who had local fishing knowledge of the immediate area. Anglers were provided with a rod and reel or used their own. Standardized terminal gear was determined for each reserve complex individually, in accordance with advice from local fishermen. Surveys at Redfish Rocks were conducted aboard the F/V Pacific Star and the terminal fishing gear consisted of a Danielson 170 g (6 oz.) Jeopardizer Jig ("diamond jig") with a barbless 2/0 double hook was used. At Cape Perpetua and Cascade Head sites, the CPFV Miss Raven and CPFV Affair were used, respectively; terminal gear consisted of a 170 g Jeopardizer Jig and was supplemented with a Danielson 7/0 barbless pink shrimp fly attached approximately 76 cm above the jig. Fishing effort was recorded by ODFW staff using a stopwatch started at the Captain's start signal to the end of the drift. A Garmin Map 67 GPS unit recorded and saved the tracks of all drifts. To maintain standardized effort, if an angler had a problem with their gear, the crew would replace the rod and fishing would continue. If an angler stopped fishing for more than a minute, this time was subtracted from the overall time of the drift. As anglers caught and retrieved fish to the surface, the vessel crew would quickly remove the fish from the hook and return the angler to fishing. Crew members transported the fish to the scientific crew. The aim was to conduct three, 15 minute drifts in each cell. Time varied during drifts due to current speeds, or catch rate, or because the vessel was leaving the cell area. Drift times were therefore averaged for each cell.

All fish were identified to species, measured (FL, cm), weighed (0.1 kg), and released. During surveys in Cape Perpetua MR, the Postage Stamp CA, Cascade Head MR, and Schooner Creek CA; fish were released or retained for otolith extraction. Fish were released at the surface in a releasing pool or at depth using a SeaQualizer$_{TM}$ if barotrauma symptoms were present. The retained fish were tagged for identification purposes, euthanized, and placed on ice. Otoliths were extracted and fish sex determined within a few hours of landing. Otoliths have been stored in the ODFW otolith collection. No ageing data will be reported in this report.

Captain's Choice Sampling Method

Power analyses were conducted for most commonly sampled fish species to determine what sample sizes would be needed to detect a 5% change in fish total length over time in Redfish Rocks. As some of the targeted fish species (i.e. colorful demersal rockfish such as Canary Rockfish) were slightly under the targeted sample size, we explored an alternative method for angling during the last sampling period in 2013 in an attempt to boost the sample sizes of these select fish species. In order to catch particular species we allowed the boat captain's free choice to select where to fish within the boundaries of the reserve and comparison, as described below.

During this sampling method, the captain was not confined to grid cells but was confined to the larger area of the reserve or comparison area being sampled. The captain chose the location to sample based on his knowledge of where the target species might be located. Sampling was not limited to the cumulative 45 minutes as was done for grid cell sampling. Instead, sampling continued until the captain decided to change the drift or, moved to a different spot, or until the target sample size was caught. For example, if the needed number of Canary Rockfish were caught, then the captain might move the vessel to a location more suitable for another targeted species. Sampling continued until the target number of all the species likely to be encountered that day were caught or the contractually agreed upon fishing time had been reached. If there was time remaining after the targeted fish had been caught, sampling reverted back to the standard cell sampling for the remainder of the time.

Data Analyses

Here, the hook and line analyses consisted primarily of data summaries as we continue to collect data and assess natural annual variation in sampling as part of our baseline efforts for this study. At the end of our five-year baseline period for Redfish Rocks (i.e. through 2015), we will compile a thorough analysis of the initial dataset pooled amongst the first five years of monitoring from which we can evaluate future change. Through continued data collection over the next 10-15 years, we will begin to be able to assess changes over time by comparing future trends to the initial baseline data.

For the summaries presented in this report, drifts occurring within a single cell's sampling effort were pooled such that angler effort and fish landed were calculated at the cell scale. Composition of fish species landed was displayed as a proportion of the total fish landed for a given site, irrespective of marine reserve or comparison area. A summary of fork lengths was provided for all fish species landed, including a mean length ±SE and range for each sampling area (reserves versus comparison areas), however statistical significance of potential mean length differences among areas was not analyzed. Lastly, the sample sizes for all landed species were provided for each area sampled in 2012 and 2013.

III. Benthic Extraction

Co-Primary Investigators: Dr. Gayle Hansen and Dr. David Elvin

Introduction

A benthic biodiversity study in subtidal hard-bottom habitats was conducted to sample the species diversity and abundance of macroinvertebrates and macroalgae not readily captured by our visual survey methods. This sampling approach allows us to resolve species-specific taxonomy for both the algal community and sponge community through collaborative partnership with Dr. Gayle Hansen, a phycologist with Oregon State University, and Dr. David Elvin, a sponge taxonomist and lead of the Oregon Porifera Project.

We asked the following questions using this benthic extraction dataset:

Q1: Does total sponge and macroalgal abundance and biomass differ between reserves and comparison areas?

Q2: Does community composition of sponges and macroalgae differ between reserves and comparison areas?

Q3: What species, and in what proportions, define the sponge and macroalgal communities in the reserve and comparison areas?

Lastly, we were interested in identifying any new records of species occurrence in subtidal nearshore habitats for the state of Oregon.

Study Design and Sampling Conducted

We contracted with local commercial urchin divers to conduct the surveys in early August of 2013 (8/1-8/5/2013) at Cascade Head Marine Reserve (MR) and the Cavalier comparison area (CA). No benthic extraction sampling occurred in the Cape Perpetua site as the appropriate subtidal rocky habitat (i.e. benthic rocky reef between depths of ~10-15m) does not exist at this site. Benthic extraction surveys only occurred in 2013; not in 2012.

We used a stratified random sampling design, restricting the placement of random points to areas of consolidated rock substrate targeting 10m and 15m depths (based on Oregon State University's Active Tectonics and Seafloor Mapping Lab's V3_5_TerrSea habitat data). Ten random points, separated by a minimum of 40m, were generated in both the marine reserve and comparison area sites. *In situ* transect sampling was then initiated at six (6) of these randomly selected points within each site; three (3) transects at approximately 10m and three (3) transects at approximately 15m depth. If no hard substrate was encountered at the point, the captain maneuvered the boat to the nearest area of consolidated substrate at the appropriate depth (10m or 15m). Three transects were completed per sampling day; a total of four (4) days were needed to complete the full set of 12 transects, six (6) transects in the marine reserve and six (6) transects from the comparison area (Table 16).

Table 16. Benthic extraction transects sampled in Cascade Head MR and Cavalier CA in 2013.

Site	Date	Transect	Latitude	Longitude	Depth (m)	Habitat type
Reserve	8/3/2013	7	45.029	124.0226	13	Boulders
Reserve	8/3/2013	8	45.02655	124.024	14	Boulders
Reserve	8/3/2013	9	45.02407	124.0231	15	Flat Bedrock
Reserve	8/5/2013	10	45.02865	124.0214	12	Boulders
Reserve	8/5/2013	11	45.02812	124.021	11	Boulders
Reserve	8/5/2013	12	45.02513	124.0217	11	Boulders
Cavalier	8/1/2013	1	44.83722	124.0639	14	Flat Bedrock
Cavalier	8/1/2013	2	44.83192	124.0683	14	Bedrock + Boulders
Cavalier	8/1/2013	3	44.82833	124.0705	13	Flat Bedrock
Cavalier	8/2/2013	4	44.8366	124.0633	10	Flat Bedrock
Cavalier	8/2/2013	5	44.83235	124.069	8	Flat Bedrock
Cavalier	8/2/2013	6	44.82933	124.0701	10	Rugose Bedrock

Protocol

Once on location, transect start points were verified for feasibility and appropriate depth. The contracted divers descended at the point and laid a 20m transect following a constant depth contour. Quarter meter squared quadrats were used to sample the macroalgal and invertebrate communities as this spatial scale was found to be the most appropriate scale in previous studies (Dayton 1971; Pringle 1984; Medina et al. 2005). Divers placed three (3) replicate 0.25m^2 quadrats at the 0, 10 and 20m marks. If consolidated rock substrate was not encountered at these quadrat locations the quadrats was moved along the transect line to the nearest area that contained 0.25m^2 of continuous rocky substrate. The divers utilized paint scrapers to remove all macroalgae and invertebrates from the substrate surface, and an airlift (supplied with compressed air from the surface) was used to collect the removed biotic material into a fine mesh bag (6.3 mm mesh). One diver scraped at the surface of the substrate while the other used the airlift to suck up the loosened material.

The contents of the bags were taken to a wet laboratory, grossly separated into macroalgal and invertebrate containers, and fixed in either 5% or 10% formalin, respectively. Dr. Gayle Hansen (Oregon State University) identified all macroalgae to species, when possible, and measured total biomass (g) of each species per quadrat. Invertebrate samples were sorted to taxonomic phyla for future identification to lower taxonomic levels. Invertebrate samples were converted to EtOH (70%) for storage following one initial exchange to EtOH after 48 hours in formalin, and a second exchange after another 10 days. Sponge samples were identified to species, when possible, and total biomass (g) of each species was measured per quadrat by Dr. David Elvin of the Oregon Porifera Project.

Data Analyses

Mean macroalgal species richness, total biomass (g), and community composition were calculated per transect from replicate quadrat subsamples. Similarly, sponge species richness, total biomass (g), and community composition were calculated per transect from replicate quadrat subsamples. Response variables were transformed if needed to improve normality and homogeneity of variance. Univariate comparisons (t-test) between the reserve and comparison area were conducted on species richness and total biomass (g) response variables for both macroalgae and sponges (Q1).

To assess differences in community composition between the reserve and comparison area, Bray-Curtis similarity was calculated at the transect scale on both species presence/absence and biomass data. ANOSIM (analysis of similarity), a multivariate analogue of univariate ANOVA, was then conducted on the Bray-Curtis values using PRIMER (v. 6.0) software (Q2). SIMPER was then used to identify which species were primarily responsible for any observed differences between the reserve and comparison area (Q3).

RESULTS

A. Oceanography

In this section we present a summary analysis of oceanographic data for the Cascade Head, Otter Rock, Cape Perpetua, and Redfish Rocks sites. In addition to using ODFW Marine Reserves Program oceanographic data, we explored existing PISCO datasets for oceanographic data that preceded or overlapped with the establishment of the marine reserves. PISCO has oceanographic mooring sites within the Cascade Head Marine Reserve (MR) and Cavalier comparison area (CA), as well as mooring sites within Cape Perpetua MR and Postage Stamp CA. A summary of the oceanographic sensors successfully deployed in each area is provided in Table 17, as well as the date range of the data collection to facilitate comparisons between the marine reserve and comparison areas. All data for the date ranges shown are available from either PISCO sources or by request from the ODFW Marine Reserves Program.

Temperature data are shown for Cascade Head in 2001 (Figure 19) and Otter Rock in 2012 (Figure 20) as daily running means. Both sites show similar seasonal fluctuations in temperature. In summer months, temperatures drop during upwelling events and peak during relaxation events. For both sites, neither the reserve nor the comparison area consistently documents warmer or colder temperatures over the course of the time series. We conclude that both comparison areas track shifts in water temperature closely to their respective reserves.

For Cape Perpetua data from 2009, temperature has been plotted as raw data and as running means of three (3) different time intervals to demonstrate the averaging capabilities of these temperature datasets. The cycle of upwelling and relaxation is not as prominent at this site compared to the Cascade Head and Otter Rock time series, though temperature drops in June-August are visible especially when viewed as daily running means (Figure 21). As with Cascade Head and Otter Rock, neither the reserve nor comparison area consistently documents warmer or colder temperatures over the course of the time series (Figure 22). The difference between the weekly running mean of the reserve to the comparison area does not exceed 0.6°C, though at various points in time the reserve is warmer than the comparison area and vice versa. These temporal patterns hold for 2008 sampling as well (Figure 23), where differences between reserve and comparison area do not exceed 0.5°C (Figure 24).

Though initial oceanographic comparisons of Redfish Rocks MR to the Humbug CA were completed in 2010-11, an additional third year of data collection was completed from fall 2012 to spring 2013 (Figure 25). Unsurprisingly, very tight coupling of temperature data was observed during the sampling season when Oregon's coastal water bodies are presumed to be more uniformly mixed (Francis Chan, pers. comm.).

Learning and Adaptation

As we move forward with our monitoring efforts, the ODFW Marine Reserves Program is looking at phasing out collection of oceanographic data. Once baseline data collection is complete in all five reserve sites, the between area comparisons of oceanographic variables becomes less informative. Rather, the interest shifts to precisely tracking minute changes in oceanographic parameters like temperature and oxygen over time. Currently, ODFW does not possess the precision instruments required to reliably collect this type of time series data, nor the expertise to interpret such datasets. Hence, we envision supporting the continued collection of OSU-PISCO datasets into the future as PISCO possesses both the instrumentation, and perhaps more importantly, the scientific expertise to track with detail and precision the climate induced changes to nearshore waters.

Table 17. Summary of oceanographic instruments that successfully logged data at marine reserves and comparison areas for comparative analysis. Date range and source for each dataset are provided.

Site	Area	Instrument Used	Data Available	Date Range	Data Source
Cascade Head	CHMR	Hobo Temps	Temperature *	4/16/2001-8/31/2001	PISCO
	Cavalier CA	Hobo Temps	Temperature *	4/16/2001-8/31/2001	PISCO
	CHMR	Onset Conductivity Sensor	Temperature +	6/27/2012-1/16/2013	ODFW
	CHMR	Wildlife Computer Archival Tag	Light	6/27/2012-1/16/2013	ODFW
	Cavalier CA	Onset Conductivity Sensor	Temperature +	6/27/2012-10/18/2013	ODFW
	Cavalier CA	Wildlife Computer Archival Tag	Light	6/27/2012-10/18/2013	ODFW
	CHMR	SeaBird CTD	Temperature, Salinity, O_2, Fluorescence	8/5/2013-2/23/2014	ODFW
	CHMR	SeaBird CTD	Temperature, Salinity, O_2, Fluorescence	5/1/2014-10/9/2014	ODFW
Otter Rock	ORMR	Hobo Temps	Temperature	4/2011-1/2013	ODFW
	Cape Foulweather	Hobo Temps	Temperature	5/8/2012-6/6/2013	ODFW
Cape Perpetua	CPMR	Hobo Temps	Temperature *	4/8/2008-9/16/2008	PISCO
	Postage Stamp CA	Hobo Temps	Temperature *	4/8/2008-9/16/2008	PISCO
	CPMR	Hobo Temps	Temperature *	4/8/2009-9/15/2009	PISCO
	Postage Stamp CA	Hobo Temps	Temperature *	4/8/2009-9/15/2009	PISCO
Redfish Rocks	Humbug CA	Hobo Temps	Temperature	9/2011-5/2012	ODFW
	RRMR	SeaBird CTD	Temperature, Salinity, O_2, Fluorescence	10/2011-3/28/2013	ODFW
	RRMR	Wildlife Computer Archival Tag	Light	10/2011-3/28/2013	ODFW
	Humbug CA (Island Rock)	Hobo Temps	Temperature	12/2011-3/28-2013	ODFW
	Orford Reef CA	Hobo Temps	Temperature	12/2011-3/28-2013	ODFW
	Humbug CA	SeaBird CTD	Temperature, Salinity, O_2, Fluorescence	5/2012-3/28/2013	ODFW
	RRMR	Onset Conductivity Sensor	Temperature +	3/28/2013-6/26/2014	ODFW
	Humbug CA	Onset Conductivity Sensor	Temperature +	3/28/2013-6/26/2014	ODFW

* Additional CTD data (e.g. salinity, fluorescence, O_2) likely available upon request from PISCO
+ Onset conductivity sensors also collected temperature data, but due to erroneous conductivity readings, only temperature data will be analyzed.

Cascade Head

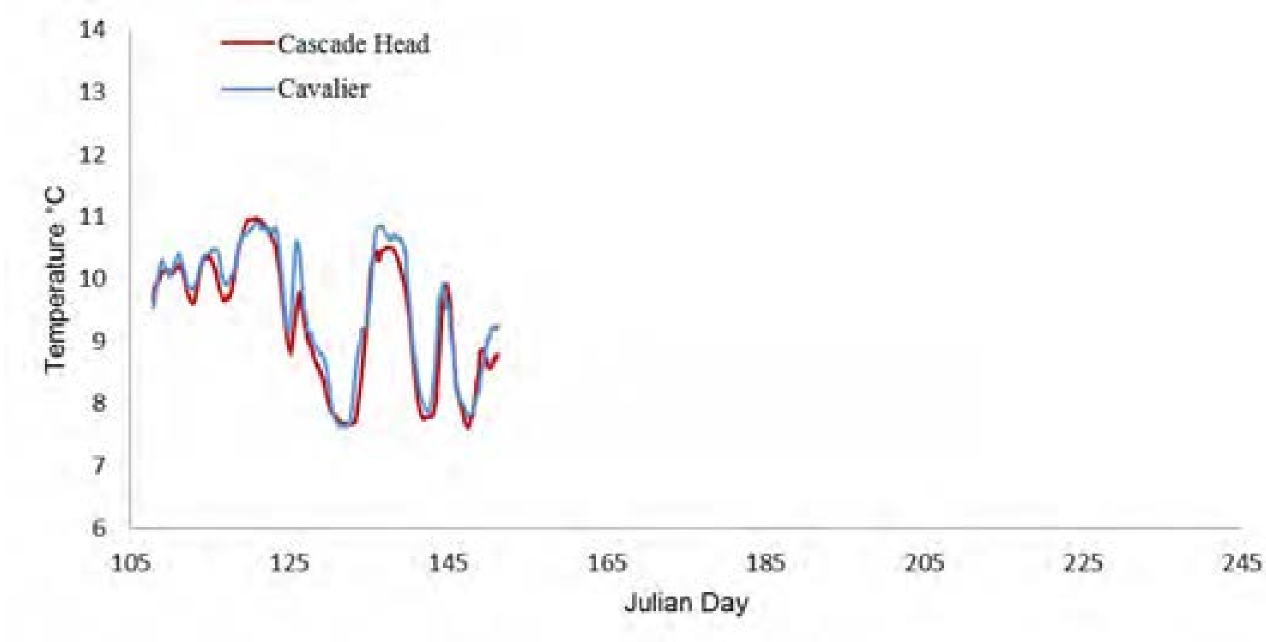


Figure 19. Daily running mean of temperature at Cascade Head MR and Cavalier CA in 2001. Data provided by PISCO.

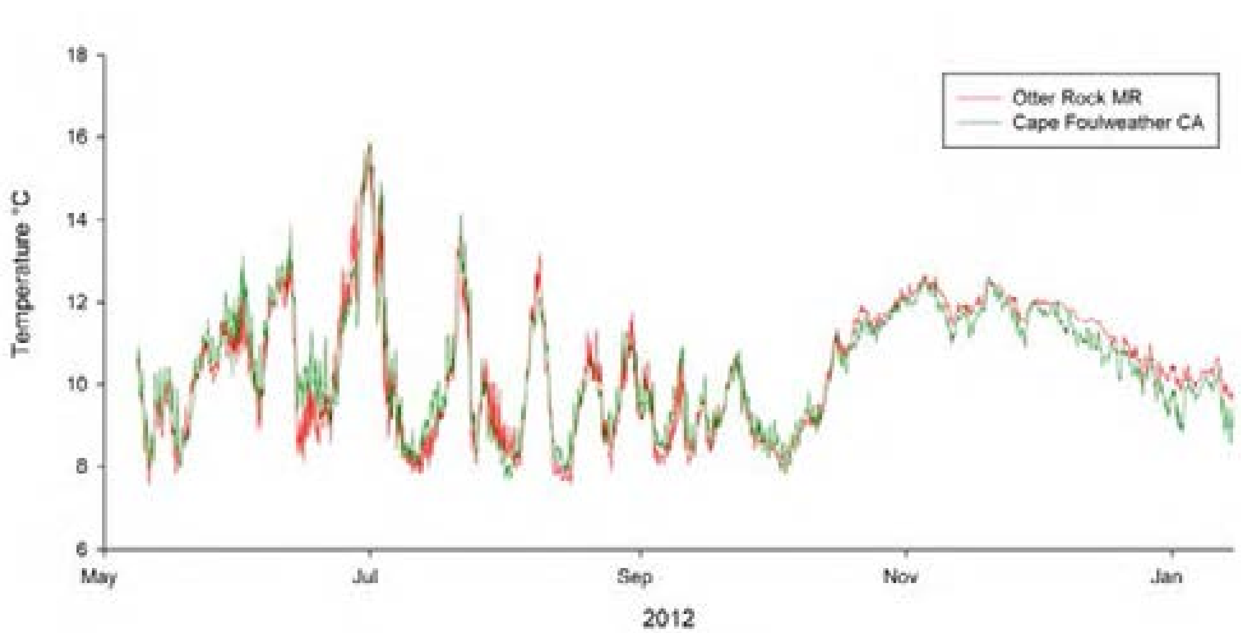


Figure 20. Temperature at Otter Rock MR and Cape Foulweather CA for 2012.

Cape Perpetua

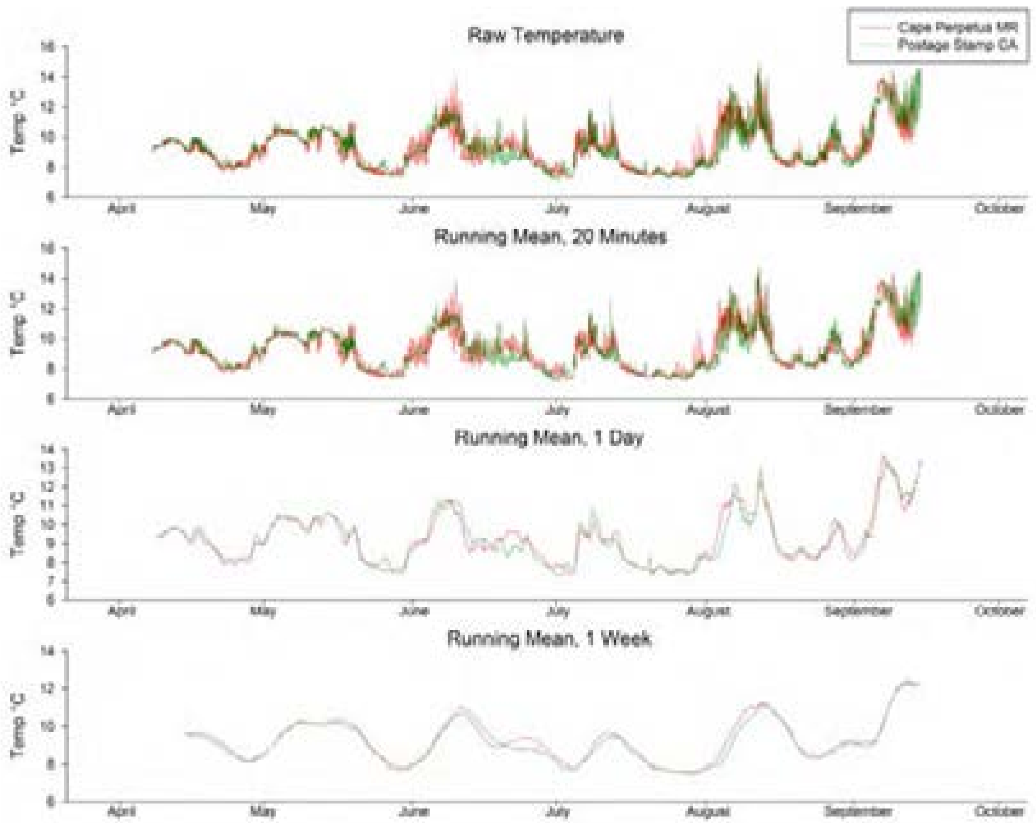


Figure 21. Cape Perpetua site temperature data 2009.

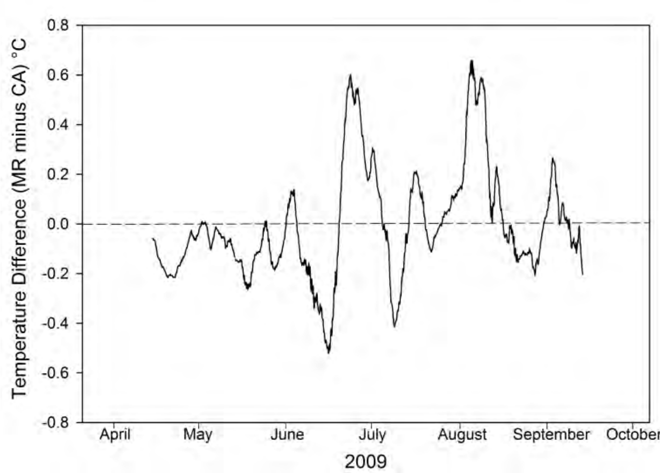


Figure 22. Temperature difference for Cape Perpetua (2009) based on one week running means from the reserve and comparison area.

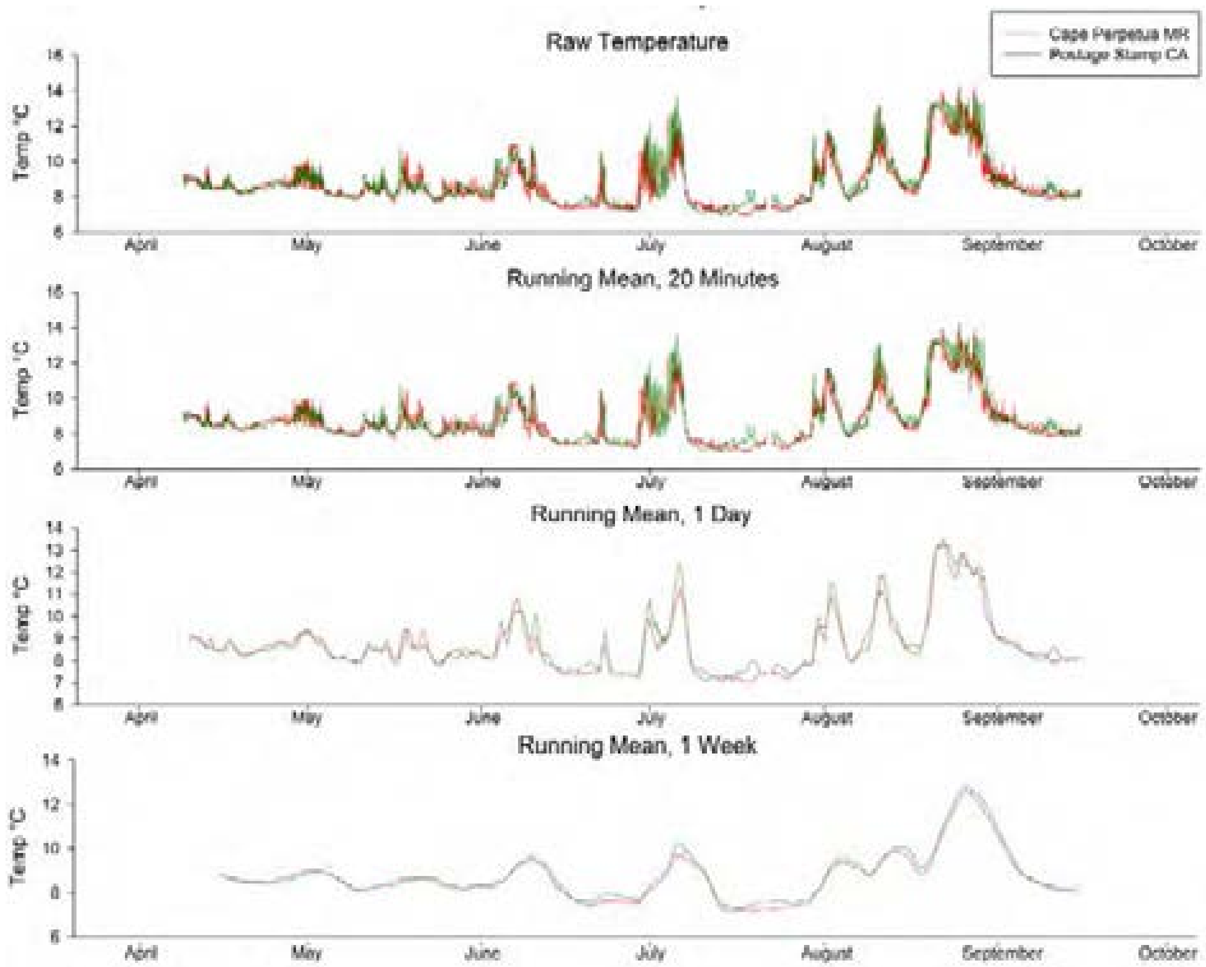


Figure 23. Cape Perpetua temperature data (2008).

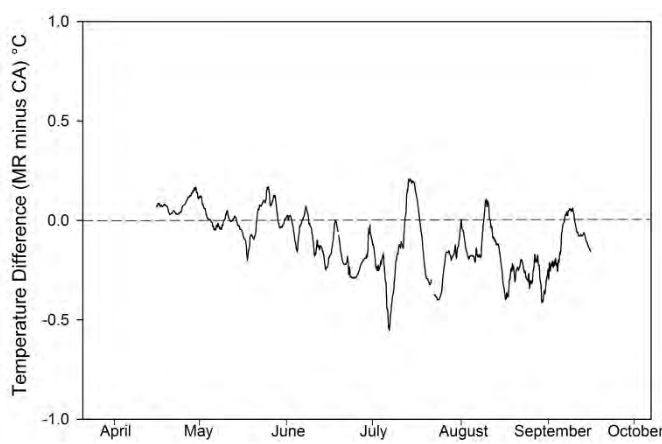


Figure 24. Temperature difference for Cape Perpetua (2008) based on one week running means from the reserve and comparison area.

Redfish Rocks

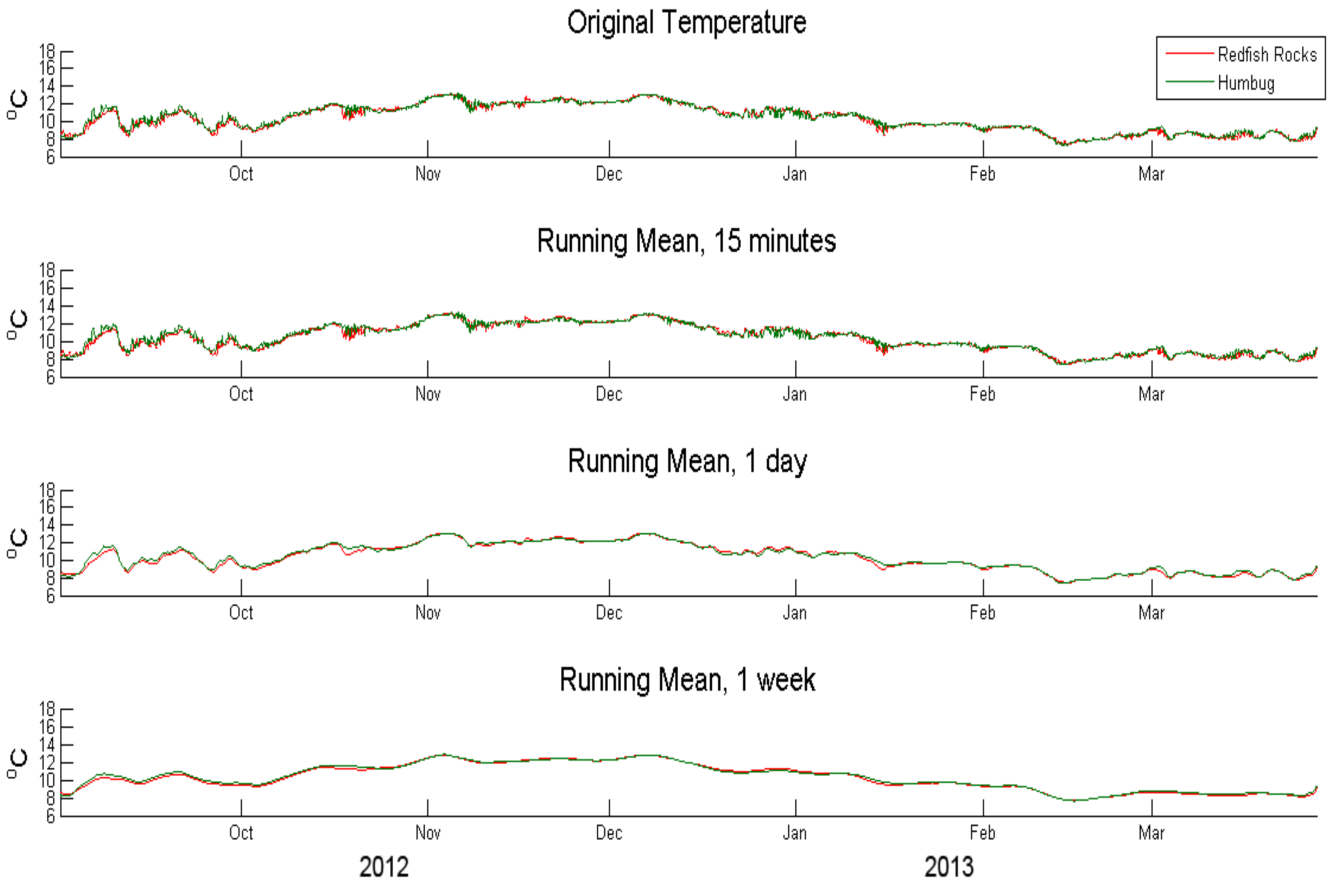


Figure 25. Temperature in Redfish Rocks MR and Humbug CA for 2012-13.

B. Visual Assessments

I. Lander

Analyses exploring the influence of confounding factors on lander response variables were conducted across all sites on pooled data from 2012-13. Year (as a proxy for camera resolution), visibility, view, drop duration, depth, habitat relief, and substrate type were evaluated as to their ability to significantly influence the response variables of fish relative abundance (MaxN) and diversity (species richness).

Year, as a proxy for lander camera resolution moving from standard definition to high definition, did not significantly influence $MaxN_a$ of unidentified fish species (Kruskal Wallace p=0.36, chi-squared = 0.84, df =1). Hence, we conclude that our ability to resolve species-specific identification of fishes was comparable across the two years.

Visibility was found to significantly influence fish $MaxN_a$ (Kruskal Wallace p=0.002, chi-squared = 12.88, df =2) and fish species richness (Kruskal Wallace p=0.001, chi-squared =

12.88, df =2). A post-hoc multiple comparison analysis showed greater relative abundance at visibility scores of 2 or 3, where fish ID could be performed, compared to 1 where the ability to ID fish was compromised (Figure 26). Visibility score also significantly influenced $MaxN_a$ of unidentified species, such that greater relative abundances of unidentified fish species were observed under higher visibility conditions (Kruskal Wallace p=0.002, chi-squared = 12.41, df =2). In total, 98% of the drops conducted for the 2012-2013 effort were given a visibility score of 1 or 2 (Table 18).

Table 18. Summary of the visibility scores and the corresponding relationship to mean $MaxN_a$ and mean species richness.

Visibility Score	N	Mean $MaxN_a$	Mean Species Richness
1	115	1.31	0.47
2	392	2.63	0.84
3	7	11.57	2.29

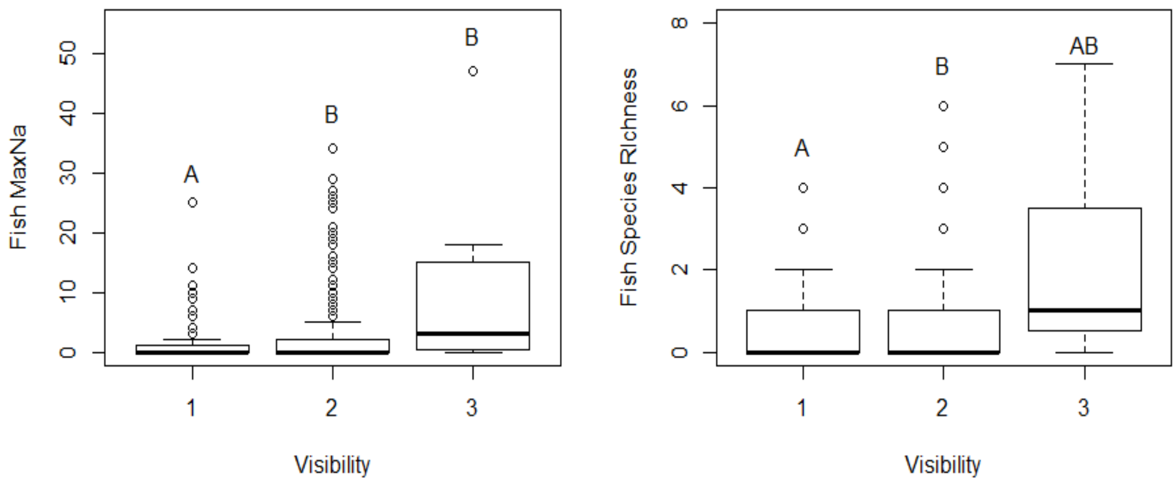


Figure 26. Relationship between visibility score to $MaxN_a$ and species richness. Shared letters above visibility scores indicated statistical similarities; differing letters indicate statistical differences.

View, categorized as either unobstructed or partially obstructed, did not influence $MaxN_a$ (Kruskal Wallace p=0.90, chi-squared = 0.02, df =1) or species richness (Kruskal Wallace p=0.86, chi-squared = 0.03, df =1).

Drop duration averaged 4.43 ± 0.12 (decimal minutes) and ranged in duration from 0 – 7.1 (decimal minutes). Despite this wide range, there was no significant linear relationship between drop duration (decimal minutes) and $MaxN_a$ or species richness.

Relief significantly influenced $MaxN_a$ (Kruskal Wallace p←0.001, chi-squared = 125.34, df =2) and species richness (Kruskal Wallace p←0.001, chi-squared = 72.39, df =2) such that high relief habitats had greater relative abundance and diversity of fishes compared to medium or low relief habitats (Figure 27).

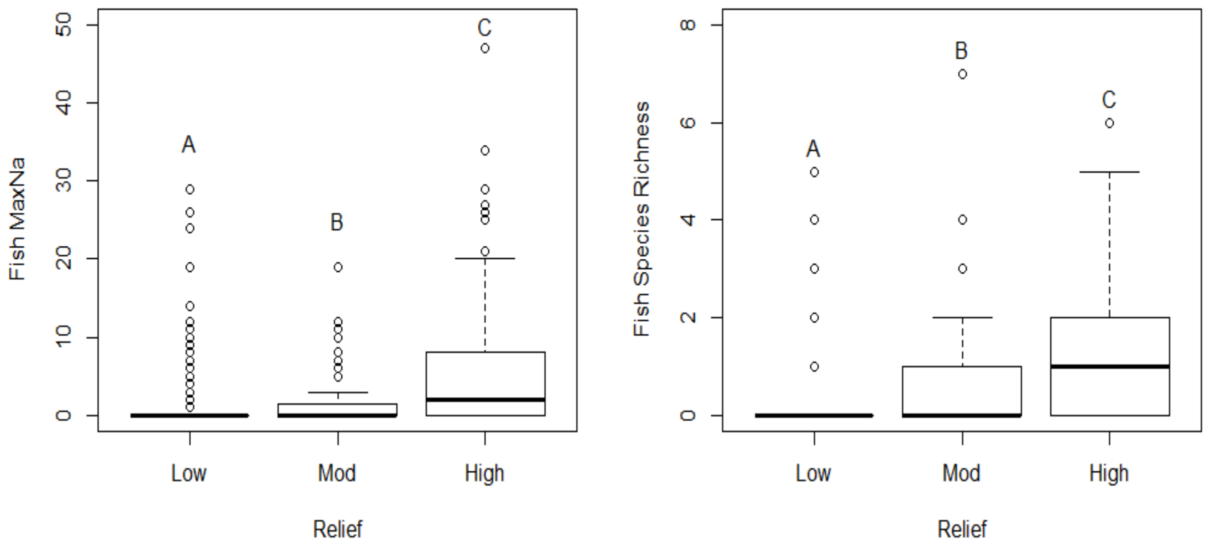


Figure 27. Relationship between relief classification and $MaxN_a$ and species richness. Shared letters above relief scores indicated statistical similarity; differing letters indicate statistical differences.

<u>Habitat (substrate)</u> type significantly influenced $MaxN_a$ (Kruskal Wallace p←0.001, chi-squared = 66.42, df =6) and species richness (Kruskal Wallace p←0.001, chi-squared = 75.78, df =6). Post-hoc multiple comparison analysis showed that bedrock outcrop and large boulder (our two classifications of highest relief) showed significantly greater relative abundance of fishes from all unconsolidated habitats (Figure 28). The same relationship was found for species richness in which bedrock outcrop and large boulder habitats supported a greater diversity of fish species compared to all unconsolidated habitats (Figure 29). These results corroborate with results from the relief analysis as boulder and bedrock outcrop habitats are presumed to exhibit higher relief values.

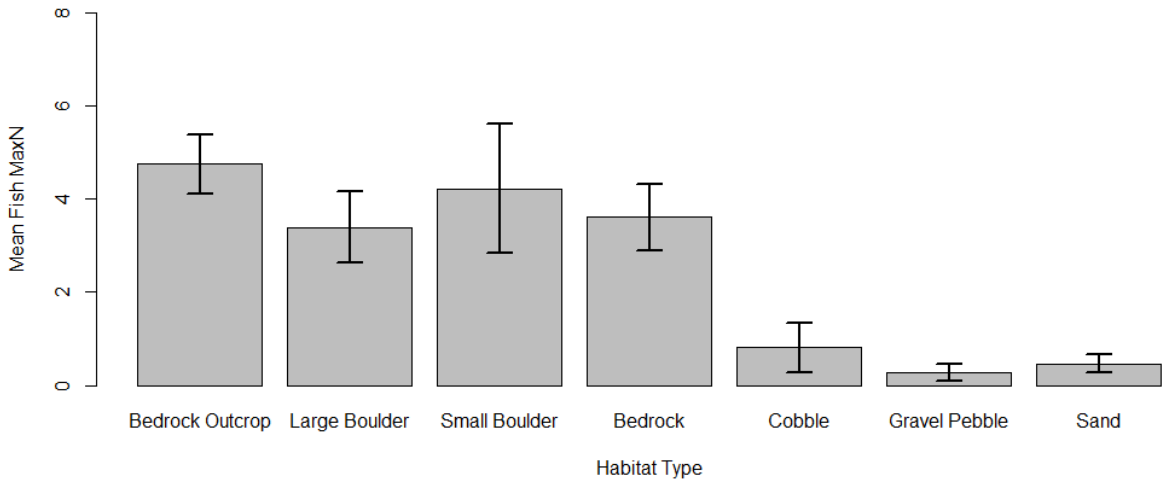


Figure 28. Relationship between mean fish $MaxN_a$ and habitat types, ranked in order from high to low relief (left to right).

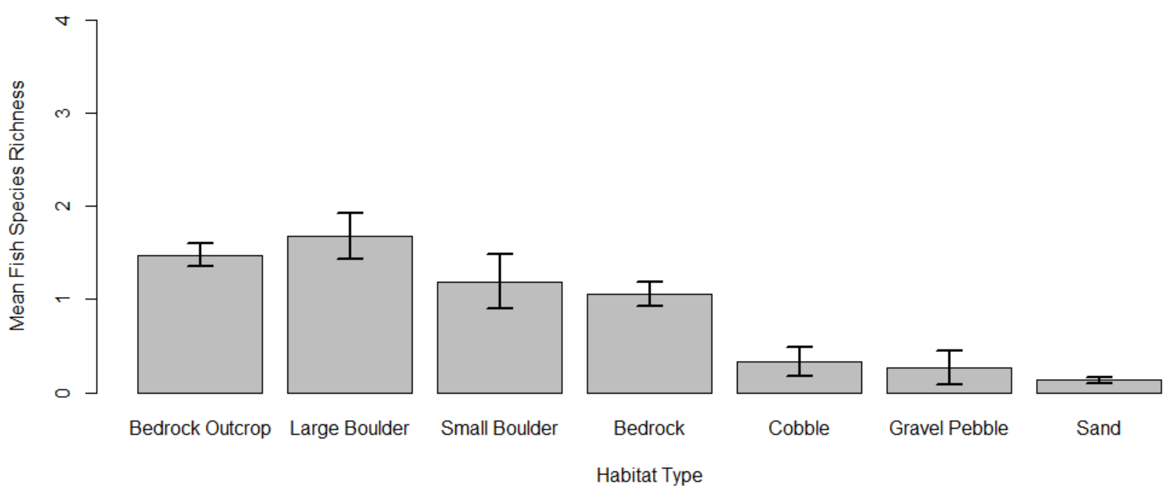


Figure 29. Relationship between mean fish species richness and habitat types, ranked in order from high to low relief (left to right).

MaxN for individual species mirror the patterns seen for $MaxN_a$, with the highest relative abundances for any given species occurring in one of the four habitat types with the highest complexity (Table 19).

Table 19. Mean MaxN for each fish species for the all the primary habitat types, ranging in complexity from high to low. The largest mean MaxN values observed are bolded in red.

Common Name	Complex Habitats → Less Complex Habitats						
	Bedrock Outcrop	Large Boulder	Small Boulder	Bedrock	Cobble	Gravel Pebble	Sand
Black Rockfish	1.41	**1.56**	0.96	1.13	0	0.07	0.07
Blue Rockfish	**1.03**	0.52	0	0.12	0	0	0
Cabezon	**0.01**	0	0	0	0	0	0
Canary Rockfish	0.67	0.4	**0.85**	0.36	0.62	0.07	0.31
China Rockfish	**0.01**	0	0	0	0	0	0
Copper Rockfish	0.04	0	**0.08**	0.03	0	0	1
Kelp Greenling	0.34	0.2	**0.35**	0.29	0.1	0.07	0.01
Lingcod	**0.29**	0.12	0.23	0.21	0	0	0.04
Longfin Sculpin	**0.01**	0	0	0	0	0	0
Northern Ronquil	0	**0.12**	0.04	0.05	0	0	0
Pile Perch	0.01	0	0	0	**0.05**	0	0
Quillback Rockfish	**0.06**	0.04	0.04	0.04	0.05	0	0
UNID Juvenile Rockfish	0.77	0.36	**1.65**	1.3	0	0.07	0.02
Vermillion Rockfish	0	**0.04**	0	0	0	0	0
Wolf Eel	**0.01**	0	0	0	0	0	0
Yelloweye Rockfish	**0.05**	0	0	0.01	0	0	0
Yellowtail Rockfish	0.05	0.04	0.04	**0.09**	0	0	0

The proportion of primary habitat type surveyed differed among study sites (Figure 30). Given that the lander sampling design was structured to target consolidated rock habitats, the proportion of unconsolidated substrates actually encountered was both variable among sites and exceedingly high in certain sites (i.e. Cape Perpetua).

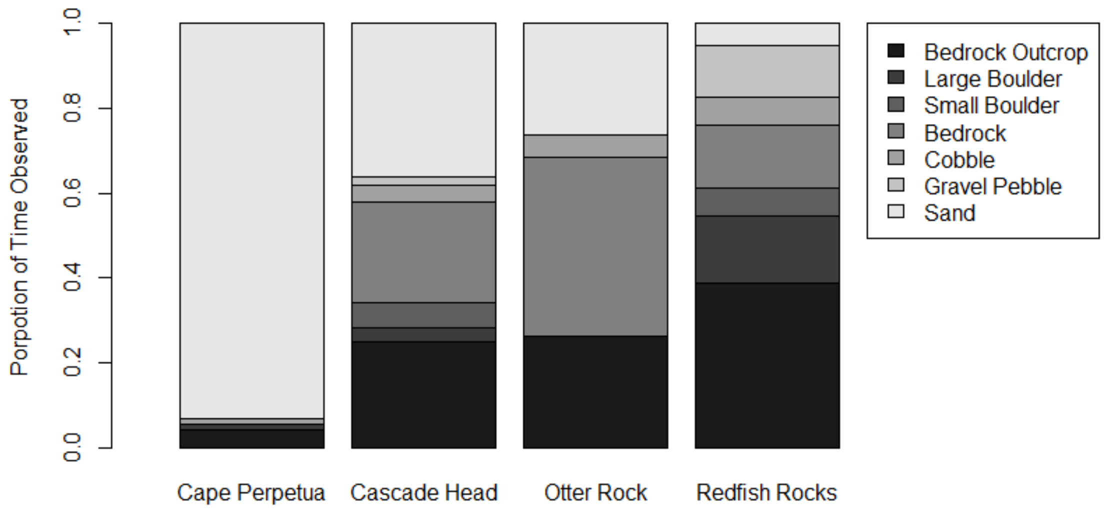


Figure 30. Proportion of primary habitats observed at four marine reserves sites (MR and CAs combined) for all drops completed, regardless of whether fish were observed.

Depth, for all drops regardless of habitat encountered, averaged 28.2m ± 12.5m and ranged in depth from 3.4m – 54.3m. There was no significant linear relationship between drop depth (m) as a continuous variable and $MaxN_a$ or species richness (Figure 31). As lander sampling design in 2012-2013 was based on random sampling within pre-determined depth bins, depth was then separated into 10m bins between 0 and 60m to investigate if there was a significant difference in fish relative abundance or diversity among bins. While both relative abundance and species richness was greatest between 30-50m, no significant difference in $MaxN_a$ (Kruskal Wallace p=0.42, chi-squared = 5.00, df =5) or species richness (Kruskal Wallace p=0.42, chi-squared = 5.00, df =5) was found among depth bins (Table 20).

Given that habitat type was shown to significantly influence fish response variables of abundance and richness, we reanalyzed the data exploring depth as a confounding factor by restricting to only those drops encountering consolidated habitat type (i.e. bedrock outcrop, large and small boulder, and bedrock). For these drops, depth bins still did not significantly influence $MaxN_a$ (Kruskal Wallace p=0.07, chi-squared = 10.18, df =5) though abundance was greater at increasing depth bins (Table 21). However, depth bin did significantly influence species richness (Kruskal Wallace p=0.02, chi-squared = 12.37, df =5) such that greater fish diversity was observed at increasing depths. Additional sampling in the 50-60m depth bin would help make these trends more robust and informative.

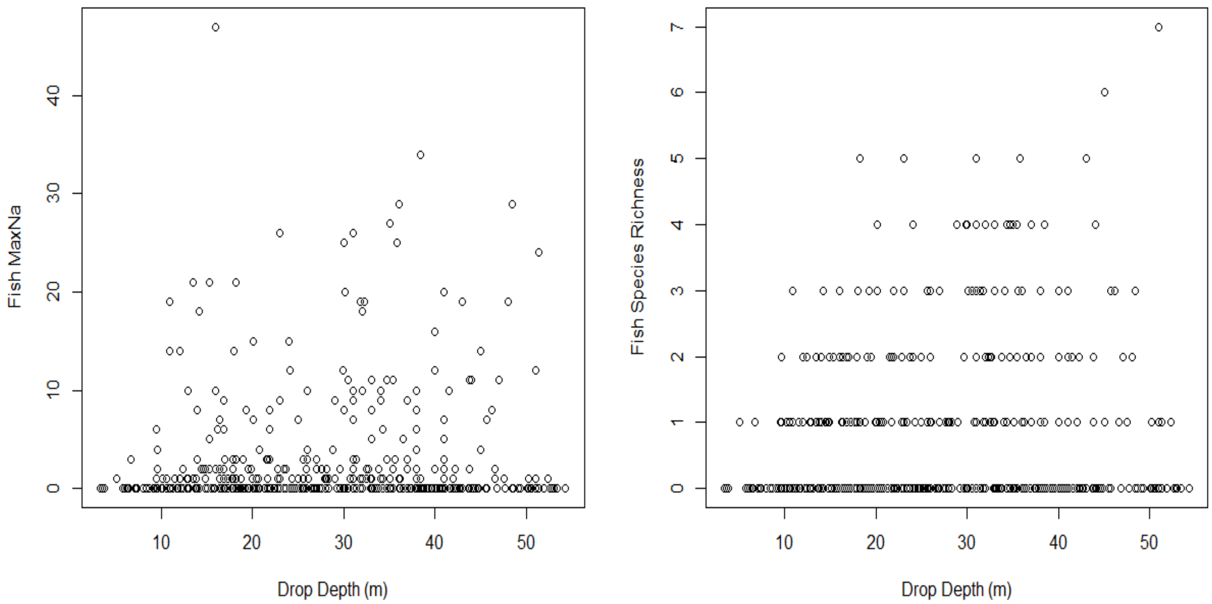


Figure 31. Relationship between depth (m) and MaxN$_a$ (left) and species richness (right) for all drops regardless of habitat encountered.

Table 20. Sample size, MaxN$_a$ and species richness of all completed drops in 2012-13 (regardless of habitat type encountered) by 10 m depth bins.

Depth Bins	Total Drops	Mean MaxN$_a$	Mean Species Richness
0-10m	36	0.47	0.19
10-20m	119	2.71	0.79
20-30m	115	1.72	0.74
30-40m	143	3.23	1
40-50m	75	2.96	0.8
50-60m	26	1.5	0.42

Table 21. Sample size, MaxN$_a$ and species richness of drops encountered consolidated habitats only in 2012-13 by 10 m depth bins.

Depth Bins	Total Drops	Mean MaxN$_a$	Mean Species Richness
0-10m	11	1.45	0.55
10-20m	82	3.83	1.11
20-30m	73	2.63	1.08
30-40m	82	5.48	1.63
40-50m	24	5.75	1.83
50-60m	3	12.00	2.67

The following analyses explore site specific patterns for the significant confounding factors identified when data was pooled across sites. The number of lander drops per site that met these requirements are shown in Table 22.

Table 22. Total number of lander drops completed within a site and the number and percentage encountered the targeted consolidated habitat types.

Site	Total Drops	Drops on Consolidated Habitats	Percent of Drop on Consolidated Habitats
Cascade Head	347	201	58%
Cape Perpetua	73	4	5%
Otter Rocks	19	13	68%
Redfish Rocks	75	57	76%

In Cascade Head, the various habitat types were encountered with relatively equal proportions among the three sampling areas (Figure 32). Consolidated substrates account for approximately 50% of all drops conducted in this site.

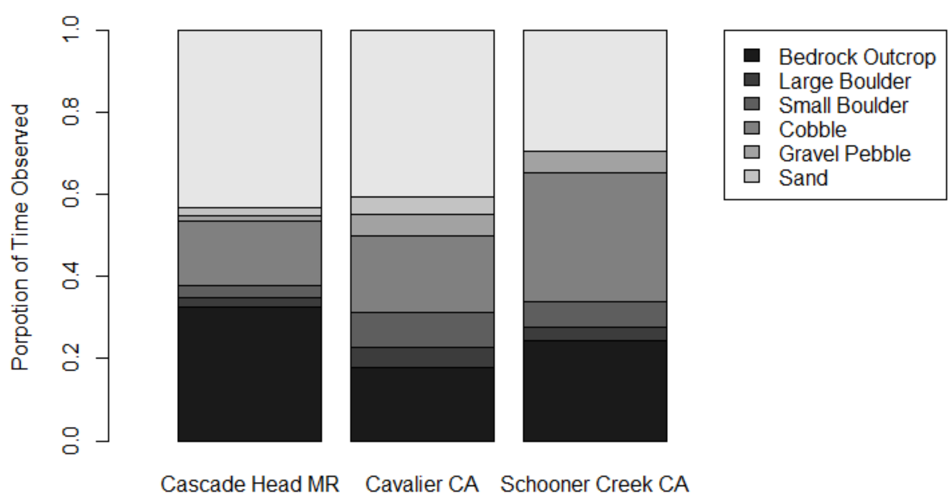


Figure 32. Proportion of various habitats types encountered in the marine reserve and comparison areas of Cascade Head in 2012-13.

For drops encountering consolidated substrates, visibility in Cascade Head was dominated by scores of 2, while relief scores were dominated by low relief (Figure 33).

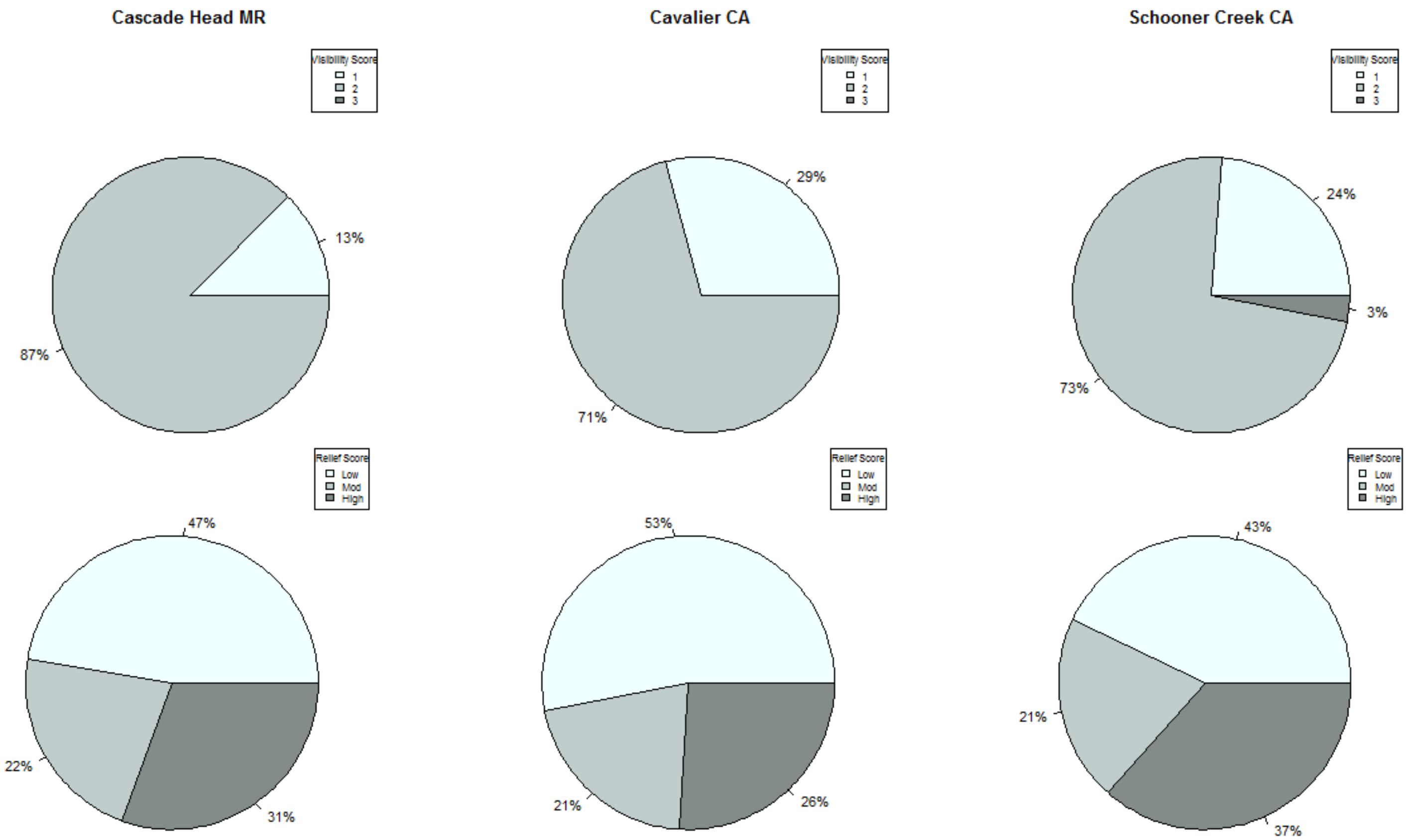


Figure 33. Proportion of lander drops with varying visibility scores (top panel) and structural relief of habitat (bottom panel) in the Cascade Head site among the reserve and comparison areas.

In Cape Perpetua, the various habitat types were encountered with relatively equal proportions among the two sampling areas (Figure 34). Consolidated substrates account for less than 5% of all drops conducted in this site. Rather, sand was the dominate substrate encountered.

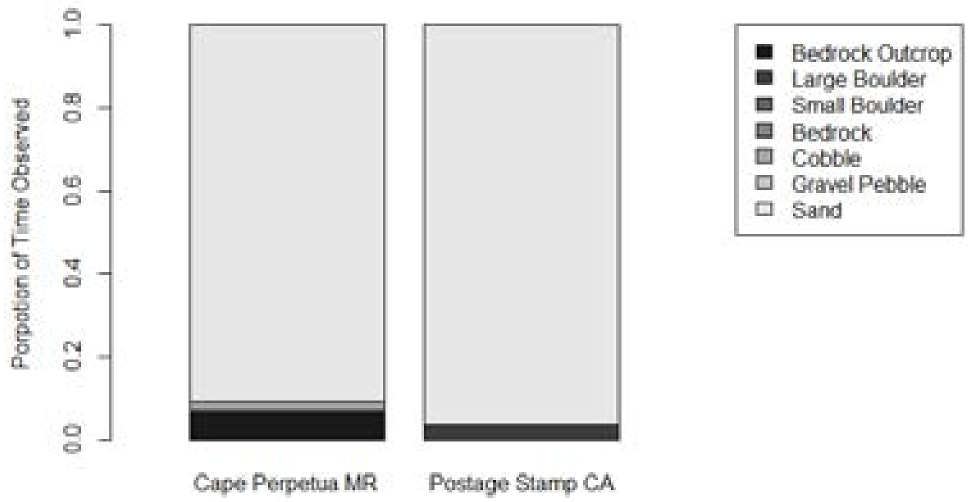


Figure 34. Proportion of various habitats types encountered in the marine reserve and comparison areas of Cape Perpetua in 2012-13.

For drops encountering consolidated substrates, visibility in Cape Perpetua was dominated by scores of 2, while relief scores were dominated by low relief (Figure 35).

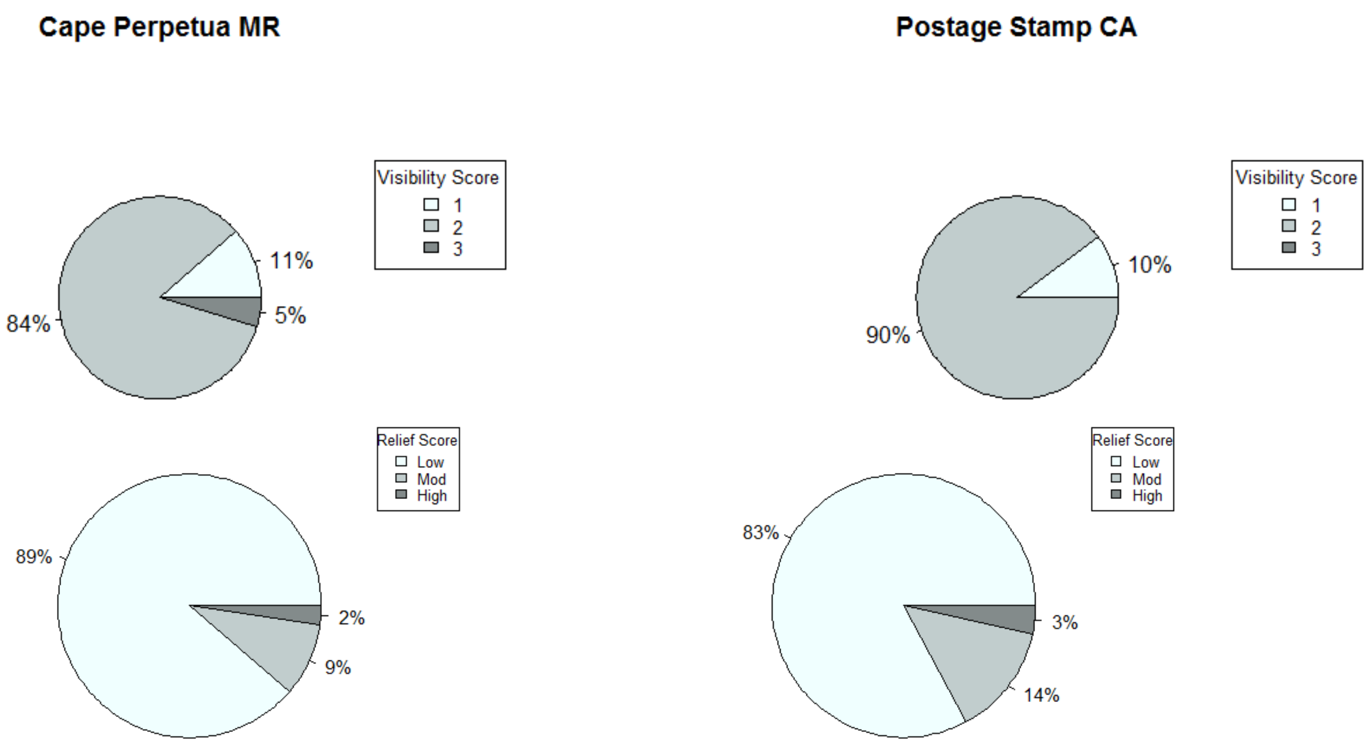


Figure 35. Proportion of lander drops with varying visibility scores (top panel) and structural relief of habitat (bottom panel) in the Cape Perpetua site among the reserve and comparison area.

In Otter Rock, consolidated substrates were encountered more often in the comparison area than the reserve (Figure 35). Consolidated substrates were the dominate habitat encountered at this site.

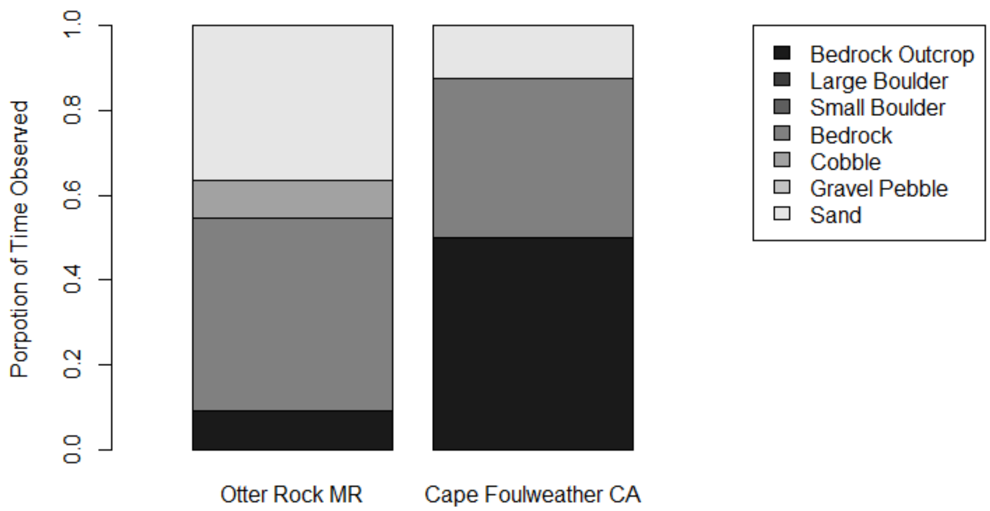


Figure 36. Proportion of various habitats types encountered in the marine reserve and comparison area of Otter Rock in 2012-13.

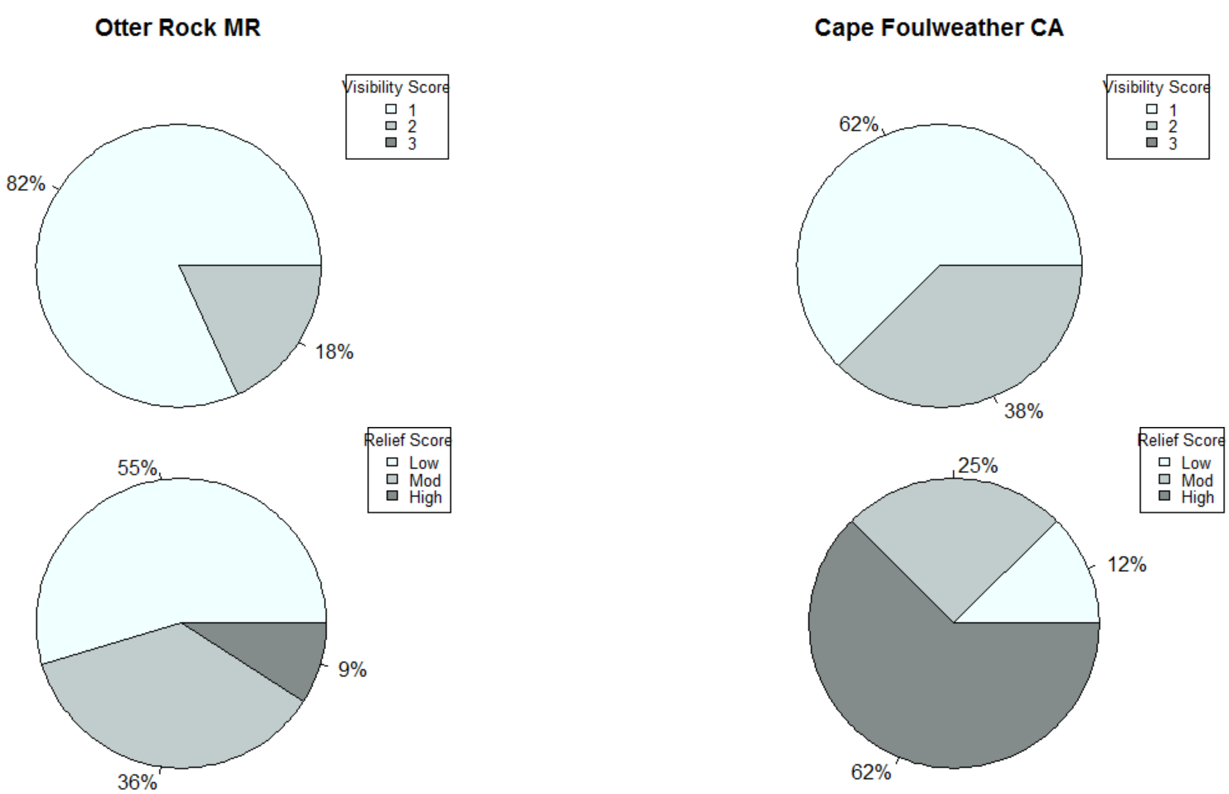


Figure 37. Proportion of lander drops with varying visibility scores (top panel) and structural relief of habitat (bottom panel) in the Otter Rock site among the reserve and comparison area.

For drops encountering consolidated substrates, visibility in Otter Rock was dominated by scores of 1, while relief scores were dominated by low relief in the reserve and high relief in the comparison area (Figure 35).

In Redfish Rocks, the habitats encountered varied widely among the study areas (Figure 38). Consolidated substrates were the dominate habitat encountered at the McKenzie Reef CA, while Humbug had fewest encounters with consolidated substrates among the four areas.

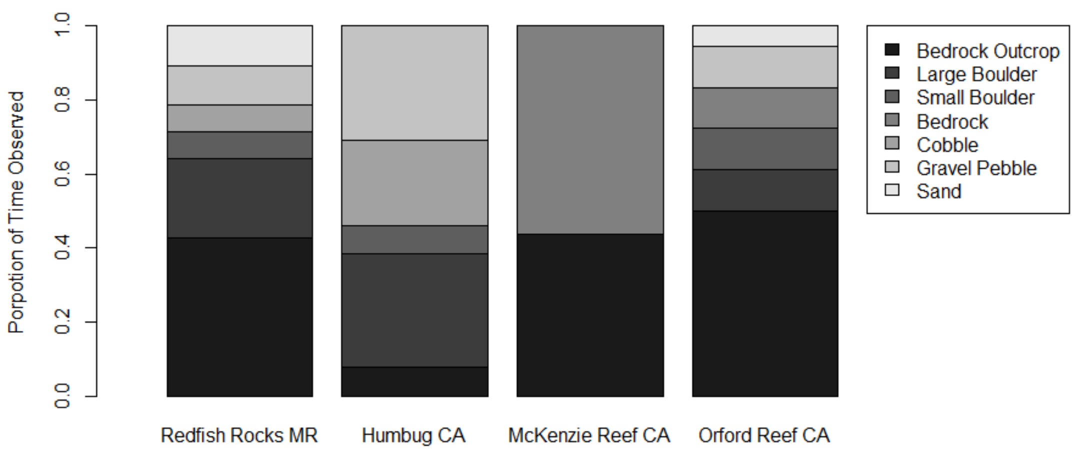


Figure 38. Proportion of various habitats types encountered in the marine reserve and comparison areas of Redfish Rocks in 2012-13.

For drops encountering consolidated substrates, visibility in Redfish Rocks was dominated by scores of 2 except for Humbug CA where visibility was dominated by lower scores. Relief scores were variable with highest relief encountered in Orford Reef CA. Both Humbug CA and Redfish Rocks MR shared similar encounter rates for high relief habitat (Figure 35).

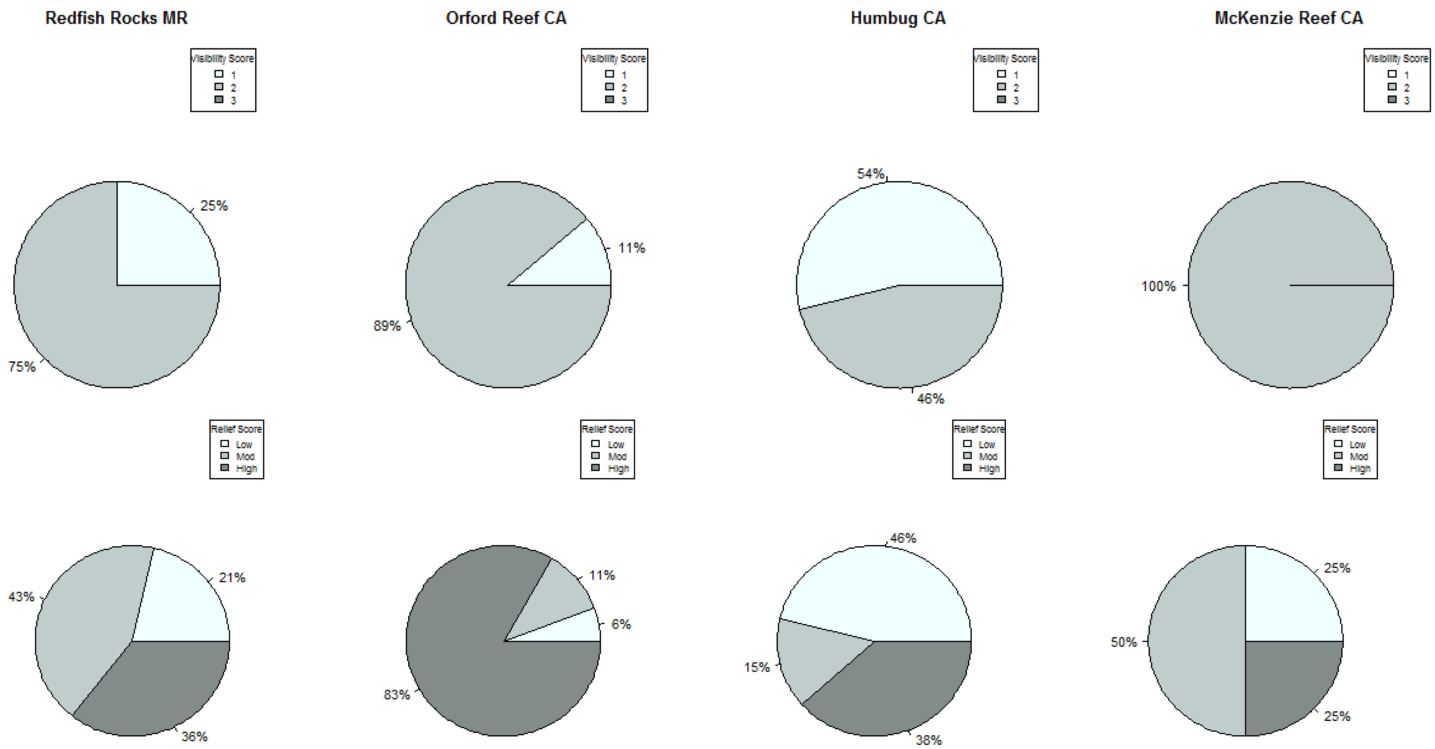


Figure 39. Proportion of lander drops with varying visibility scores (top panel) and structural relief of habitat (bottom panel) in the Redfish Rocks site among the reserve and comparison areas.

Learning and Adaptation

The analyses presented here aimed to identify which confounding factors present in the lander data collected in 2012-13 significantly influenced the response variables of relative fish abundance and species richness. Our results suggest that camera type (standard versus high definition), view, and drop duration were not significant drivers of variation in the dataset. However, future drops will be all scored to a fixed bottom time duration. This time will be near the eight (8) minute duration, though ongoing research is currently underway to refine this drop duration for Oregon's nearshore habitats; finalized results anticipated in Spring 2015. In addition, high definition cameras will be used for all future drops to help maximize species-specific identification and capitalize on the new low light filming features of newer camera models.

To minimize those confounding factors that did significantly influence the response variable of relative abundance and species richness, lander drops must meet certain criteria for analysis, including:

- Visibility must score a 2 or 3; exclude visibility scores of 1 and revisit the statistical difference between drops scoring 2 versus 3 with additional lander data.

- Habitat must be consolidated; soft sediment primary habitat (anything other than bedrock and boulder categories) results in significantly lower species richness and MaxN. If hard bottom habitats are rare or limited (i.e. Cape Perpetua) consider not using the lander at these sites in favor of ROV sampling.
- Aim to target habitats with high relief by using hillshade maps created from multibeam bathymetry to supplement benthic habitat maps that only display rock habitat as a single type irrespective of relief (i.e. TerraSea habitat map).
- Depth appears to influence fish abundance and diversity with the trend that deeper depth (→30m) support more abundant and diverse fish assemblages. Consider targeting lander drops at specified depths (30, 40 and 50m) and re-evaluated with additional lander data. The lander should not be used in depths shallower than 10m.

Lastly, our site specific data exploration indicates that the lander tool is not uniformly successful in generating usable data among the four (4) reserve sites presented here. Cape Perpetua is not an appropriate site for lander work given the small size and deep depth of hard bottom in that site. Rather, the ROV would be a more reliable sampling tool. Cascade Head, Redfish Rocks and Otter Rock sites seem to generate useful lander data, though the above criteria should be carefully considered before additional sampling is conducted in these sites in order to maximize the usable data from this tool.

II. SLED

Here we present the species densities for organism observed in sand habitats during our 2012 sled surveys at the Cascade Head and Cape Perpetua sites. Our analysis was restricted to those species or species groups who would be found within soft sediments. In 2012, 39 sled tows with video of sufficient quality for analysis were completed at the two sites. Eight were completed at Cape Perpetua Marine Reserve and the Postage Stamp Comparison Area, and 31 were completed at Cascade Head Marine Reserve and the Schooner Creek and Cavalier Comparison Areas.

Densities were estimated per transect by dividing the total count by the transect length. Note that this does not account for the section of the total transect length that may have encountered consolidated substrate (and were excluded from the organism count but not the total transect length). Hence, this density data should be treated as a conservative estimate.

Table 23. Cascade Head species densities for fishes, Dungeness crab, seastars, and sea pens observed during sled transects. Estimated density was calculated as number of individuals/transect length (m). Transect width was assumed constant and not involved in the calculation.

Organism/Organism Group	Schooner Creek CA	Cavalier CA	Cascade Head MR
Big Skate	←0.001	0.001	←0.001
Pacific Sanddab	←0.001	←0.001	0.002
Skate	←0.001	0.002	←0.001
UNID Flatfish	0.006	0.004	0.004
Dungeness Crab	0.002	0.002	0.002
Basket Star	0.004	0.000	0.000
Pink Sea Star	0.002	0.004	0.002
Sand Star	0.002	0.002	0.002
Sunflower Star (Pycnopodia)	0.002	0.002	0.002
UNID Seastar	0.002	0.002	0.001
Sea Pen	0.303	0.008	0.013

Table 24. Cape Perpetua species densities for fishes, Dungeness crab, and seastars observed during sled transects. Estimated density was calculated as number of individuals/transect length (m). Transect width was assumed constant and not involved in the calculation.

Organism/Organism Group	Postage Stamp CA	Cape Perpetua MR
Big Skate	0.002	←0.001
UNID Flatfish	0.003	0.005
Dungeness Crab	0.007	0.001
Pink Sea Star	0.003	0.001
Sand Star	←0.001	0.001
Sunflower Star (*Pycnopodia*)	←0.001	0.001
UNID Seastar	0.002	←0.001

Given the limitations of the 2012 sled data, the decision was made not to score 2013 for organism abundance. Each video from 2013 surveys was reviewed and any qualitative observations of note were recorded. For example, a large swarm of juvenile Dungeness crab was observed in the Tokatee Comparison Area.

Learning and Adaptation

As we move forward with our monitoring efforts, we are tentatively discontinuing use of the sled as a sampling tool due to poor species-specific resolution capabilities. A review of the video data shows that even with HD video, species-level or group-level identification of flatfish is difficult and impossible for those fish less than 150mm in length. Worth noting is that this tool does appear to capture abundance (and estimated spatial position) of Dungeness crab fairly well. If specific research or monitoring questions are developed pertaining to Dungeness crab, the sled may be reconsidered for use as a sampling tool.

III. ROV

Here we present a summary analysis from our ROV surveys completed in September 2012 at each of two areas: 11 transects at Cascade Head Marine Reserve (MR), and 11 transects at Cavalier comparison area (CA) (Figure 40). The total length of all completed transects was 6.8km at Cascade Head MR, and 5.9km at Cavalier Reef CA, with an average transect length of 575m.

Substrates

Substrate types interpreted during video review largely corroborated the previously mapped broad categories of bottom type interpreted from multibeam surveys, but added substantial spatial detail and additional categories of particle size (Figure 41). Transects at the two areas covered similar proportions of bedrock, the dominant primary substrate type (Table 25). In the smaller particle size ranges, transects at Cavalier CA included 12% cobble/gravel, while Cascade Head MR did not have appreciable representation in this substrate size, instead featuring more sand.

Invertebrates

A total of 29 invertebrate taxa were documented in the two areas, with 22 taxa comprising 99% of the total invertebrate abundance. Twelve taxa were sufficiently abundant to constitute at least 1% of total abundance. This group of abundant species included sponges, anemones, sea cucumbers, basket stars, tunicates, and tube worms. Abundance of individual taxa varied between the two surveyed areas, with cloud sponges and blood stars being the most abundant invertebrates at Cascade Head MR, and burrowing cucumbers and plumose anemones the most abundant invertebrates at Cavalier CA (Table 26). Among the abundant invertebrates, four taxa varied significantly in abundance between areas, with giant sea cucumbers, basket stars, and tennis ball sponges all more abundant at Cascade Head MR (Welch's t-tests on square root transformed abundance, $p = 0.004$, 0.039, and 0.040, respectively), and pink sea stars more abundant at Cavalier CA ($p = 0.005$; Figure 42). Plumose anemones and burrowing cucumbers were numerically much more abundant on some transects at Cavalier CA than at Cascade Head MR, but high variability among transects resulted in marginally non-significant t-tests. Shannon Diversity Indices for Cascade Head MR and Cavalier CA were 1.26 and 1.49 respectively, and Pielou's Evenness Indices were 0.39 and 0.43

respectively, reflecting generally similar diversity and distribution of abundance among invertebrate taxa.

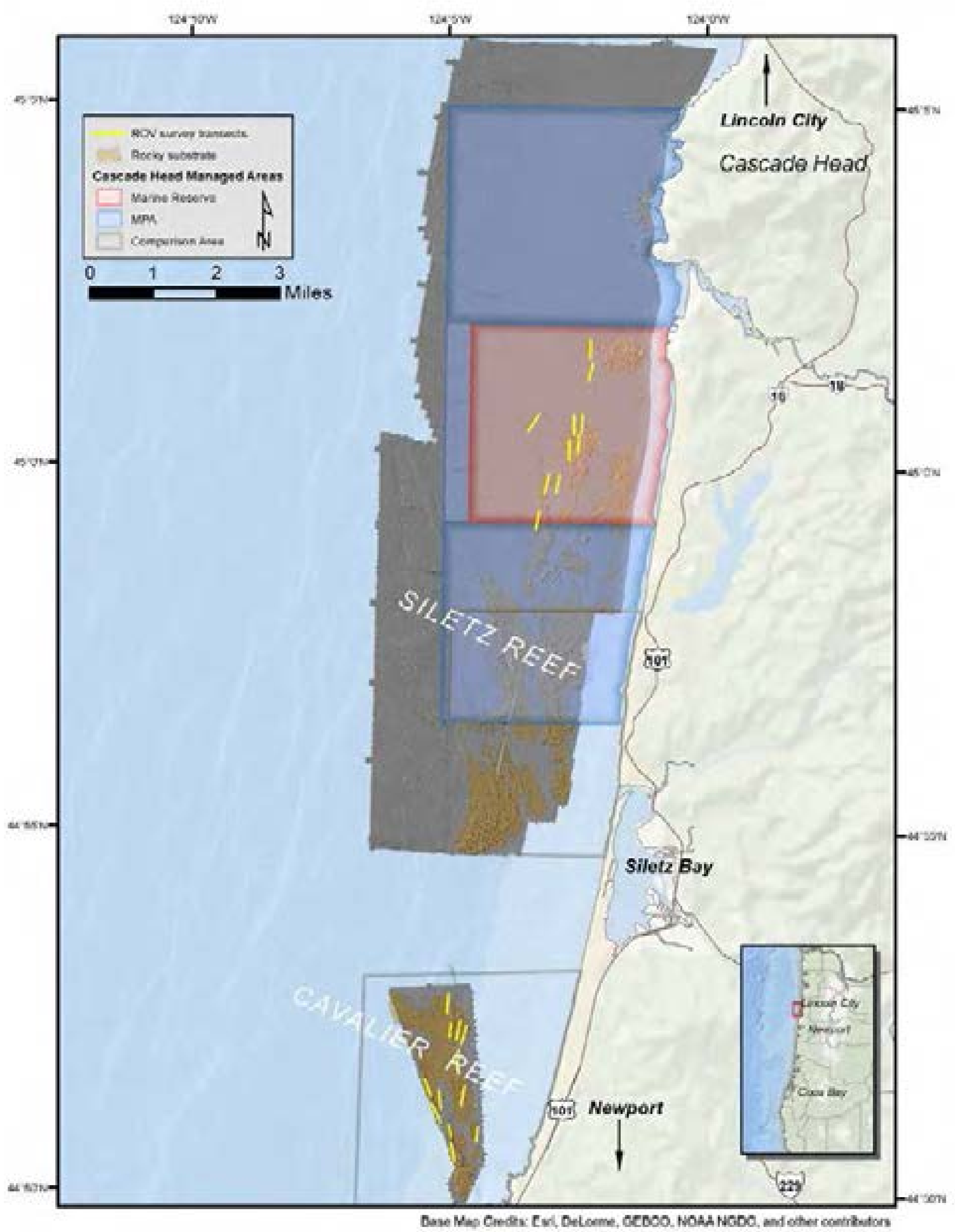


Figure 40. Location of 22 ROV survey transects conducted in September 2012 in Cascade Head MR and Cavalier CA.

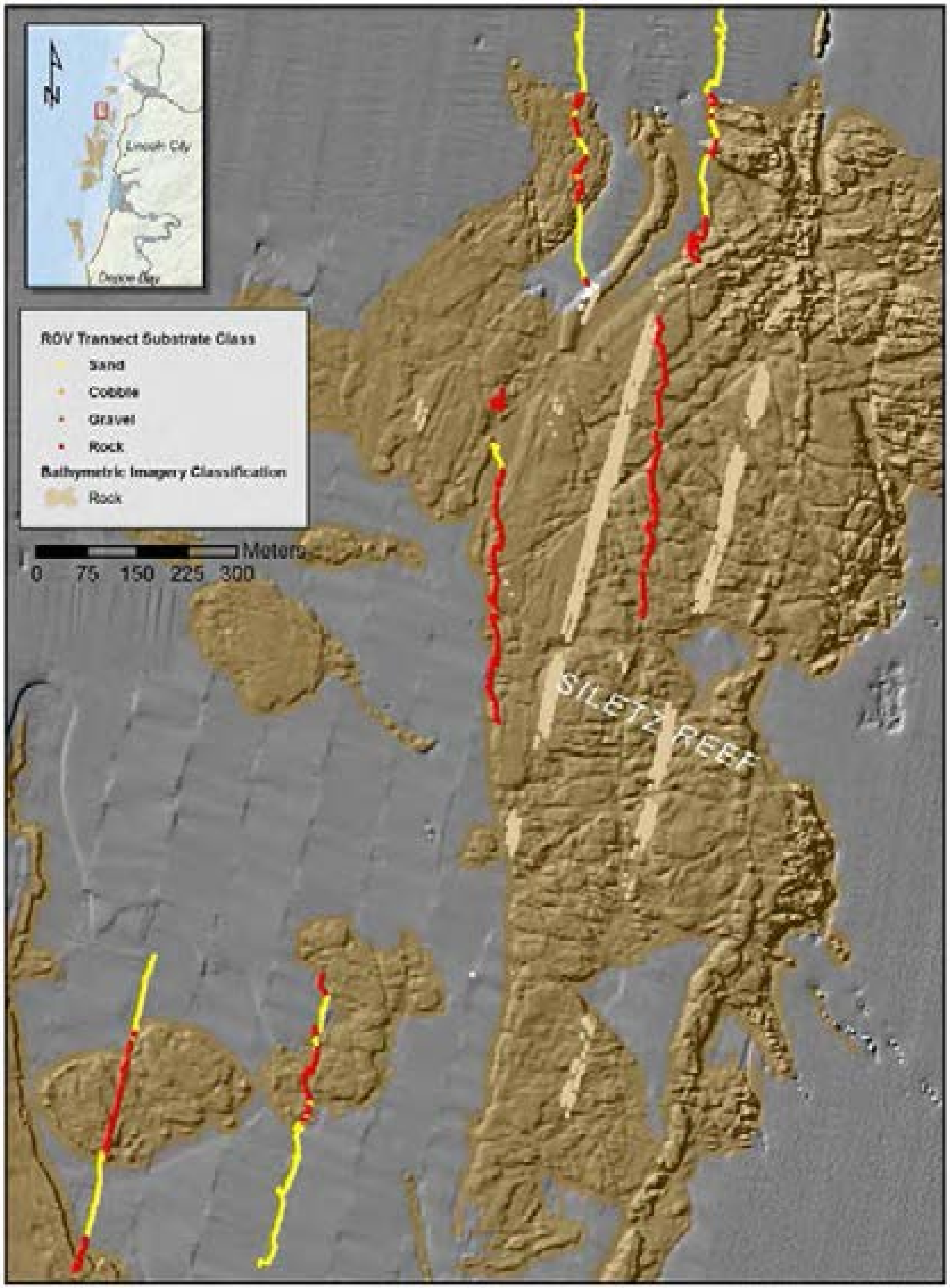


Figure 41. Primary substrate classification interpreted from video of seafloor habitat along example ROV transects from Cascade Head MR, overlaid on previous substrate classification and bathymetry interpreted from a prior multibeam mapping survey.

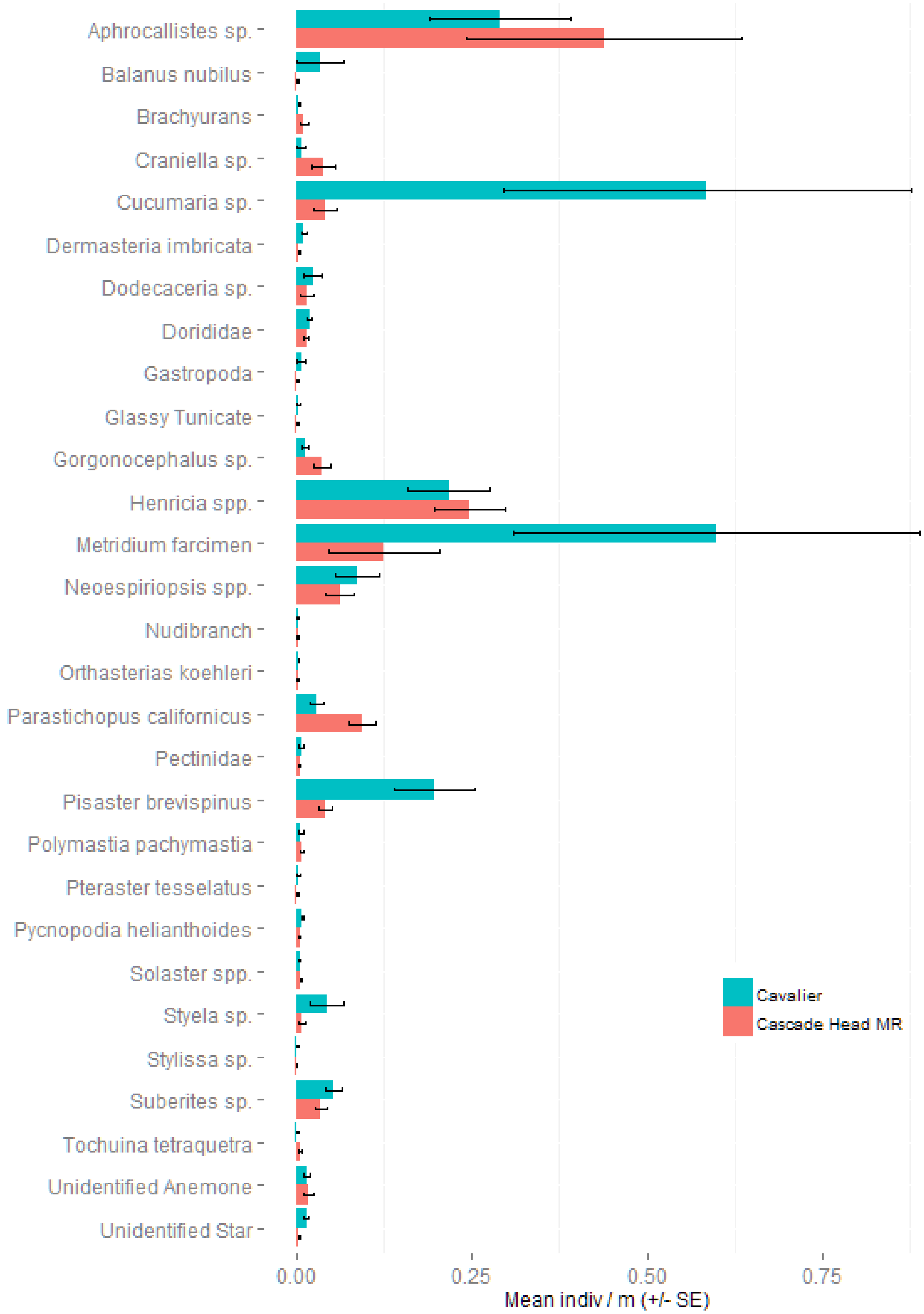
Table 25. Relative abundance of primary substrates observed in 22 ROV transects conducted at Cascade Head MR and Cavalier CA in September 2012.

Geologic Habitat	Cascade Head MR	Cavalier CA
Bedrock	51.2%	56.9%
Large Boulder	0.1%	0.9%
Small Boulder	4.8%	3.1%
Cobble	0.8%	6.1%
Gravel	0.4%	5.9%
Sand	42.8%	27.0%

Table 26. Relative invertebrate abundance in 11 ROV transects conducted at Cascade Head MR and 11 transects at Cavalier CA in September 2012.

Cascade Head MR				Cavalier CA			
Rank	Taxon	n	Percent	Rank	Taxon	n	Percent
1	*Aphrocallistes sp.*	3,047	34.90%	1	*Cucumaria sp.*	3,485	25.81%
2	*Henricia spp.*	1,695	19.41%	2	*Metridium farcimen*	3,399	25.17%
3	*Metridium farcimen*	789	9.04%	3	*Aphrocallistes sp.*	1,791	13.26%
4	*Parastichopus californicus*	633	7.25%	4	*Henricia spp.*	1,309	9.69%
5	*Neoespiriopsis spp.*	422	4.83%	5	*Pisaster brevispinus*	1,106	8.19%
6	*Pisaster brevispinus*	283	3.24%	6	*Neoespiriopsis spp.*	505	3.74%
7	*Cucumaria sp.*	274	3.14%	7	*Suberites sp.*	332	2.46%
8	*Craniella sp.*	267	3.06%	8	*Styela sp.*	246	1.82%
9	*Gorgonocephalus sp.*	256	2.93%	9	*Parastichopus californicus*	197	1.46%
10	*Suberites sp.*	246	2.82%	10	*Balanus nubilus*	162	1.20%
11	*Unidentified Anemone*	113	1.29%	11	*Dodecaceria sp.*	149	1.10%
12	*Dodecaceria sp.*	103	1.18%	12	*Dorididae*	114	0.84%
13	*Dorididae*	100	1.15%	13	*Unidentified Star*	86	0.64%
14	*Brachyurans*	78	0.89%	14	*Gorgonocephalus sp.*	85	0.63%
15	*Polymastia pachymastia*	60	0.69%	15	*Unidentified Anemone*	85	0.63%
16	*Styela sp.*	54	0.62%	16	*Dermasteria imbricata*	67	0.50%
17	*Tochuina tetraquetra*	45	0.52%	17	*Pycnopodia helianthoides*	56	0.41%
18	*Solaster spp.*	44	0.50%	18	*Gastropoda*	48	0.36%
19	*Pectinidae*	36	0.41%	19	*Pectinidae*	42	0.31%
20	*Pycnopodia helianthoides*	36	0.41%	20	*Polymastia pachymastia*	42	0.31%
21	*Dermasteria imbricata*	28	0.32%	21	*Craniella sp.*	41	0.30%
22	*Unidentified Star*	25	0.29%	22	*Solaster spp.*	34	0.25%
23	*Nudibranch*	19	0.22%	23	*Brachyurans*	23	0.17%
24	*Orthasterias koehleri*	16	0.18%	24	*Pteraster tesselatus*	22	0.16%
25	*Glassy Tunicate*	14	0.16%	25	*Orthasterias koehleri*	20	0.15%
26	*Pteraster tesselatus*	14	0.16%	26	*Glassy Tunicate*	19	0.14%
27	*Gastropoda*	13	0.15%	27	*Nudibranch*	15	0.11%
28	*Balanus nubilus*	12	0.14%	28	*Tochuina tetraquetra*	12	0.09%
29	*Stylissa sp.*	9	0.10%	29	*Stylissa sp.*	10	0.07%
	Total:	8,731			Total:	13,502	

Figure 42. Mean abundance of invertebrates observed in ROV transects at Cascade Head MR and Cavalier CA (no. of indiv./m, +/- std. error, n = 11 transects per site).


Aphrocallistes sp.
Balanus nubilus
Brachyurans
Craniella sp.
Cucumaria sp.
Dermasteria imbricata
Dodecaceria sp.
Dorididae
Gastropoda
Glassy Tunicate
Gorgonocephalus sp.
Henricia spp.
Metridium farcimen
Neoespiriopsis spp.
Nudibranch
Orthasterias koehleri
Parastichopus californicus
Pectinidae
Pisaster brevispinus
Polymastia pachymastia
Pteraster tesselatus
Pycnopodia helianthoides
Solaster spp.
Styela sp.
Stylissa sp.
Suberites sp.
Tochuina tetraquetra
Unidentified Anemone
Unidentified Star
0.00
0.25
0.50
0.75
Mean indiv / m (+/- SE)
Cavalier
Cascade Head MR

Fish

A total of 21 fish taxa were documented, with 14 taxa comprising 99% of the total fish abundance. Eleven taxa were sufficiently abundant to constitute at least 1% of total fish abundance (Table 27). Black Rockfish and Blue Rockfish were the most abundant, jointly comprising 63% of individuals observed. These two species displayed substantial aggregation, with some transects recording no individuals while nearby transects featured large schools. Qualitatively examining patterns of Black Rockfish distribution within and among transects in relation to vertical relief, aggregations were frequently observed in association with reef margins and high-relief areas.

Black Rockfish, Blue Rockfish, and Cabezon showed the greatest degree of association with bedrock substrate among the abundant fishes, while canary rockfish and yellowtail rockfish were also abundant over substrates with smaller particle size (Figure 43). Flatfish (including Petrale Sole and Sanddabs) were found almost exclusively over sand, and the observation that almost all unidentified fish were observed over sand suggests that most unidentified fish (beyond unidentified rockfish) were likely flatfish.

Among the abundant fish taxa, the main differences in community composition between the two areas was the marginally higher abundance of flatfish and Kelp Greenling at Cascade Head MR (Figure 44), although t-tests comparing abundance showed no significant differences ($p = 0.23$ and $p = 0.10$ respectively). Variance among transects in the proportion of sand habitat likely drove the variability in flatfish abundance; further investigations of fish community structure should make comparisons within substrate types. Marginally higher abundance of Yellowtail Rockfish was observed at Cavalier CA, though variance among transects was high and t-tests showed no significant difference compared with Cascade Head MR ($p = 0.12$). Shannon Diversity Indices for fish taxa at Cascade Head MR and Cavalier CA were 1.84 and 1.82 respectively, and Pielou's Evenness Indices were 0.64 and 0.63 respectively, reflecting very similar diversity and distribution of abundance among fish taxa.

Learning and Adaptation

As we move forward with our monitoring efforts, we will continue to consider the ROV as one of several tools in our marine reserves monitoring toolbox. While the ROV may be the ideal tool to survey specific areas that contain certain habitats, it may be less well suited to other areas (e.g. the shallow rocky reefs of Cape Falcon MR).

At this point, we envision continuing ROV data collection at the deep reefs within Cape Perpetua MR. These reefs have been targeted by numerous ODFW studies over the past two decades providing a robust baseline and time series dataset from which we can evaluate future changes. However, the lack of a comparable deep water fish reef may limit using the ROV in any of the existing Cape Perpetua CAs. Hence, the ROV may solely be used in the marine reserve at this site.

The ROV appears well suited for surveying the deeper (30-40m) rocky reefs present in the Cascade Head and Redfish Rock sites. Ideally the data collected from the ROV in these locations can be used to monitor populations within these sites, but also to: (1) groundtruth the accuracy of our benthic habitat maps constructed from multibeam data and (2) develop predictive habitat suitability models for species of interest that can inform marine reserve sampling designs for future ROV, lander, hook and line and SCUBA surveys.

Table 27. Relative fish abundance in 11 ROV transects conducted at Cascade Head MR and 11 transects at Cavalier CA in September 2012.

Cascade Head MR				Cavalier CA			
Rank	Taxon	n	Percent	Rank	Taxon	n	Percent
1	Black Rockfish	445	37.43%	1	Blue Rockfish	462	34.53%
2	Blue Rockfish	228	19.18%	2	Black Rockfish	448	33.48%
3	Kelp Greenling	172	14.47%	3	Kelp Greenling	105	7.85%
4	Unidentified Flatfish	152	12.78%	4	Yellowtail Rockfish	67	5.01%
5	Canary Rockfish	54	4.54%	5	Canary Rockfish	48	3.59%
6	Lingcod	52	4.37%	6	Lingcod	45	3.36%
7	Unidentified Rockfish	16	1.35%	7	Unidentified Fish	45	3.36%
8	Eelpout	15	1.26%	8	Unidentified Flatfish	36	2.69%
9	Quillback Rockfish	15	1.26%	9	Unidentified Rockfish	27	2.02%
10	Yellowtail Rockfish	12	1.01%	10	Eelpout	16	1.20%
11	Cabezon	11	0.93%	11	Cabezon	15	1.12%
12	Copper Rockfish	6	0.50%	12	Unidentified Sculpin	12	0.90%
13	Yelloweye Rockfish	3	0.25%	13	Ratfish	4	0.30%
14	Pleuronectids	3	0.25%	14	Quillback Rockfish	2	0.15%
15	Wolfeel	2	0.17%	15	Yelloweye Rockfish	2	0.15%
16	Unidentified Sculpin	1	0.08%	16	China Rockfish	2	0.15%
17	Ratfish	1	0.08%	17	Vermillion Rockfish	1	0.07%
18	China Rockfish	1	0.08%	18	Widow Rockfish	1	0.07%
19	Unidentified Fish	0	0.00%	19	Copper Rockfish	0	0.00%
20	Vermillion Rockfish	0	0.00%	20	Pleuronectids	0	0.00%
21	Widow Rockfish	0	0.00%	21	Wolfeel	0	0.00%
	Total:	1,189			Total:	1,338	

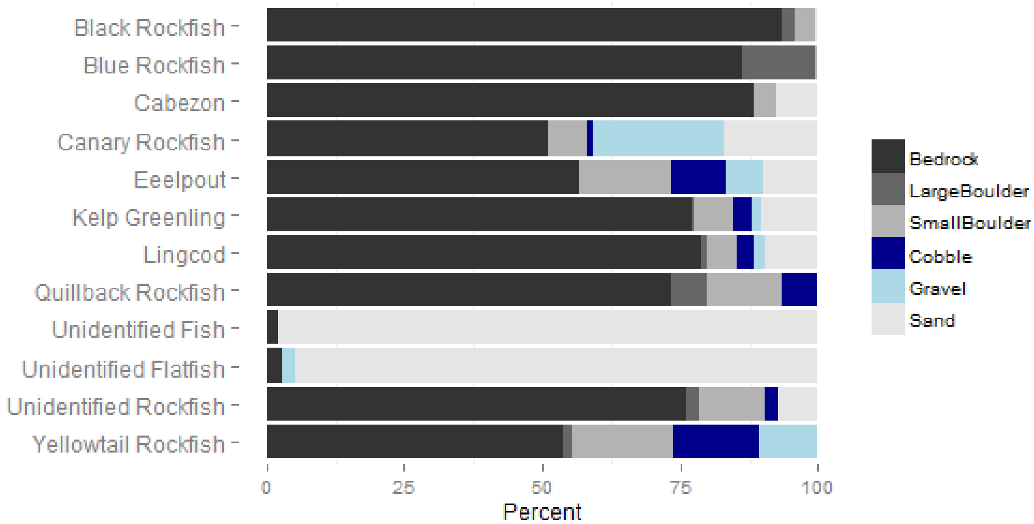


Figure 43. Relative abundance of fish observed over 6 primary substrate categories in 22 ROV transects conducted at Cascade Head MR and Cavalier CA in September 2012. Species with fewer than 15 observations are excluded.

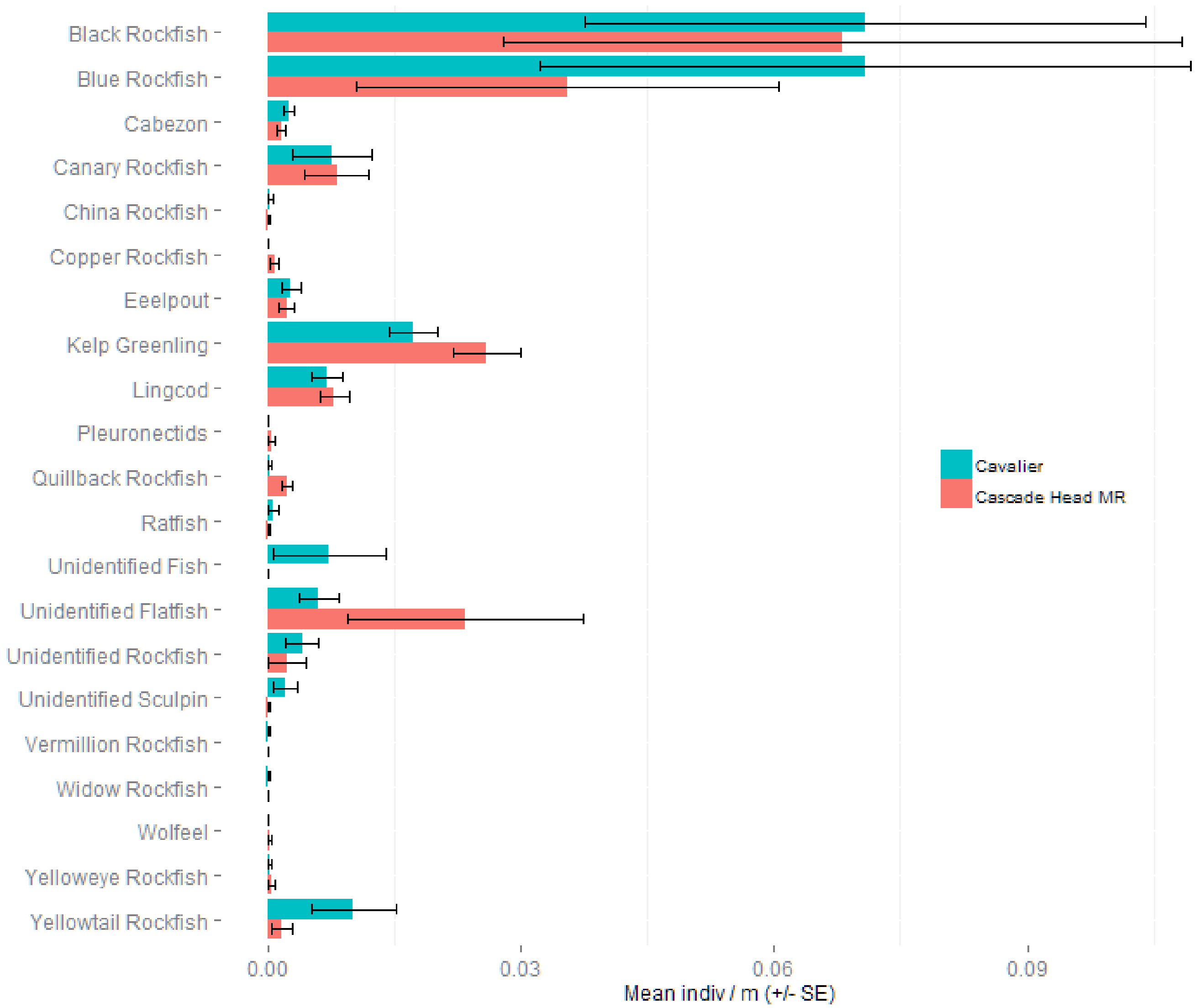


Figure 44. Mean abundance of fish observed in ROV transects at Cascade Head MR and Cavalier CA (no. of indiv./m, +/- std. error, n = 11 transects per site).

IV. SCUBA

For this report, SCUBA results have not been compiled as the divers and methods were still in refinement during 2013. Any data deemed accurate from surveys conducted in 2013 will be analyzed with data from the 2014 sampling effort.

No SCUBA surveys were completed in 2012.

V. RED URCHIN SURVEYS

Here we present a summary of the red sea urchin, *Strongylocentrotus franciscanus*, surveys performed in the area of Depoe Bay, Oregon. Surveys focused on relating temporal changes to density and size distribution when compared to similar work performed in the 1990's. Preliminary results from this survey show: 1) a single, episodic recruitment event from more than twenty years ago dominates the population, 2) evident reductions to the density of indexed populations, 3) dissimilar growth rates at northern (deeper, less vegetated) areas than southern, 4) significantly larger mean sizes within reserve areas and among reserve populations, which has incrementally increased with closure time.

Densities in the Depoe North area were reduced over time (Table 28.). Significant changes to density were found with the arrival and emergence of settlers in a large recruitment event which occurred ~1992. Testing using one way ANOVA showed the 1.92/ m^2 increase of red sea urchin density from 1991 to 1996 and the subsequent reduction of 1.5/ m^2 by 2012 to be highly significant ($P= 0.0032$ and $P= 0.01$ respectively). Densities within the Depoe South area were also lower, though smaller sample sizes in these areas make inferences less robust. Densities in Whale Cove Habitat Refuge (HR) were also reduced from previous reporting. However, Whale Cove is a very small area featuring highly variable habitats (rocky and sandy) where slight differences in position of index surveys could strongly influence measured densities. Surveys within the recently created Otter Rock Marine Reserve (MR) were located in two different sites and not performed in each year; data were pooled from both sites.

Table 28. Mean density (and 95% CI) of red sea urchins per meter squared at pooled areas of Depoe Bay, OR

	1991	1994	1996	1997	1998	2012
Depoe North	0.55 (-0.34)	1.55 (-0.33)	2.47 (-0.29)		1.53 (-0.21)	0.97 (-0.18)
Depoe South		0.81 (-0.32)	0.69 (-0.24)		0.78 (-0.34)	0.33 (-0.17)
Otter Rock MR*	0.15 (-0.2)	0.49 (-0.33)	0.69 (-0.63)		0.08 (-0.11)	0.49 (-0.26)
Pirates Cove RR						0.26 (-0.17)
Whale Cove HR**			*0.54*	*0.72*	*1.73*	0.42 (-0.17)

* Otter Rock includes data pooled from two sampling locations
** Data from Montano 2001

Size Distributions in Protected Areas

Given differences in closure times to red sea urchin harvest (1963, 1993, and 2012), the three protected areas were treated as different strata. Mean size at each area were incrementally larger as closure time was increased (Figure 45). At Whale Cove HR, where harvest was disallowed prior to the inception of the fishery, red sea urchins were very large. At Pirates Cove RR, which was closed shortly after the boom of the fishery (1993), urchins were substantially larger than those from nearby harvested areas. Finally at Otter Rock MR, which was very recently closed (2012) size distributions were similar to harvested areas.

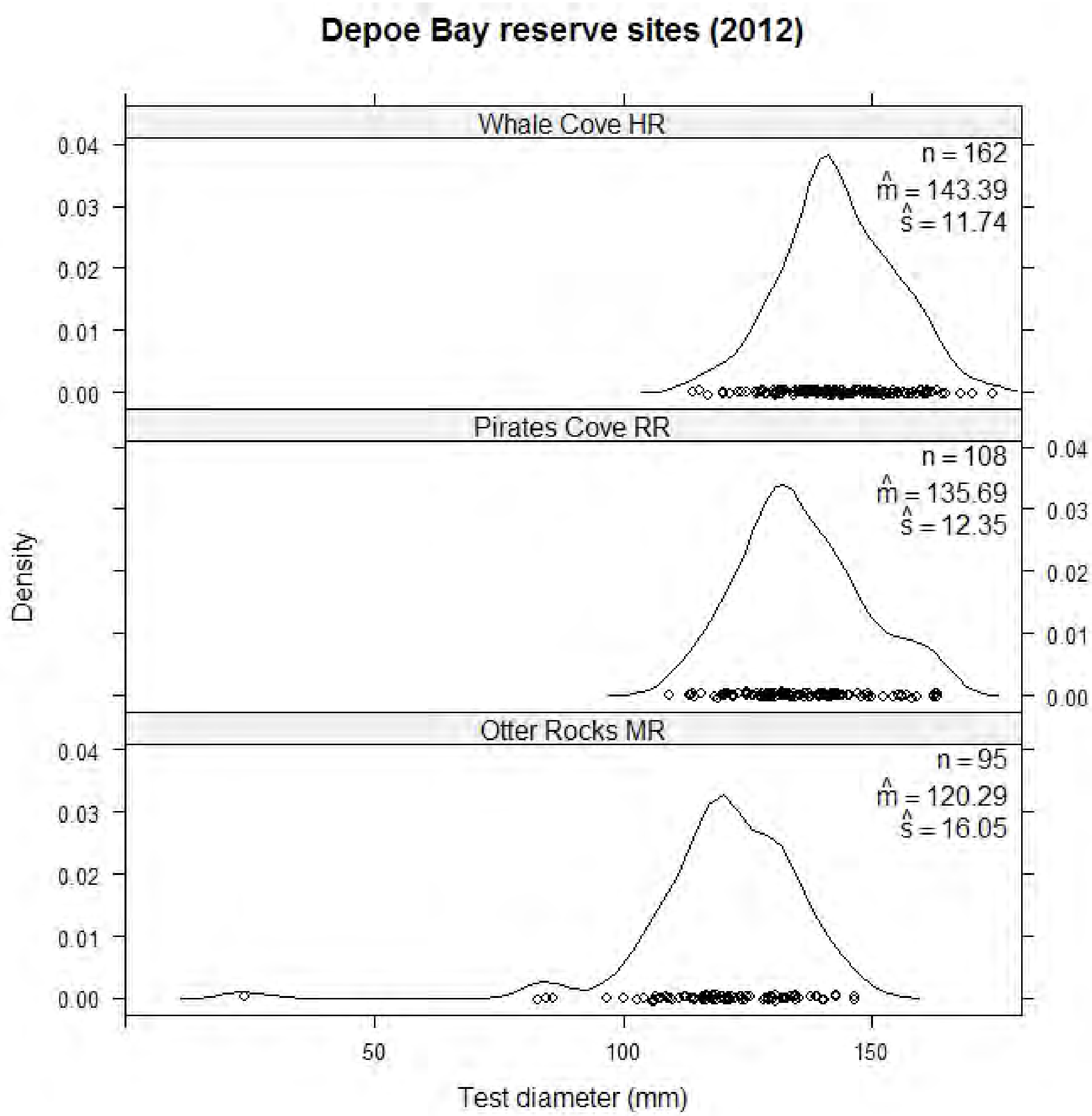


Figure 45. Depoe Bay protected area size distributions

Conclusions

In the Depoe Bay area, red sea urchin densities have reduced over time. This would be expected, given consistent fishing pressure, natural mortality, and without evidence of any recent recruitment. In Depoe Bay South, where fishing and kelp production has been continuous without recruitment, fishing pressure alone may best explain these changes. In Depoe Bay North, which is open to harvest but hasn't been fished, densities are also reduced. Given the lower kelp presence in this area, this may be explained by emigration and/or high natural mortality rates. In the protected areas where red sea urchin harvest is prohibited, a lack of robust temporal data prevents interpretation aside from noting that their current lack of great densities (coupled with unimodal size distributions) call further attention to a lack of recent recruitment events.

Size distribution data from this area show similar trends as recent work in Port Orford (ODFW unpublished memo). Red sea urchin populations typically have bimodal size distributions, the smaller being an incoming recruit class, the larger being the adult population. In the cases of these 2012 data, size distributions were unimodal, including only the large adult population, indicating a lack of recent recruitment.

Size distributions within protected areas were related to time of closure for each area (i.e. the longer the closure time the larger the mean size), similar to how urchin populations have reacted in other states' protected areas.

Learning and Adaptation

Looking forward, the Shellfish Program of ODFW aims to continue these red sea urchin population surveys and share their findings with the Marine Reserves Program. Scott Groth (ODFW-Charleston) leads the current survey efforts and is the best point of contact to discuss future work.

C. Extractive Assessments

I. SMURFS

SMURFS were successfully used to sample juvenile fishes recruiting to the nearshore in 2011, 2012, and 2013. The total number of fishes sampled in each of these three years was highly variable, as was the community composition (Figure 46). In 2011, the year with the fewest fishes sampled, the catch was dominated by Red Irish Lords with Copper Rockfish comprising the most abundant rockfish species. In contrast, 2012 captured 5 times as many fishes compared to 2011 and Copper rockfish were the dominant species in the overall catch. Finally, 2013 sampling yielded by far the largest sample size of fishes over the summer sampling period, with Splitnose Rockfish comprising the majority of the catch.

Fish recruitment rates (calculated as the number of fishes captured in a sampling period divided by the number of days the SMURF was deployed) were averaged for the reserve and the comparison area (Figure 47). Recruitment rates varied across seasons and years with a conspicuous pulse of recruitment in Cape Foulweather CA in 2012 and a similar conspicuous pulse of recruitment in the Otter Rock MR in 2013.

Additional research on these collected fishes will include tissue samples preserved for genetic analysis, and otolith extraction for age and growth studies. Juvenile sagittal otoliths will be dissected and examined to determine early life history traits such as pelagic larval duration, size at age, age and size at settlement, juvenile age, and larval and juvenile growth rates (e.g. Laidig 2010, Grorud-Colvert and Sponaugle 2011). Genetic analysis will be used to assess potential kinship among juveniles settling in large and spatially distinct pulses of recruitment (e.g. Johansson et al. 2008).

Overall, these data show the high spatial and temporal variability in recruitment of rockfishes and other species. As marine reserve monitoring continues in Oregon, it becomes ever more important to follow fish recruitment over time in order to track this variability, to establish a baseline for considering the importance of habitat protected within marine reserves, and the potential outcomes of reserve protection on life stages. Improved understanding of juvenile fish habitat use in the existing marine reserves has the potential to influence future longevity of the reserve system and to guide future management decisions about marine reserves in Oregon waters.

Learning and Adaptation

SMURF efforts are expanding under the direction of Dr. Kirsten Grorud-Colvert (OSU). In 2014, SMURF sampling was successfully pilot tested at the Redfish Rocks site. The collaboration of OSU/PISCO, ODFW and the Oregon Coast Aquarium to build, deploy and bi-monthly sample the SMURFs will ideally continue into the future at both Otter Rock and Redfish Rocks, facilitating a comparison of fish recruitment in Northern versus Southern Oregon. Dr. Grorud-Colvert is leading the effort to secure grant funds to support annual SMURF monitoring in both locations.

We are just beginning to understand the habitats that are important for nearshore fish species across their life stages and how connectivity between nearshore and estuarine habitats is facilitated via species' life cycles. Through results-sharing of SMURF data with colleague, Dr. Scott Heppell at Oregon State University's Department of Fish and Wildlife, our goal is to identify whether the same or different species settle among our two nearshore sites and six Oregon coast estuaries. Together, these data can further identify the importance of both nearshore and estuarine areas for conservation and management. In keeping with the goals of Oregon's marine reserves, continued SMURF sampling will provide key information about nearshore fish recruitment and determine whether the marine reserves are providing refuges for fishes during this key life stage.

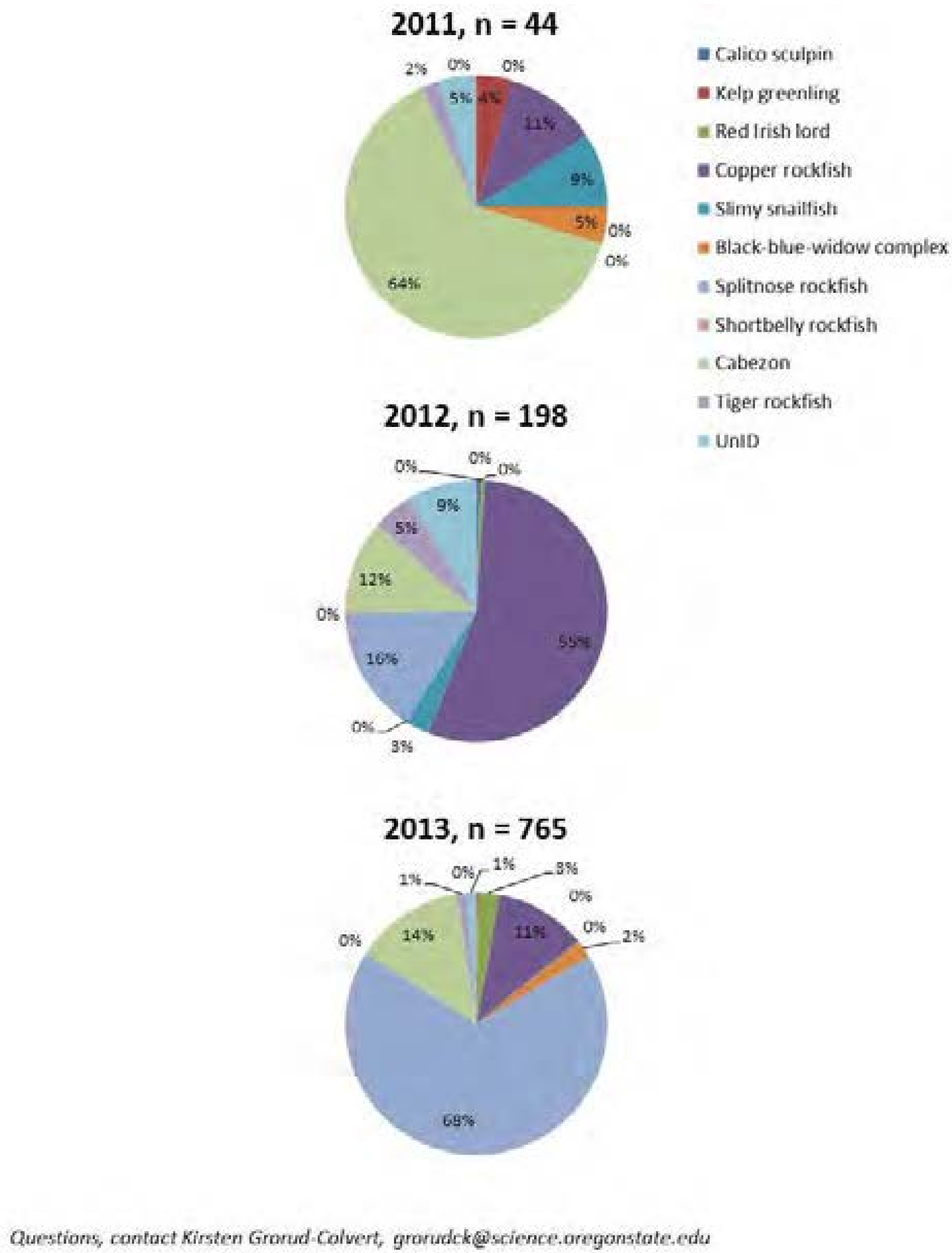


Figure 46. Fish species composition from SMURF sampling at Otter Rock sites from 2011-2013. Total number of fishes sampled per year (n) are shown.

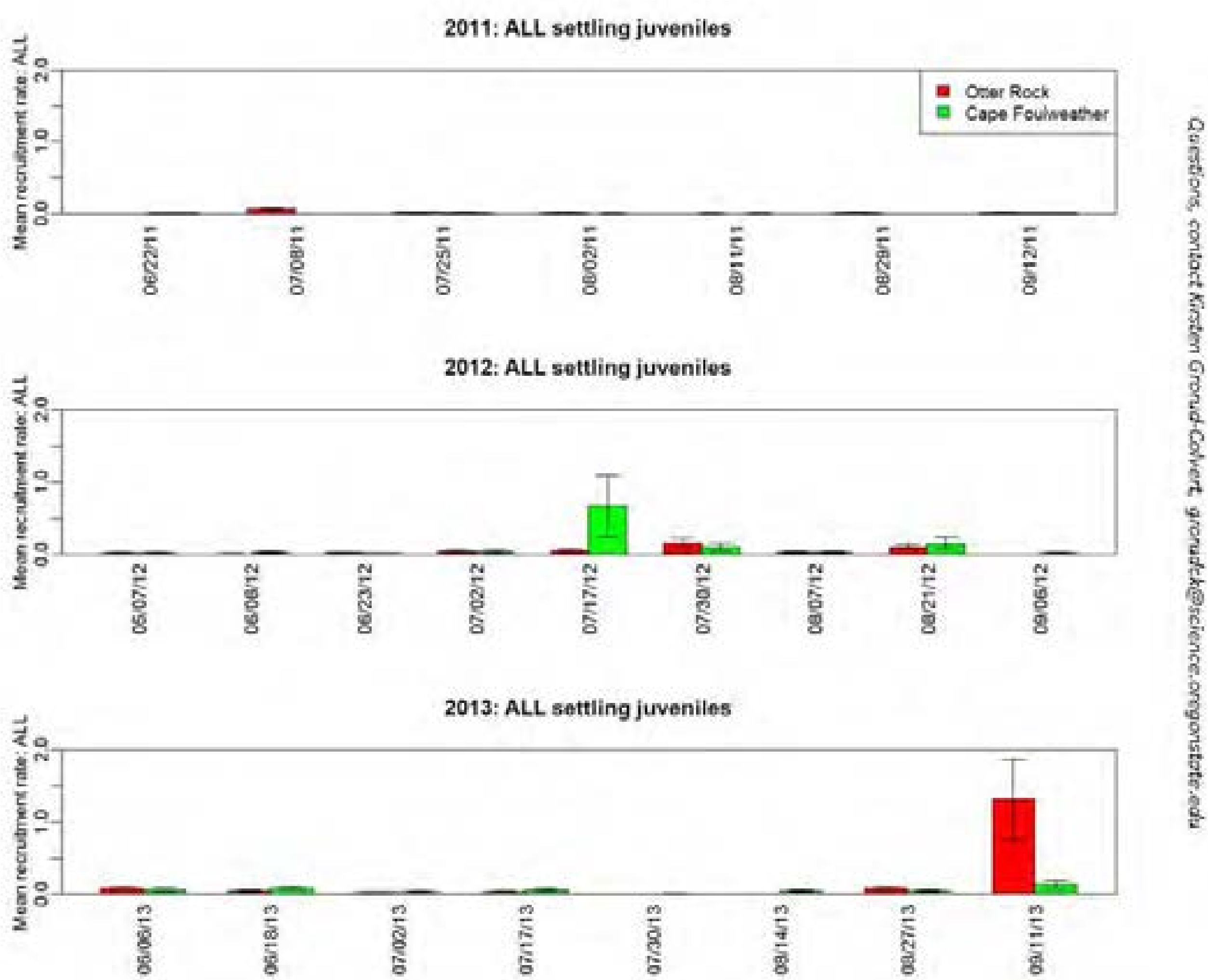


Figure 47. Recruitment rate of juvenile fish to SMURFs in 2011, 2012, and 2013. Mean recruitment rates ± SE for Otter Rock MR (red) and Cape Foulweather CA (green) are shown across the sampling season from May through September.

II. HOOK AND LINE

Here we present a summary analysis of our hook and line surveys conducted in 2013 at Cascade Head, Cape Perpetua, and Redfish Rocks sites. A total of 660 fish, representing 15 species, were landed and released in Redfish Rocks in 2012 (Table 29). A total of 3,054 fish, representing 27 different species, were landed and released during the 2013 hook and line surveys. Black Rockfish comprised the greatest proportion of the catch among all three sites (Figure 48). The greatest diversity of fishes was landed in Cape Perpetua while the most fishes landed were in Redfish Rocks.

Table 29. Number of fish landed in 2012 at (A) Redfish Rocks MR and (B) Humbug CA from each depth bin.

A) Redfish Rocks MR	←18.5m	18.6-24.5m	24.6-30.5m	30.6+m	Total
Black Rockfish	33	46	53	63	**195**
Black-and-Yellow Rockfish	1				**1**
Blotched Blue Rockfish	1	2			**3**
Blue Rockfish	1	11	13	15	**40**
Cabezon	3				**3**
Canary Rockfish	1		3	6	**10**
China Rockfish	4		1		**5**
Copper Rockfish	1				**1**
Grass Rockfish	1				**1**
Kelp Greenling	15	3	1		**19**
Lingcod	17	6	10	8	**41**
Quillback Rockfish			2	5	**7**
Vermilion Rockfish			2	1	**3**
Yelloweye Rockfish				2	**2**
Yellowtail Rockfish			1	8	**9**
Grand Total	71	68	86	108	**340**

B) Humbug CA	←18.5m	18.6-24.5m	24.6-30.5m	30.6+m	Total
Black Rockfish	56	36	61	50	**202**
Blue Rockfish	1		4	2	**7**
Buffalo Sculpin		1			**1**
Cabezon	2				**2**
Canary Rockfish			3	5	**8**
China Rockfish	2	1			**3**
Kelp Greenling	17	2	2		**21**
Lingcod	37	16	6	5	**64**
Quillback Rockfish			1	2	**3**
Red Irish Lord	1		1		**2**
Vermilion Rockfish	1		1	1	**3**

Yellowtail Rockfish			1	1	**2**
Unidentified Sculpin			1		**1**
Grand Total	117	56	81	66	**319**

Table 30

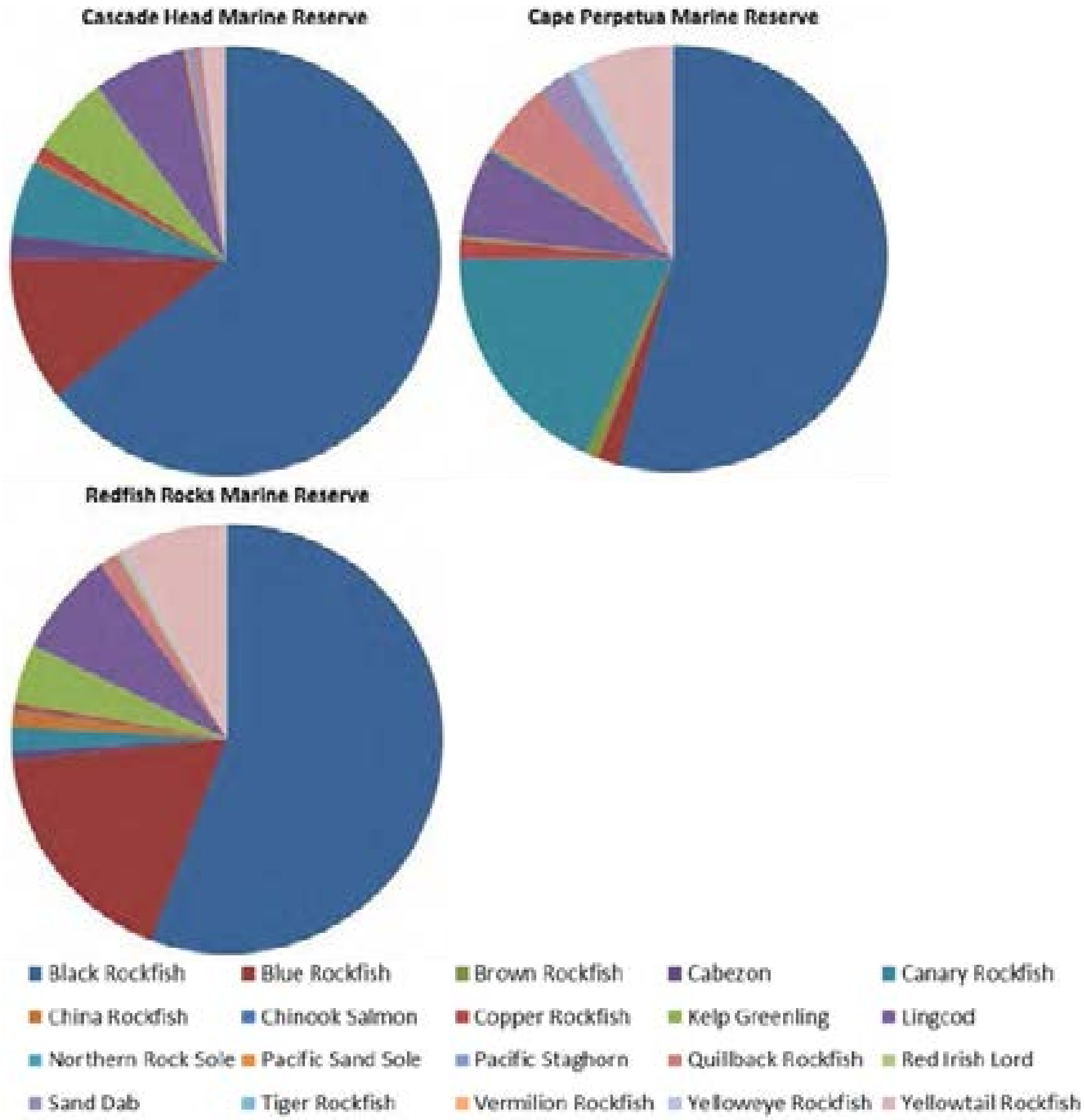


Figure 48. Proportion of fish species landed by site (pooled among the reserve and comparison areas) during 2013 hook and line surveys.

Table 29. Number of fish landed in 2012 at (A) Redfish Rocks MR and (B) Humbug CA from each depth bin.

A) Redfish Rocks MR	**←18.5m**	**18.6-24.5m**	**24.6-30.5m**	**30.6+m**	**Total**
Black Rockfish	33	46	53	63	**195**
Black-and-Yellow Rockfish	1				**1**
Blotched Blue Rockfish	1	2			**3**
Blue Rockfish	1	11	13	15	**40**
Cabezon	3				**3**
Canary Rockfish	1		3	6	**10**
China Rockfish	4		1		**5**
Copper Rockfish	1				**1**
Grass Rockfish	1				**1**
Kelp Greenling	15	3	1		**19**
Lingcod	17	6	10	8	**41**
Quillback Rockfish			2	5	**7**
Vermilion Rockfish			2	1	**3**
Yelloweye Rockfish				2	**2**
Yellowtail Rockfish			1	8	**9**
Grand Total	71	68	86	108	**340**

B) Humbug CA	**←18.5m**	**18.6-24.5m**	**24.6-30.5m**	**30.6+m**	**Total**
Black Rockfish	56	36	61	50	**202**
Blue Rockfish	1		4	2	**7**
Buffalo Sculpin		1			**1**
Cabezon	2				**2**
Canary Rockfish			3	5	**8**
China Rockfish	2	1			**3**
Kelp Greenling	17	2	2		**21**
Lingcod	37	16	6	5	**64**
Quillback Rockfish			1	2	**3**
Red Irish Lord	1		1		**2**
Vermilion Rockfish	1		1	1	**3**
Yellowtail Rockfish			1	1	**2**
Unidentified Sculpin			1		**1**
Grand Total	117	56	81	66	**319**

Table 30. Angler effort summary including number of fish landed and fish richness for the three marine reserve sites (pooled among the reserve and comparison areas) sampled in 2013.

Site	Angler Hrs	# of Volunteers	Survey Days	Fish landed (N)	Species Richness
Redfish Rocks	154.03	24	8	1197	17
Cape Perpetua	122.74	30	10	1092	21
Cascade Head	107.03	30	8	723	18
Total	**384**	**75**	**26**	**3012**	**26**

Mean fish lengths by species are show in Table 31, while sample sizes are provided in Table 32. As baseline sampling is still underway at these sites, no comparisons of CPUE or fish lengths between the reserve and comparison areas were performed. Rather, Hook and Line data will be analyzed in combination with 2014 sampling to explore what confounding factors are influencing our response variables of CPUE and fish length.

Table 31. Summary of fork length (cm) for 2013. Mean ± SE provided per species. Cells with only one number symbolize the only fish caught of that species. Blanks indicate that none of those species were caught at that location during the 2013 survey.

	Cape Perpetua		**Cascade Head**		**Redfish Rocks**	
Species	**MR**	**Postage Stamp CA**	**MR**	**Schooner Creek CA**	**MR**	**Humbug CA**
Black Rockfish	40.03 (0.36)	38.33 (0.2)	40.49 (0.27)	41.23 (0.57)	40.94 (0.15)	39.13 (0.37)
Blotched Blue Rockfish		26.45 (1.55)	31.46 (1.94)	31.47 (0.64)	36.5 (1.5)	27.25 (3.59)
Blue Rockfish	33.71 (1.29)	25.75 (2.29)	33.55 (0.85)	34 (0.47)	31.9 (0.44)	27.68 (1.14)
Brown Irish Lord		15				
Brown Rockfish	39.25 (2.95)					
Buffalo Sculpin		27 (3.51)				34.25 (1.65)
Cabezon		48.5 (9.5)	54.21 (1.83)	53.2 (3.09)	47.2 (3.61)	46.83 (3.22)
Canary Rockfish	31.05 (0.45)	34.5 (1.5)	36.3 (1.34)	30.4 (0.78)	35.71 (1.69)	33.76 (1.07)
China Rockfish			37		34.39 (0.42)	35.5 (1.5)
Chinook Salmon				74	88	
Coho Salmon		74.25 (0.75)				
Copper Rockfish	41.17 (3.61)		45.75 (1.8)		42 (3.06)	
Kelp Greenling	32	35	34.52 (0.64)	34.75 (1.05)	34.71 (0.43)	34.74 (0.3)
Lingcod	63.18 (3.46)	59.25 (3.34)	55.07 (1.91)	54.97 (2.49)	62.08 (1.67)	58.65 (1.36)
Northern Rock Sole	36					
Pacific Sand Sole	29		37	22		
Pacific Sanddab	21.7 (1.33)	26				
Pacific Staghorn		21	16.0 (3.0)			
Quillback Rockfish	33.96 (1.19)		40.0 (1.0)	39.5 (2.5)	37.45 (1.83)	38.31 (1.42)
Red Irish Lord					35	36

Spotted Ratfish		46				
Tiger Rockfish	41			40.5 (1.71)	43	
UNID Sculpin						3
Vermilion Rockfish				58.5	46.5 (2.5)	53
Widow Rockfish				26		
Yelloweye Rockfish	44.17 (5.36)		35	46.25 (1.95)	54 (4.73)	44.67 (3.84)
Yellowtail Rockfish	30.78 (0.77)	30.23 (0.89)	32.08 (1.95)	26.9 (1.12)	31.5 (0.54)	29.67 (1.08)

Table 32. Sample sizes of each species landed by area in 2013. PS = Postage Stamp; SC = Schooner Creek; H = Humbug.

	Cape Perpetua		**Cascade Head**		**Redfish Rocks**	
Species	MR	PS CA	MR	SC CA	MR	H CA
Black Rockfish	227	602	249	63	416	231
Blotched Blue Rockfish	0	11	13	55	2	4
Blue Rockfish	7	4	29	92	131	34
Brown Irish Lord	0	1	0	0	0	0
Brown Rockfish	4	0	0	0	0	0
Buffalo Sculpin	0	3	0	0	0	4
Cabezon	0	2	7	5	5	6
Canary Rockfish	76	2	22	49	14	25
China Rockfish	0	0	1	0	9	2
Chinook Salmon	0	0	1	0	1	0
Coho Salmon	0	2	0	0	0	0
Copper Rockfish	6	0	4	0	3	0
Kelp Greenling	1	1	23	8	34	49
Lingcod	28	10	28	29	59	59
Northern Rock Sole	1	0	0	0	0	0
Pacific Sand Sole	1	0	1	1	0	0
Pacific Sanddab	10	1	0	0	0	0
Pacific Staghorn	0	1	2	0	0	0
Quillback Rockfish	23	0	2	2	11	13
Red Irish Lord	0	0	0	0	1	1
Spotted Ratfish	0	1	0	0	0	0
Tiger Rockfish	1	0	0	4	1	0
UNID Sculpin	0	0	0	0	0	1
Vermilion Rockfish	0	0	0	1	2	1
Widow Rockfish	0	0	0	1	0	0
Yelloweye Rockfish	6	0	1	8	3	3
Yellowtail Rockfish	27	33	6	15	57	15

Learning and Adaptation

Hook and line sampling in 2013 reflected a significant departure from the study design employed in 2011 and 2012. Most importantly, grid cells were implemented as our sampling unit, in which replicate drifts will be pooled for future analyses. At the grid scale, aspects of habitat type and depth can be determined. We also restricted sampling to the fall and spring months only as sampling through the summer led to a marked different in fish community composition (see monitoring report results from 2010-11). By reducing within-year variance in temporal sampling, we aim to increase our ability to detect temporal change in the fish community over yearly or decadal time scales. Additionally, oceanographic parameters were collected beginning in 2013 to explore influences of water temperature and light on CPUE.

As 2013 represented the first hook and line surveys for Cape Perpetua and Cascade Head, baseline data collection is considered ongoing to allow for increased data collection. Likewise, method refinement is ongoing. The 2013 data will be used in conjunction with 2014 to explore how sampling month, grid cell, season, angler number etc., may serve as confounding factors influencing our response variables. Results from this analysis (2013-2014 Method Refinement for Hook and Line Sampling) are available in a separate report.

III. BENTHIC EXTRACTION

Here we present a summary analysis of the macroalgal and sponge communities, from our benthic extraction surveys conducted for the Cascade Head site in 2013.

Macroalgal Community

At the Cascade Head site, 62 different species of macroalgae were identified and weighed by Dr. Gayle Hansen. A species list of which alga was found in the reserve and the comparison area can be found in Appendix A. Species-accumulation curves predicting species richness through Chao2 and Jacknife extrapolation permutations indicate that we are likely under-sampling the total macroalgal diversity of these regions (Colwell and Coddington 1994). As the estimated species counts exceed the observed species counts, we likely undersampled the algal biodiversity in the region. However, budgetary constraints limit increased sampling at this time.

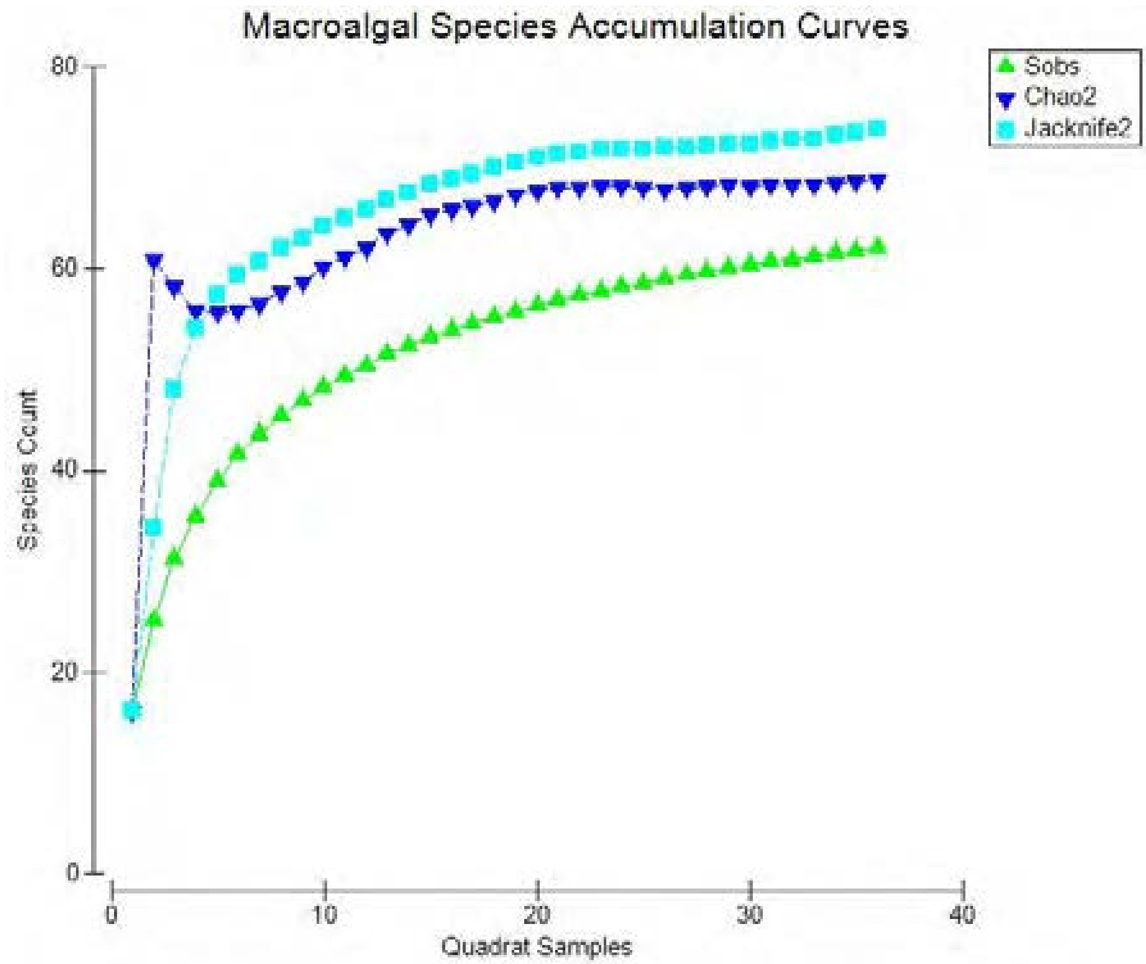


Figure 49. Species accumulation curves for the actual observed macroalgal species (green) and two estimates of biodiversity, Chao2 (blue) and Jacknife 2 (aqua).

Slight differences exist in the community composition of macroalgae between the reserve and the Cavalier comparison area (CA) (ANOSIM, Global R = 0.24, P = 0.004, based on Bray-Curtis similarity on 4th root transformed macroalgal biomass). At the transect-scale, 33% similarity is shared among both the reserve and comparison area (Figure 50). Three species accounted for 20% of the dissimilarity in community composition at the transect scale between the reserve and the comparison area, *Laminaria longipes, Pleurophycus gardneri*, and *Fryeella gardneri,* in part because these are species with larger thalli who drive the biomass patterns.

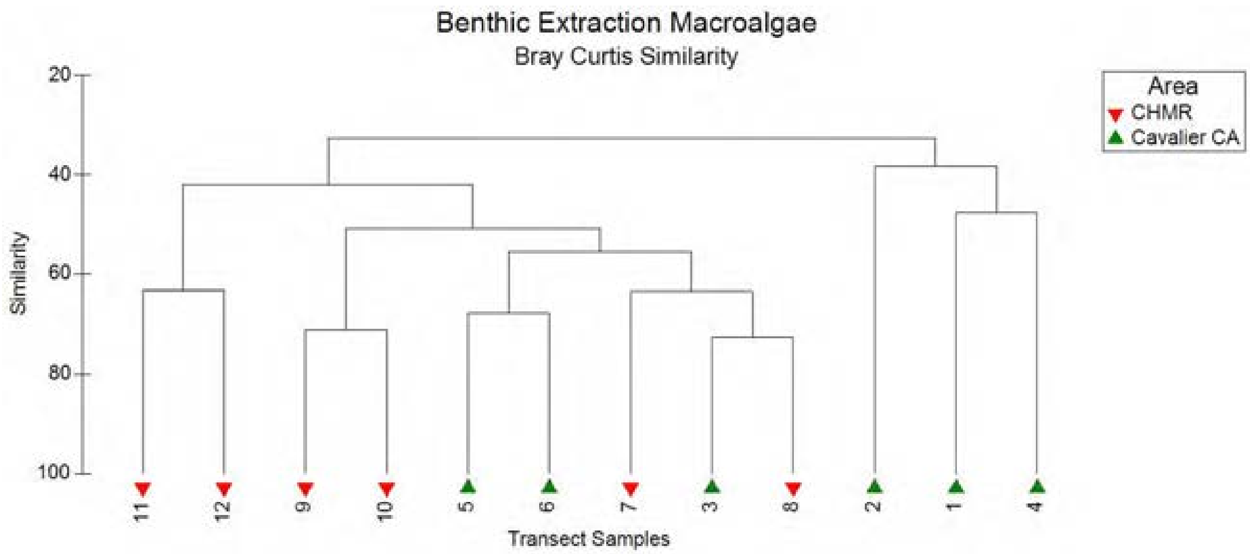


Figure 50. Cluster diagram of Bray-Curtis similarity of macroalgal community composition (biomass) among transects sampled inside the Cascade Head Marine Reserve (red) and the Cavalier Comparison Area (green). Biomass of macroalgal species were averaged across three replicated quadrats per transect to generate mean community composition at the transect scale.

Rhodymenia californica & pacifica, Cryptopleura farlowiana, Callophyllis flabellulata, and two kelp species, *Pleurophycus gardneri* and *Laminaria longipes* were the macroalgal species with greatest abundance amongst all samples pooled between the marine reserve and comparison area (Table 33). However, the biomass of these five species did not differ significantly between the reserve and the comparison area reflecting high variance in biomass at the transect scale, not the area scale.

Table 33. Abundance (g/m^2) ± SE for the five most dominant algal taxa sampled at the Cascade Head Marine Reserve and comparison area.

Macroalgal Species	Cascade Head MR	Cavalier CA
Callophyllis flabellulata	5.156(1.73)	7.174 (2.86)
Cryptopleura farlowiana	0.725 (0.55)	9.434 (6.54)
Laminaria longipes	130.361 (66.68)	0.422 (0.42)
Pleurophycus gardneri	10.909 (8.31)	9.301 (9.30)
Rhodymenia californica & pacifica	4.389 (1.74)	5.093 (2.73)

The Cascade Head Marine Reserve (MR) supports over 3x the total biomass of macroalgae (mean = 166.1 g/m^2 ± 63.4 SE) present in the Cavalier CA (mean = 49.7 g/m^2 ± 21.8 SE). This difference was not significant (T-test, t ratio= 2.09, df = 8.85, P = 0.067; Figure 51). Data analysis is based on log(biomass) at the transect scale (three replicate quadrats averaged per transect). It should be noted that contamination by bryozoans and hydroids did occur on some species biasing the data.

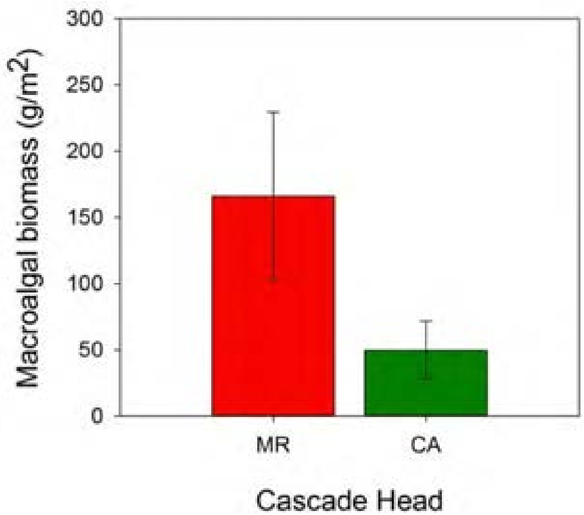


Figure 51. Mean macroalgal biomass (g/m^2) in the Cascade Head MR (red) and the Cavalier CA (green).

The species richness of the macroalgal community did not differ between the Cascade Head MR (mean = 16.0 species/m^2 ± 2.0 SE) and the Cavalier CA (mean = 16.2 species/m^2 ± 3.2 SE; T-test, t ratio= -0.07 3, df = 27.1, P = 0.95; Figure 52). Data analysis based on mean species richness per transect.

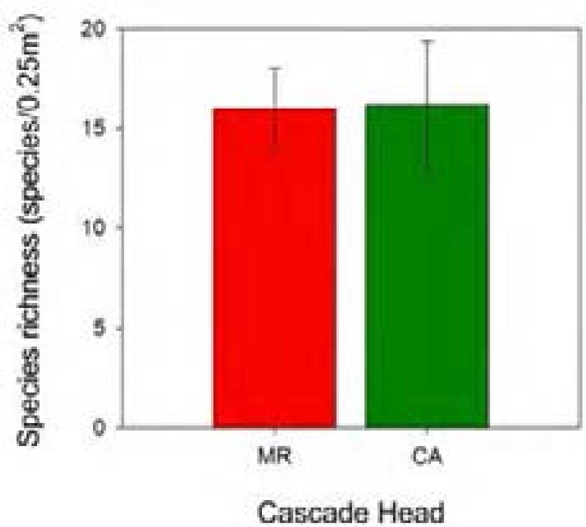


Figure 52. Mean species in the Cascade Head MR (red) and the Cavalier CA (green).

While macroalgal species richness and total biomass did not differ significantly between Cascade Head MR and the Cavalier CA, pooled macroalgae biomass was nearly three times greater in the reserve largely due to the greater abundance of the kelp *Laminaria longipes* in the marine reserve compared to the comparison area. This could reflect a sampling artifact reflecting our small samples sizes.

Sponge Community

The community composition of sponge families did not differ between Cascade Head MR and Cavalier CA (Figure 19; ANOSIM, Global R = 0.111, P = 0.165, based on Bray-Curtis similarity on 4^{th} root transformed transect-scale sponge volume). However, transects shared only 7% similarity among all samples indicating that between transect differences in the sponge community, regardless of the sampling area, were high.

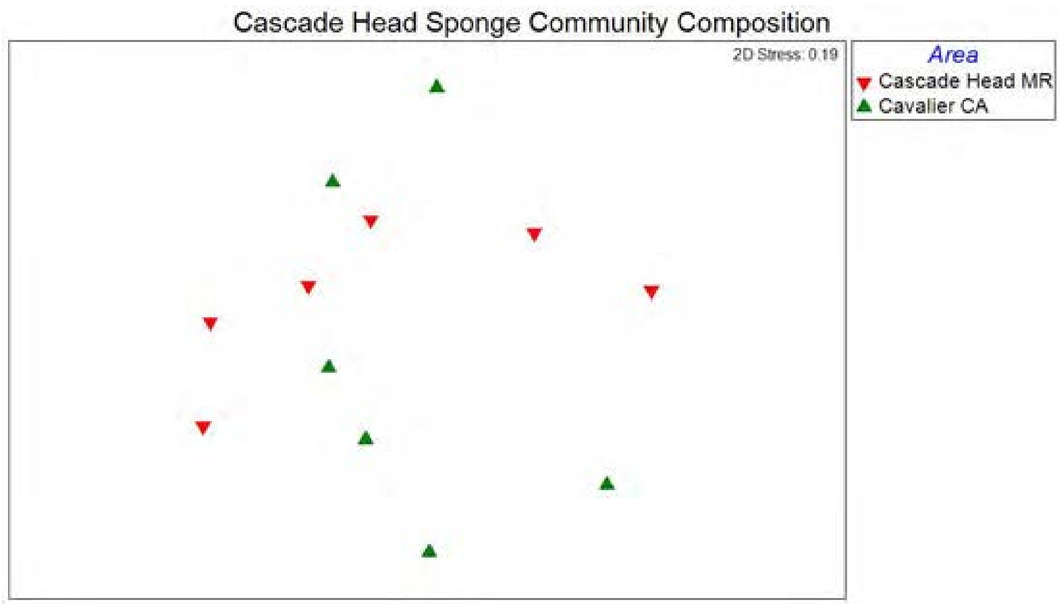


Figure 53. nMDS plot of the community composition of sponges found in the Cascade Head MR (red) and Cavalier CA (green). Data represented are replicate transects (n=6) samples within each area. No clear grouping by area was found.

Genus-specific differences in relative abundance between Cascade Head MR and Cavalier CA were analyzed. Eleven sponge genera were found to be the most dominant sampled (comprising →1% of the total sponge biomass collected) and constitute 99.7% of the marine reserve biomass and 96.7% of the comparison area biomass.

The biomass of each sponge genus averaged across sampled transects are found in the table below (Table 34).

Table 34. Mean biomass of each sponge genus sampled during benthic extraction in 2013at Cascade Head. Data reflects mean values from replicate transects (quadrats were averaged per transect).

Genus	Cascade Head MR	Cavalier CA
Acarnus	0.000	8.278
Antho	0.176	0.780
Clathria	73.539	15.772
Clathrina	0.000	0.002
Cliona	0.042	0.032
Craniella	0.000	19.600
Dragmacidon	0.000	0.002
Forcepia	0.006	0.000
Halichondria	0.004	0.006
Haliclona	0.011	5.414
Hamacantha	0.000	0.002
Hymedesmia	0.008	1.947
Hymeniacidon	0.026	0.001
Isodictya	84.548	4.926
Leucandria	0.000	0.005
Leucosolenia	0.000	0.004
Lissodendoryx	0.004	13.278
Mycale	0.217	23.472
Myxilla	0.006	1.188
Neopetrosia	0.015	0.052
Niphates	0.012	0.019
Plocamionida	0.000	0.112
Polymastia	0.015	4.692
Suberites	0.005	0.006
Sycon	0.000	0.003
Tedania	0.187	0.530
Tellida	0.000	10.139
Xestospongia	9.563	30.441

While sponges from the genus Isodictya and Clathria were the clear dominants found in the marine reserve, Xestospongia and Mycale were the most common genus found in the comparison area (Figure 54).

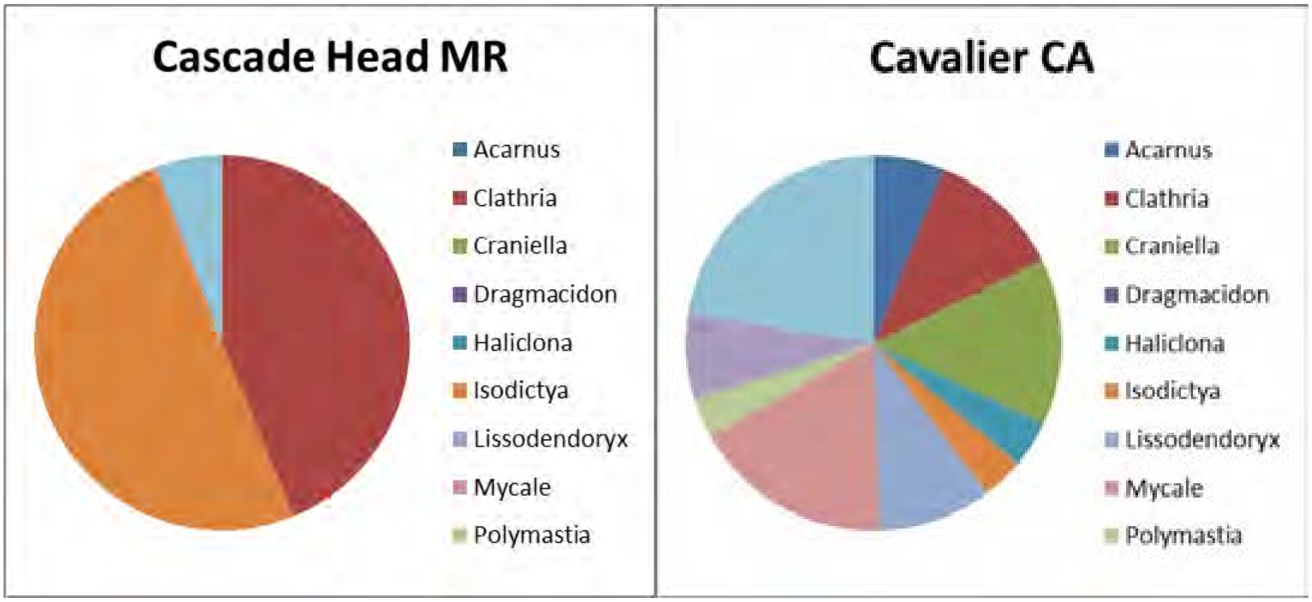


Figure 54. For the nine (9) dominant sponge genera, proportions of the total biomass in each sampling area are shown.

The total volume of sponges did not differ between Cascade Head MR (mean = 168.4 cm^3/m^2 ± 74.3 cm^3/m^2 SE) and Cavalier CA (mean = 140.7 cm^3/m^2 ± 54.1 cm^3/m^2 SE; T-test, t ratio= -0.30, df = 9.14, P = 0.77). Data based on replicate transect means.

Although greater average diversity of sponge genera were presented in Cavalier CA (mean = 10.17 species/m^2 ± 2.15 species/m^2 SE), this difference was not significantly different to the diversity found in Cascade Head MR (mean = 5.67 species/m^2 ± 1.09 species/m^2 SE; T-test, t ratio= 1.87, df = 7.39, P = 0.10). Data based on replicate transect means.

Learning and Adaptation

As we move forward with our monitoring efforts, no additional benthic surveys are planned for other marine reserve sites (i.e. Cape Perpetua and Cape Falcon). The needed sample sizes to conduct an exhaustive species-specific biodiversity survey of the subtidal are cost prohibitive for sampling. However, the three completed biodiversity surveys to date in the marine reserves may serve as a unique dataset of macroalgal and sponge diversity in subtidal Oregon waters.

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