DRAFT

Ecological Monitoring Synthesis Report

March 2018

This draft has been created for the Scientific and Technical Advisory Committee (STAC) for feedback on developing monitoring syntheses reports

Introduction

With marine reserves being a new management tool here in Oregon, the Oregon Legislature has called for an evaluation of the Oregon Marine Reserves Program and a report to the Legislature due on March 1, 2023. This evaluation will reflect upon all aspects of the Program including the management, scientific monitoring, outreach, community engagement, compliance, enforcement, and funding for the five marine reserve sites. It also marks a point where the state will consider if and how marine reserves will continue to be used as a nearshore resource management tool moving into the future.

Evaluation of the Oregon Marine Reserves Program will begin in the year 2022, and will be led by an Oregon public university selected by the Scientific and Technical Advisory Committee (STAC). The Oregon Department of Fish and Wildlife's (ODFW's) Marine Reserves Program is being tasked with writing a synthesis report, that covers all aspects of the program, in the year 2021 that will be submitted to the university for the evaluation.

Purpose of This Monitoring Report

This current monitoring report is an attempt to summarize the ecological monitoring efforts of the Marine Reserves Program since data collection began in 2010, with an eye towards what may be included as a part of the synthesis report to be generated for the 2023 evaluation. As such the purpose of this report is four-fold:

1. To define several concepts as they relate to Oregon's Marine Reserves including biodiversity, community structure, species-habitat correlations and change over time, and put forth a suggested list of focal species
2. To provide a summary of data collection efforts and analyses by reserve in relation to the Marine Reserves six core ecological research questions.
3. To provide some Programmatic analyses that describe key trade-offs made in ecological monitoring decisions and demonstrate value gained for money and staff resources used to date pertaining to marine reserves ecological monitoring.
4. To generate discussions that will help identify essential components that should be included in the 2021 synthesis report and any critical programmatic gaps that the ODFW Marine Reserves Program can look to address prior to the evaluation.

Development of this report was also a way for ODFW to begin to assess what might realistically be able to be produced for an ecological monitoring synthesis in 2021 with existing staff levels, resources, and expertise.

How to Use This Report

This report is laid out in six sections.

Section 1. **Background.** An overview of Oregon's marine reserve sites, the ODFW Marine Reserves Program, the Oregon's marine reserve goals and objectives, our six ecological research questions, and the tools we use to collect data.

Section 2. **Monitoring Approach**. An overview of our monitoring approach, including the definition of key concepts and a draft list of focal species.

Section 3. **Learning and Adapting.** A summary of how our data collection as evolved over time as we have learned to adapt research tools and monitoring protocols conducive to working in the challenging nearshore marine environment in Oregon.

Section 4. **Available Data & Analyses.** A discussion of the data available for each research question and initial analyses conducted, each described at three different spatial scales.

Section 5. **Results.** A report out on the results for each research question, by reserve. Results are presented beginning with our oldest reserves (Redfish Rocks and Otter Rock) and moving through to our newest reserve (Cape Falcon).

Section 6. **Programmatic Analysis**. A discussion of the available staff and funding resources, trade-offs and innovations that have been made to meet the program's mandates within the limited program's resources, and the program's contributions to date related to ODFW's ecological monitoring efforts. The intent is to provide Oregonians with a means of gauging value gained for dollars spent during the development of this new long-term monitoring program.

SECTION 1. BACKGROUND

In 2012, Oregon completed the designation of five marine reserve sites (Figure A). All five reserves are located within state waters and are areas dedicated to conservation and scientific research. Each site includes a marine reserve where no extractive activities are allowed, with an exception provided for scientific research if it is deemed necessary for evaluating the reserves (OPAC 2008). Most of the sites also include one or more Marine Protected Area (MPA) adjacent to the reserve. The MPAs prohibit ocean development but allow for some fishing activities. The fishing prohibitions and allowances are specific to each MPA. These sites are managed as a system by the State of Oregon.

1.A Oregon's Five Sites

In Figures B – F we provide a brief overview of site characteristics for the Cape Falcon, Cascade Head, Otter Rock, Cape Perpetua, and Redfish Rocks marine reserve sites.

1.B The ODFW Marine Reserves Program

The Oregon Department of Fish and Wildlife (ODFW) is the lead agency responsible for overseeing the management and scientific monitoring of Oregon's marine reserves. The ODFW Marine Reserves Program was created in 2009 when the Oregon Legislature approved an austerity program that provides staff and funding to support marine reserves planning and implementation.

Currently there are six full-time, permanent staff that comprise ODFW's program of which three staff are dedicated to ecological monitoring efforts. Additional information on staff and funding resources for ecological monitoring are presented in Section 6.

1.C Mandates

Marine reserve mandates are the requirements, as well as guiding principles, to be carried out for the planning and implementation of Oregon's reserves. These mandates come from:

- **Statutes** - Passed by the Oregon Legislature
- **Agency Administrative Rules** - Adopted by state agency Commissions and Boards
- **Policy Recommendations** – Developed by the Ocean Policy Advisory Council (OPAC)

Included in the mandates are the goals and objectives for Oregon's marine reserves. They also require that ODFW develop monitoring plans and conduct ecological monitoring as part of marine reserves implementation.

Marine Reserve Goals
Marine reserves have been created around the world to achieve different outcomes. Here in Oregon, the marine reserves were created to accomplish the following goals (OPAC 2008):

> Protect and sustain a system of fewer than ten marine reserves in Oregon's Territorial Sea to conserve marine habitats and biodiversity; provide a framework for scientific research and effectiveness monitoring; and avoid significant adverse social and economic impacts on ocean users and coastal communities.

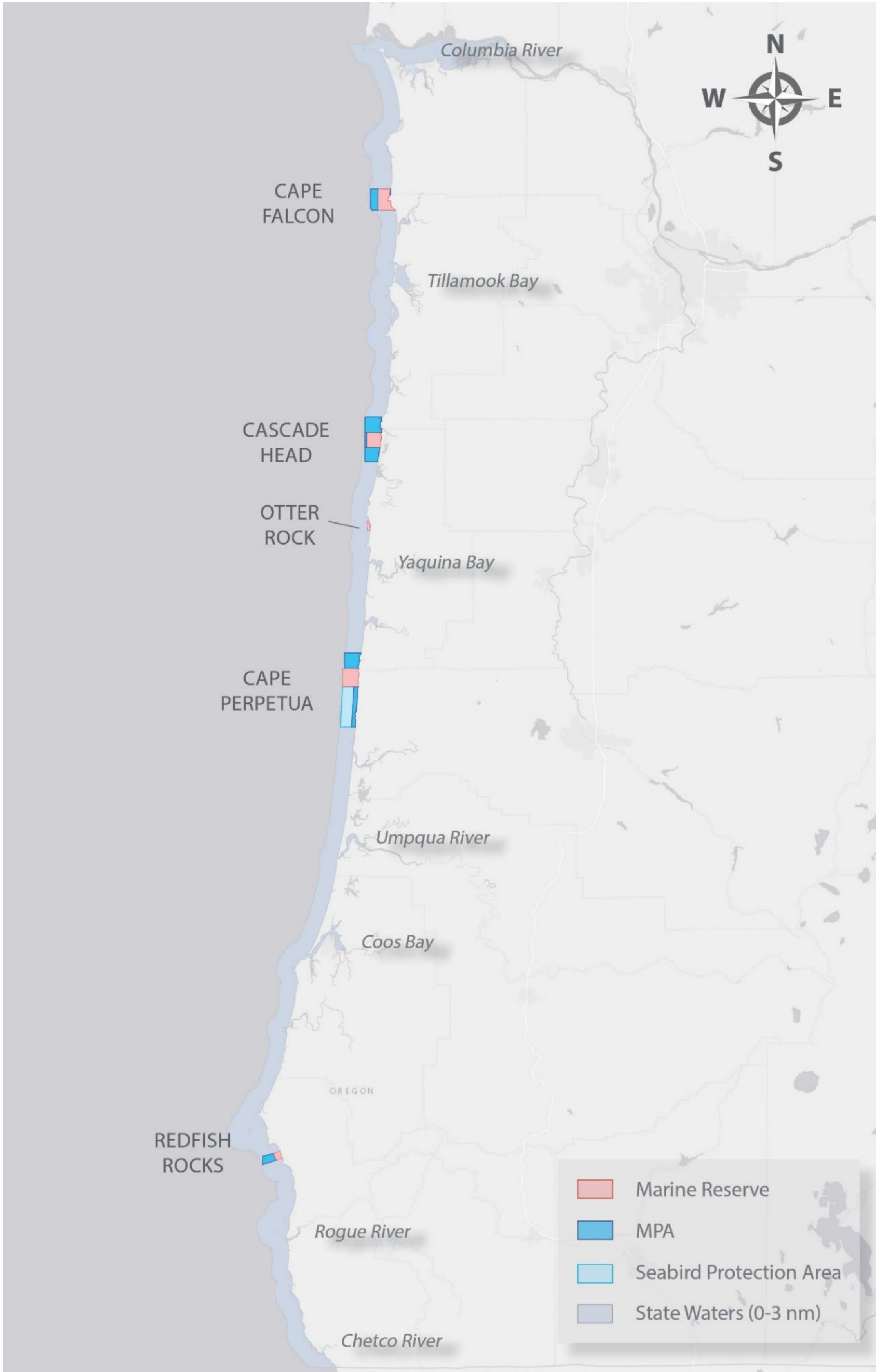


Figure A. Oregon's five marine reserve sites

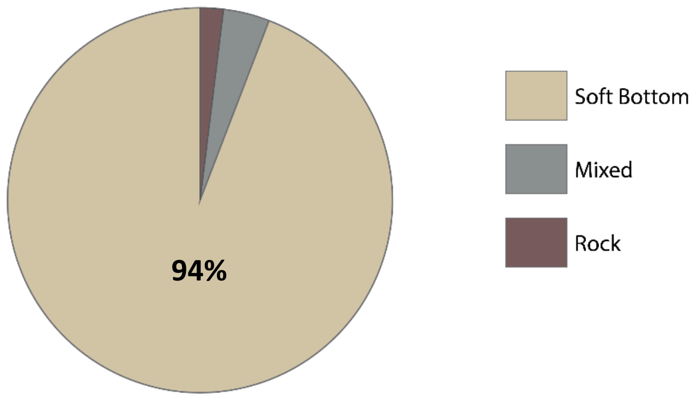
Figure B. Cape Falcon Marine Reserve

Site Characteristics

For marine reserve only

Monitoring Began	2014
Closure Date	2016
Size	Area: 32 km2 Alongshore: 7 km Offshore: 5 km
Depth Range	0 – 55 m
Habitat Connectivity	Small, isolated, low-relief rocky reef
Prior Fishing Pressure	Low groundfish effort Moderate crab effort Low shoreside effort (crab, groundfish, surfperch, intertidal harvest)

Habitats



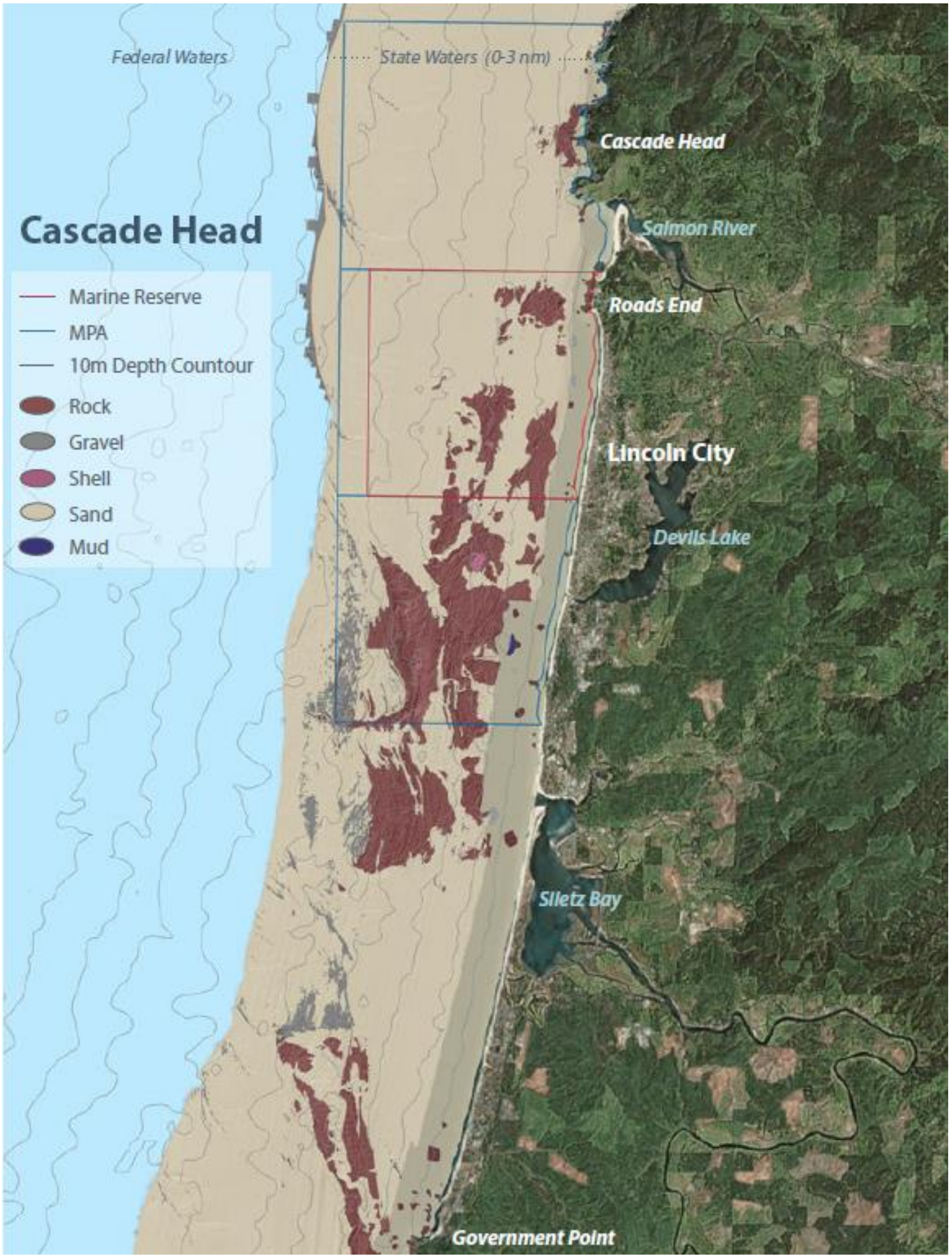


Figure C. Cascade Head Marine Reserve

Site Characteristics

For marine reserve only

Monitoring Began	2012
Closure Date	2014
Size	Area: 25 km2 Alongshore: 5 km Offshore: 5 km
Depth Range	0 – 50 m
Habitat Connectivity	Rocky reef habitat extends beyond the boundaries of the reserve
Prior Fishing Pressure	High groundfish effort Low crab effort Moderate salmon effort Moderate shoreside effort (crab, groundfish, surfperch, intertidal harvest)

Habitats

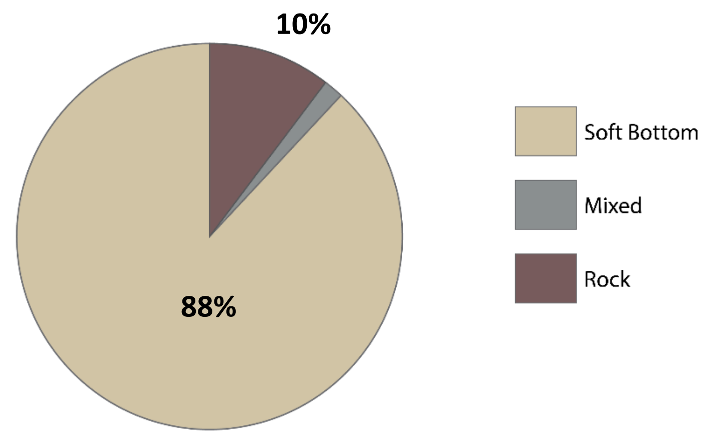


Figure D. Otter Rock Marine Reserve

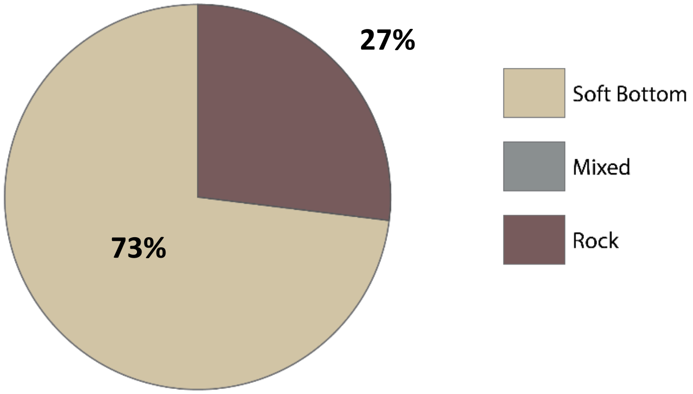
Site Characteristics

For marine reserve only

Monitoring Began	2010
Closure Date	2012
Size	Area: 3 km2 Alongshore: 3.5 km Offshore: 1.2 km
Depth Range	0 – 18 m
Habitat Connectivity	Rocky reef habitat extends beyond the boundaries of the reserve.
Prior Fishing Pressure	Low groundfish effort Low crab effort Moderate urchin effort Moderate shoreside effort (surfperch)

Habitats

Reserve includes kelp beds



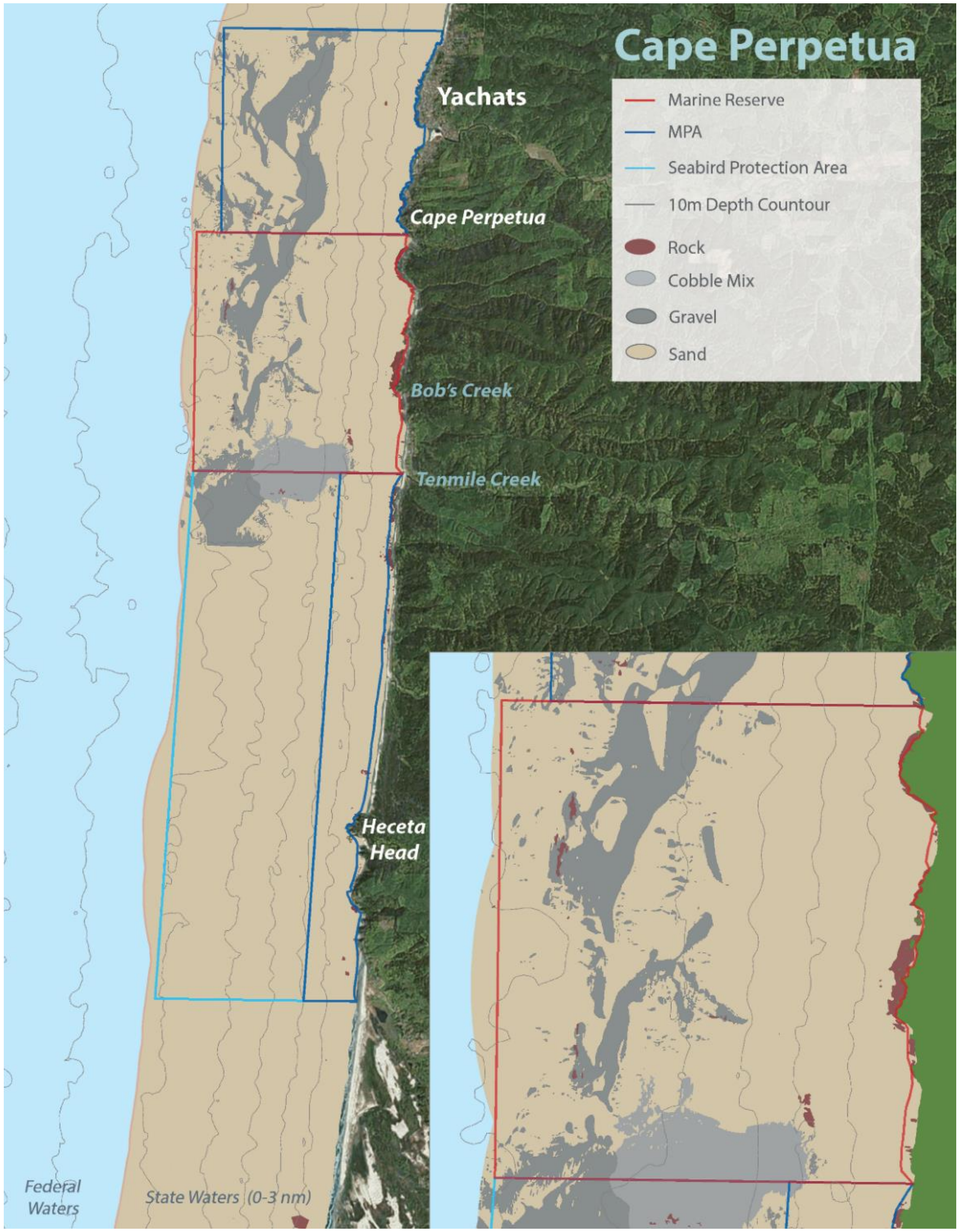


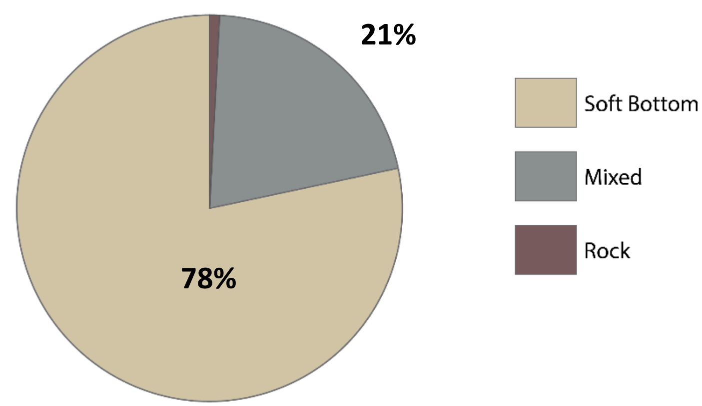
Figure E. Cape Perpetua Marine Reserve

Site Characteristics

For marine reserve only

Monitoring Began	2012
Closure Date	2014
Size	Area: 37 km2 Alongshore: 7 km Offshore: 6 km
Depth Range	0 – 55 m
Habitat Connectivity	Isolated rocky reef contained within the reserve boundaries
Prior Fishing Pressure	Low groundfish effort High crab effort High salmon effort Low halibut effort High shoreside effort (groundfish, surfperch, intertidal harvest)

Habitats



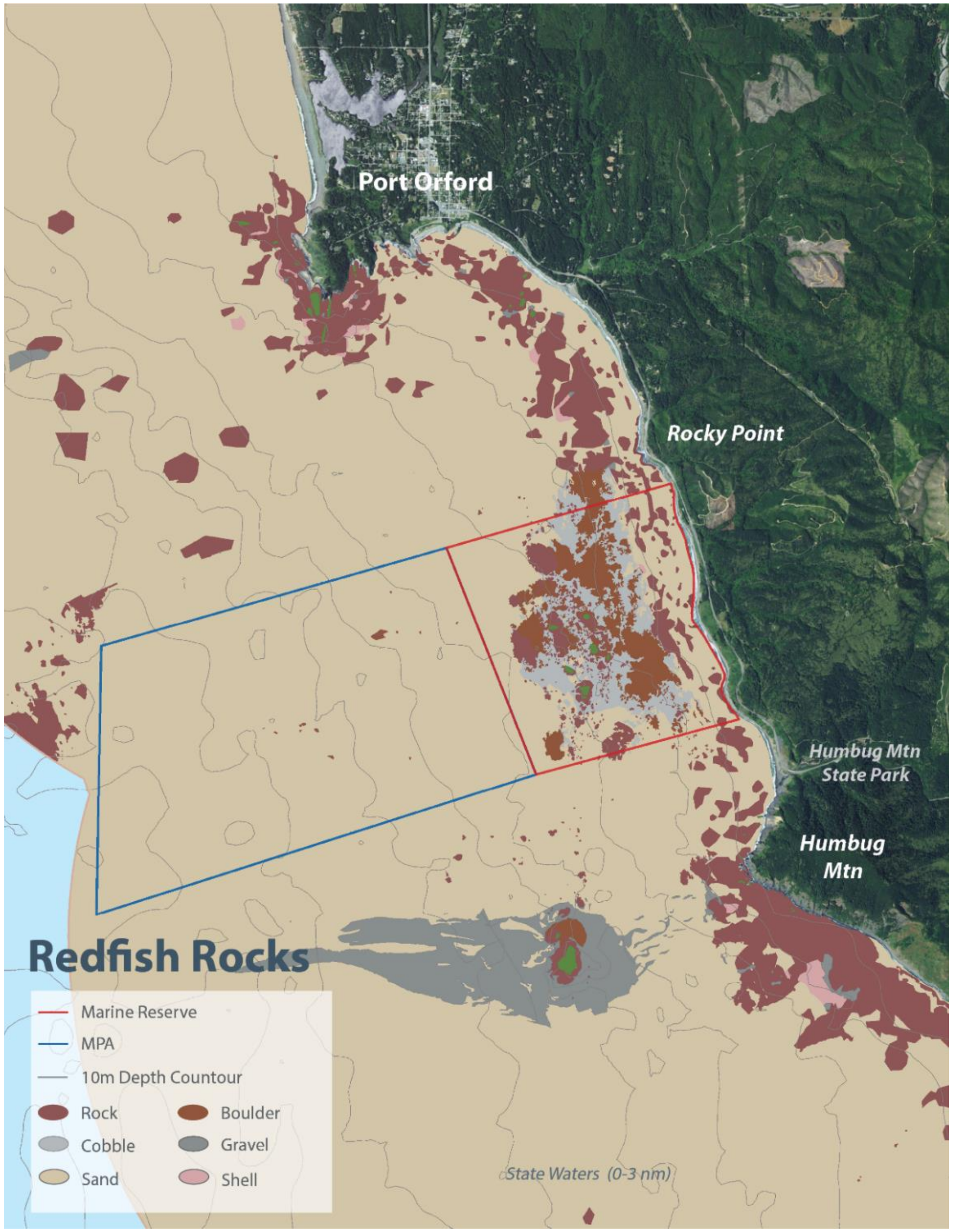


Figure F. Redfish Rocks Marine Reserve

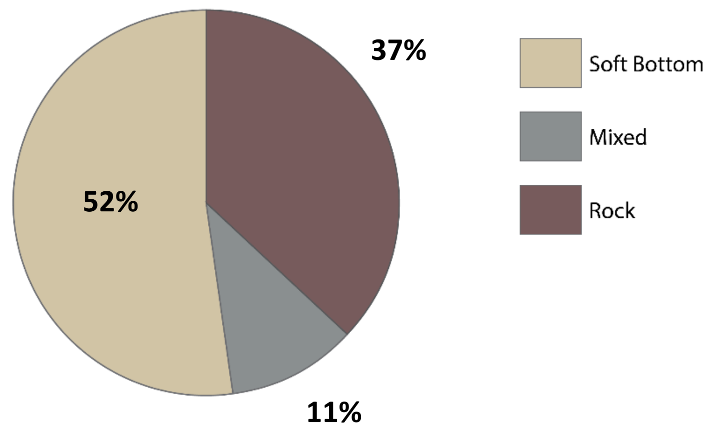
Site Characteristics

For marine reserve only

Monitoring Began	2010
Closure Date	2012
Size	Area: 7 km2 Alongshore: 2.8 km Offshore: 2.5 km
Depth Range	0 – 40 m
Habitat Connectivity	Rocky reef extends beyond the boundary of the reserve.
Prior Fishing Pressure	High groundfish effort Moderate crab effort High urchin effort Low abalone effort

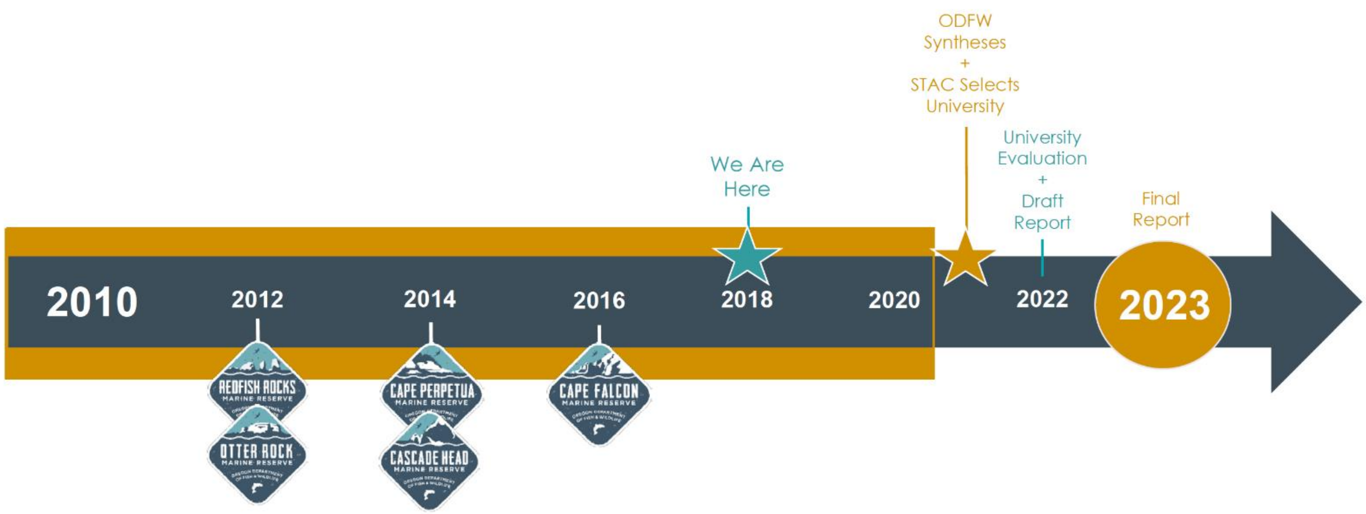
Habitats

Reserve includes kelp beds



A system is a collection of individual sites that are representative of marine habitats and that are ecologically significant when taken as a whole.

Program Evaluation in 2023
The Oregon Legislature has called for an evaluation of the Marine Reserves Program and a report submitted to the Legislature by March 1, 2023. With Oregon's temperate marine ecosystem, scientists project a minimum of 10-15 years after extractive activities (e.g., fishing) have ceased before we might begin to scientifically detect any ecological changes. However, this duration does provide time for constructive ecological research that helps inform marine reserves design and placement, and nearshore resource management, here in Oregon.



1.D Designation History

Marine reserve discussions began at the state level in the year 2000. Marine reserves planning began in March 2008, with Governor Kulongoski issuing [Executive Order 08-07] (EO 08-07) and a letter to OPAC. The Governor asked OPAC to lead a public nomination process, with assistance from state agencies, and to forward recommendations for up to nine sites to be considered for marine reserve designation. EO 08-07 also stated that recommended sites, individually or collectively, be "large enough to allow scientific evaluation of ecological benefits, but small enough to avoid significant economic or social impacts" and that priority consideration be given to nominations developed by groups representing a diversity of interests.

Phase 1 Planning (2008 - 2009)
In the summer of 2008, OPAC received 20 marine reserve site proposals from the public. After thorough deliberation, OPAC forwarded recommendations to the Governor in November 2008 including:

- Two sites be designated immediately as pilot marine reserve sites (Redfish Rocks and Otter Rock).
- Three sites undergo further evaluation and community dialogue as potential marine reserve sites (Cape Perpetua, Cascade Head, Cape Falcon).
- One area undergo a local community process, led by the International Port of Coos Bay, to consider developing a new marine reserve proposal (Cape Arago).

- The OPAC August 19, 2008 *Oregon Marine Reserves Policy Recommendations*.

In 2009, the Oregon Legislature passed House Bill 3013 (HB 3013) directing state agencies to implement the OPAC recommendations. The Legislature also approved funding and dedicated staffing for state agencies to carry out the evaluation and implementation of the two pilot marine reserve sites.

Phase 2 Planning (2010)
In 2010, as prescribed in HB 3013, ODFW formed three community teams that included representation from specified stakeholder interests. Each team met over the course of 11 months, evaluating the proposals recommended by OPAC for Cape Perpetua, Cascade Head, and Cape Falcon. The evaluation consisted of determining whether the site could meet sideboards established in Executive Order 08-07, namely: was the site was large enough to allow scientific evaluation of ecological benefits, but small enough to avoid significant economic or social impacts?

All three teams made changes to the original proposals recommended by OPAC. In November 2010, the teams forward final marine reserve recommendations to ODFW. In December 2010, ODFW used the community teams' recommendations to forge marine reserve recommendations in consultation with OPAC. Following discussion and careful deliberation, OPAC reached a consensus supporting ODFW's recommendations for marine reserve sites. ODFW then forwarded the OPAC approved recommendations to coastal State Legislators.

The community process, led by the International Port of Coos Bay, resulted in a recommendation of no marine reserve for the Cape Arago area. This recommendation was also forwarded by the Port to coastal State Legislators.

Designation and Implementation (2012 – 2016)
During the 2012 legislative session, the Oregon Legislature passed Senate Bill 1510 (SB 1510) directing state agencies to implement ODFW's recommendations for sites at Cape Perpetua, Cascade Head, and Cape Falcon. SB 1510 also provided that an evaluation and a report to the Legislature be provided on the Oregon Marine Reserves Program by March 1, 2023.

With the Oregon Legislature passing an austerity budget and staffing for marine reserves implementation, the harvest restrictions were decided to be phased in for the five marine reserve sites to allow ODFW staff to collected two years of baseline data at each site prior to closure.

	Monitoring Began	Harvest Restrictions Began
Redfish Rocks	2010	2012
Otter Rock	2010	2012
Cape Perpetua	2012	2014
Cascade Head	2012	2014
Cape Falcon	2014	2016

Worth Noting

Not a Network There was a conscious decision made by OPAC that marine reserves in Oregon are not intended to function as a scientific network. Instead the sites are to serve as a system, which they have defined as “a collection of individual sites that are representative of marine habitats and that are ecologically significant when taken as a whole” (OPAC 2008).

Size and Spacing Guidelines Were Advisory Size and spacing guidelines were used in the planning process as follows:

- In 2008, the Scientific and Technical Advisory Committee provided a *Size and Spacing of Marine Reserves Workshop Report* to OPAC. The report included guidelines for marine reserve size, spacing, and configuration based on the best available science and expert judgement to address questions posed by OPAC.
- The guidelines were used during the planning process “to help understand potential ecological benefits of marine reserve sites proposals, rather than dictate minimums or maximums” (OPAC 2008).
- Agency analyses conducted in 2008 and 2010 evaluated each recommended site on if, how, and where the site met the size and spacing guidelines. These analyses are available for reference.
- No single recommended site met all of the guidelines, and the five reserve sites collectively did not meet the guidelines for a scientific network.

1.E ODFW’s Ecological Monitoring

Oregon’s marine reserves are living laboratories where we are learning about Oregon’s nearshore ocean environment and the effects that protections — no fishing and no ocean development — have over time on species and habitats. To fulfill our mandate, we are conducting robust, long-term monitoring and novel research in these living laboratories to support nearshore ocean management and adaptive management of marine reserves.

Reserve Objectives
The marine reserves objectives that drive our ecological monitoring research questions and approach are (OPAC 2008):

- Protect areas within Oregon’s territorial sea that are important to the natural diversity and abundance of marine organisms, including areas of high biodiversity and special natural features.
- Protect key types of marine habitat in multiple locations along the coast to enhance resilience of nearshore ecosystems to natural and human-caused effects.
- Site fewer than ten marine reserves and design the system in ways that are compatible with the needs of ocean users and coastal communities. These marine reserves, individually or collectively, are to be large enough to allow scientific evaluation of ecological effects, but small enough to avoid significant adverse social and economic impacts on ocean users and coastal communities.
- Use the marine reserves as reference areas for conducting ongoing research and monitoring of reserve condition, effectiveness, and the effects of natural and human-induced stressors. Use the research and monitoring information in support of nearshore resource management and adaptive management of marine reserves.

Research Questions

There are six core ecological monitoring questions that drive how we focus and structure our monitoring efforts:

1. What is the oceanographic condition of each site? How does it change over time?
2. What habitats exist within each site? How do they change over time?
3. What algal, invertebrate, and fish species exist at each site?
4. What are the species-habitat correlations at each site? How do they change over time?
5. Does the prohibition of extractive activities change the community structure of the reserve?
6. Are patterns or changes within the marine reserve consistent throughout the marine reserve system?

Section 2. Monitoring Approach.

In Section 1 we posed the six ecological research questions we are trying to answer in our long-term monitoring program. In this section we provide an overview of our monitoring approach to address these six research questions. Our monitoring approach has been adapted over time and developed in consultation with the Scientific and Technical Advisory Committee (STAC) and other scientific experts. We also include in this section definitions of key concepts, such as biodiversity and community structure, and provide a draft list of focal species that we propose be species focused on in marine reserves reporting and analysis.

2.A. Monitoring Overview

ODFW's ecological monitoring of the reserves began in 2010. During the past seven years, ODFW and our partners have adapted sampling tools, study designs, and approaches to best establish a robust understanding of the marine communities found within Oregon's marine reserves and comparison areas (nearby monitoring sites open to fishing). Our data collected during this time led us to understand that each of the reserve sites is unique with different sizes, depth ranges, biological and habitat attributes, and each experiencing different types and levels of fishing pressure prior to closure. Based on these findings, and in consultation with scientific experts, we developed site specific monitoring plans for each reserve, tailored to each reserve's unique characteristics. These individual monitoring plans strive to use similar sampling methods where possible. The plans for each site can be found in ODFW's 2017 Ecological Monitoring Plan, and reflect the adaptive management ODFW is taking to implementing Oregon's marine reserves.

Section 6 of this report describes tradeoffs that have been made in our ecological monitoring based on marine reserve mandates and priorities, limited staff and funding resources, and staff capacity that have also shaped our monitoring approach.

2.B. Research Questions

As previously covered in Section 1, there are six ecological monitoring questions that drive how we focus and structure our monitoring efforts:

1. What is the oceanographic condition of each site? How does it change over time?
2. What habitats exist within each site? How do they change over time?
3. What algal, invertebrate, and fish species exist at each site?
4. What are the species-habitat correlations at each site? How do they change over time?
5. Does the prohibition of extractive activities change the community structure of the reserve?
6. Are patterns or changes within the marine reserve consistent throughout the marine reserve system?

2.C. Sampling Design

To address our six research questions our monitoring is designed to:

- Characterize the habitat, oceanographic condition, and species that exist at each site;
- Determine whether or not the marine reserve (prohibition of extractive activities) changes the environment over time;
- Determine which components of the environment are affected; and
- Estimate the magnitude of the effects.

This monitoring design requires that our sampling account for:

- Differences in space;
- Differences over time; and
- Differences between reserves and comparison areas, with concurrent sampling where possible.

To meet these criteria, our sampling design consists of comparing the marine reserve with comparison areas (nearby monitoring sites still open to fishing), within specified habitat and depth strata, and repeating these comparisons over time. Our program is currently focusing sampling efforts in rocky hard bottom substrate areas (see tradeoffs explained in Section 6).

Two core components of our marine reserve monitoring are:

(1) Separating natural changes in species and habitats from human-caused changes
(2) Determining if marine reserves are effective in conserving biodiversity and certain species and habitats.

To accomplish this requires us to understand the initial conditions of the marine reserve and comparison areas, and to monitor these conditions over time. Changes from initial conditions that occur in **both** the marine reserve and comparison areas may be attributable to natural changes. Changes from initial conditions that take place only in the reserve or comparison area may be related to human-caused changes.

Comparison Areas and Beyond BACI

Each marine reserve is paired to one or more areas outside of the reserve, still open to fishing that we refer to as **comparison areas**. Our initial intent was to choose comparison areas with characteristics as similar to the reserve as possible (in depth range, size, habitat types, oceanographic conditions and fishing pressure) to enable comparison of ecological changes occurring inside the reserve to outside. This is modeled after a traditional paired-Before After Control Impact (BACI) study design. Consistent with our initial monitoring plan (ODFW 2012), we collected two years of baseline data at each reserve and comparison area prior to harvest restrictions taking effect. These data were used to construct a general characterization of each reserve and comparison area, and to validate whether we had chosen appropriate comparison sites. Based on our findings and reporting from these first two years of data (ODFW 2014; ODFW 2015) we concluded that adjustments were needed to be made to some of our comparison areas and that our BACI study design would need to altered for some reserves.

Two of our marine reserves pose challenges with respect to comparison areas and a BACI study design: Cape Perpetua and Cape Falcon. For Cape Perpetua, the main challenge is the lack of appropriate "control" sites possessing comparable habitats (e.g. deep, isolated reef) and oceanographic conditions (e.g. hypoxia, upwelling). For Cape Falcon the past extractive pressure at both the reserve and the Cape Meares comparison area was so low as to render a BACI approach ineffective for tracking change through time.

In 2015, the ODFW Marine Reserves Program held a workshop with scientific experts to identify solutions to these challenges at the Cape Perpetua and Cape Falcon sites. The workshop yielded suggestions of how to address these challenges and ODFW has implemented a path forward for both of these reserves.

For Cape Perpetua, we have chosen to monitor a nearby shallow reef, referred to as the Postage Stamp, to help us understand if the changes we see over time are occurring at a larger geographic scale, despite differences in reef structure, depth, and oceanographic conditions.

At Cape Falcon, we have added several nearby reefs with either moderate or high fishing pressure as comparison areas to help understand if the changes we see over time are attributable to human activities.

Several other changes to comparison areas were made at sites and are noted in Table 2A.

Table 2A: Changes in comparison areas associated with each of Oregon's five marine reserves over time.

Marine Reserve	Initial Comparison Areas	Decommissioned Comparison Areas	Added Comparison Areas	Current Comparison Areas
Redfish Rocks	• Humbug • Mckenzie Reef	• McKenzie Reef	• Orford Reef	• Humbug • Orford Reef
Otter Rock	• Cape Foulweather • Moolack	• Moolack	-----	• Cape Foulweather
Cascade Head	• Cavalier • Schooner Creek	-----	• Cape Foulweather	• Cape Foulweather • Cavalier • Schooner Creek
Cape Perpetua	• Seal Rock • Tokatee	• Seal Rock • Tokatee	• Postage Stamp	• Postage Stamp
Cape Falcon	• Cape Meares	-----	• Nearby reefs with varied fishing pressure	• Cape Meares • Nearby reefs with varied fishing pressure

Initial Conditions vs. Long-term Monitoring

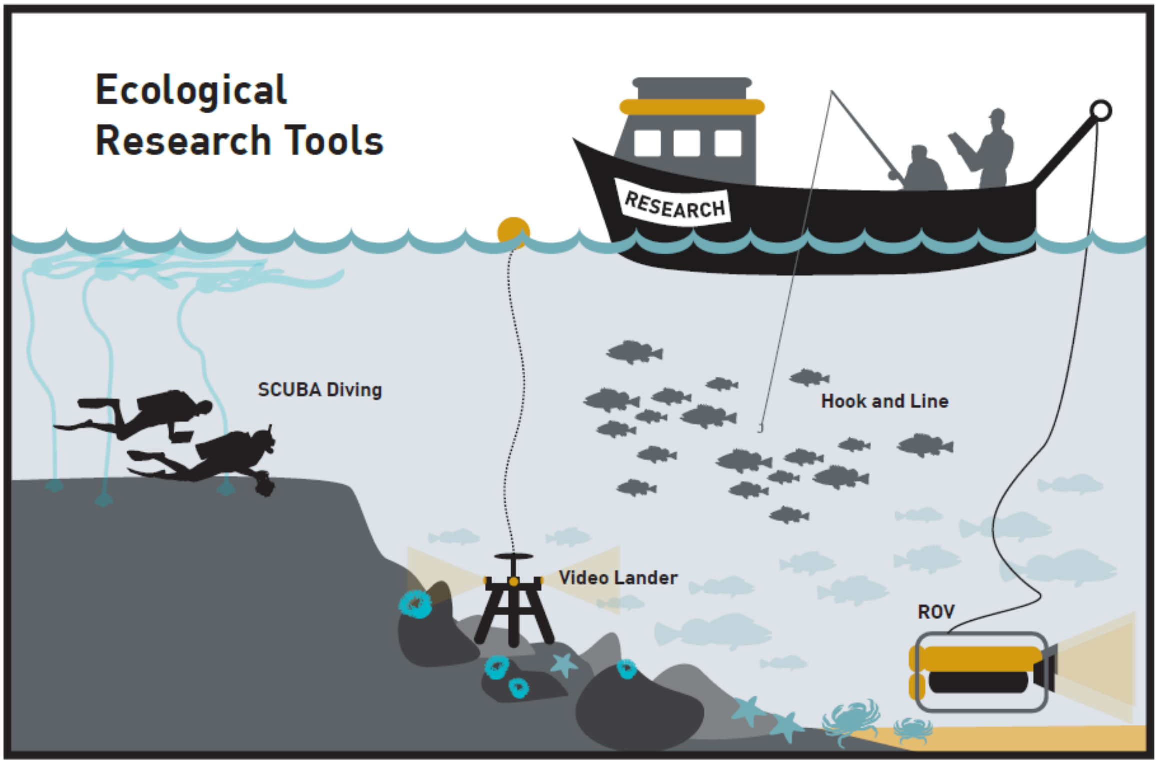
Understanding the initial conditions of the marine reserves and comparison areas is critical to separating natural changes in species and habitats from human-caused changes, and determining if marine reserves are effective in conserving biodiversity and certain species and habitats. We are just finishing the process of describing the initial conditions in four of the five (all but Cape Falcon) marine reserves. This is because in the Ecological Monitoring Report 2012-2013 (ODFW 2015), it was decided to extend the period to initially characterize the condition of each marine reserve from two years pre-closure, to additionally include data from three years post-closure for each site. This decision was made for several reasons including a meta-analyses of reserve performance worldwide (Lester et al. 2009), the biology of temperate, long-lived species (Willis et al. 2003; Ballantine 2014), and because of the challenges in surveying Oregon's nearshore environment with limited staff and funding resource available. Additionally, the state of California set a precedent for a five year baseline (all of which occurred post-closure) in their reserve monitoring efforts to characterize initial conditions (ODFW 2015). The decision to extend the time for describing initial conditions has allowed ODFW the crucial time needed to select appropriate comparison areas, refine sampling methods to nearshore environments, and to collect larger, more robust datasets. Now is the time for the marine reserves program to analyze, synthesize and report on the initial conditions in four of the five marine reserves based on data collected in the first five years of data collection. For the Cape Falcon Marine Reserve we are refining our sampling design for the site and working to collect larger, more robust datasets. For all other marine reserves, the data collected from 2018 going forward will be part of long-term monitoring.

	Monitoring Began	Harvest Restrictions Began
Redfish Rocks	2010	2012
Otter Rock	2010	2012
Cape Perpetua	2012	2014
Cascade Head	2012	2014
Cape Falcon	2014	2016

2.D. Sampling Tools and Surveys

The ODFW Marine Reserves Program is focused on four sampling tools for collecting long-term monitoring data. Sampling is predominately focused in shallow and deep rocky subtidal areas. Our four surveys include: (1) scuba diver surveys , (2) video lander surveys, (3) Remotely Operated Vehicle (ROV) surveys, (4) fishery-independent hook and line surveys. These four sampling efforts build upon the existing capacity and expertise at ODFW to survey fish, invertebrate, and macroalgal communities and habitats within Oregon's nearshore environment.

Below we provide a brief overview of each of our four surveys. ODFW also has created more detailed methods documents, summarizing each core monitoring survey method and documenting the evolution of sampling over time. The methods documents are living documents that supplement our *Ecological Monitoring Plan* by providing more in-depth information on study design, metrics, and sampling activities as well as explore which, and how, confounding factors could affect datasets.



Visual Tools

SCUBA Diver Surveys

We use scuba diver based underwater visual census (UVC) methods to identify and count macroalgal, invertebrate and fish communities. These subtidal SCUBA transects are patterned after the Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO) Subtidal Kelp Forest Transects that are used to monitor similar rocky reef / kelp communities in California, including their network of marine reserves and protected areas. SCUBA divers conduct surveys in rocky reef habitats at depths of 10, 15 and 20 meters (m). Divers work in pairs for safety. SCUBA divers survey a 60 m2 (30 m x 2 m) transect counting observed organisms and noting the type of habitat and topographic relief of the substrate encountered (UPC surveys). All surveys occur along the bottom only. During fish surveys, divers not only count species but also estimate each individual size to the nearest cm and species densities are calculated. These methods are based on those developed by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and are currently used to survey subtidal communities in California's marine reserves.

Subtidal SCUBA transects are conducted in four of the reserves (Redfish Rocks, Otter Rock, Cascade Head, and Cape Falcon) and their associated comparison areas. No subtidal rocky reefs exist at diveable depths (<25m) within the reserve at Cape Perpetua.

Tool Usage:

Depth Range: 10 – 20 m

Habitats: Shallow subtidal rock reef

Data Collected:

	SCUBA Surveys?
Redfish Rocks	Yes
Otter Rock	Yes
Cape Perpetua	No
Cascade Head	Yes
Cape Falcon	Yes

ODFW does not have a dive program and current agency policy prohibits ODFW staff from diving. Therefore, these transects are carried out by volunteer, AAUS-trained divers who have undergone additional special training in the PISCO methodology. Surveys are conducted in three sampling cells in each reserve and comparison area. In each cell we aim to complete four replicate transects for invertebrate, algae and UPC, and nine replicate transects for fish.

Video Lander Surveys

The video lander is a stationary, underwater camera system. This platform is used in rocky habitats, with high-definition GoPro™ cameras and metal frames built to withstand being dropped into complex rocky habitats. The video lander is deployed for approximately eight minutes of video collection at a time. We then review the video to estimate relative abundance for select invertebrate species and all fishes observed. The habitat characteristics, which include the depth, geologic substrate, topographic relief, and biogenic habitat (including macroalgae and sessile invertebrates) present, are recorded. The lander can be deployed across a wide range of depths. The affordable lander design and ability to use several landers simultaneously to survey an area, make this tool a cost-effective way to generate large amounts of video data. Future directions, include adding stereo-video cameras to the lander fleet to enable estimation of individual fish sizes during video review. Lander surveys began two years prior to implementation for all reserves except at Cape Falcon, where surveys began in 2016.

Tool Usage:

Depth Range: 5 – 20 m

Habitats: All habitat types

Data Collected:

	Video Lander Surveys?
Redfish Rocks	Yes
Otter Rock	Yes
Cape Perpetua	No
Cascade Head	Yes
Cape Falcon	Yes

ROV Surveys

The ODFW Marine Habitat Project, a partner research group within our agency, conducts video transect surveys using a Remotely Operated Vehicle (ROV) to assess fish and invertebrate density and benthic habitat structure within the marine reserves and the associated comparison areas. ROV surveys are conducted using ODFW's Deep Ocean Engineering Phanton HD2+2 ROV. A high definition video camera housed in a custom pressure tube with a dome port is mounted on the front of the ROV and another high definition camera is pointed straight down. Each camera is accompanied by a set of lights for illumination. Associated with the front camera is a pair of parallel red lasers spaced 10 cm apart to provide a scale reference.

ROV surveys were initiated prior to reserve closure at three of the reserves and their associated comparison areas: Redfish Rocks, Cape Perpetua, and Cascade Head. The Otter Rock and Cape Falcon sites are both too small and shallow to execute this survey type. ROV surveys occur every four to five years due to the high expense of surveys and significant data processing time ROV surveys occur every four to five years due to the high expense of surveys and significant data processing time, although the Marine Habitat Project has leveraged some externally funded projects to provide for additional sampling in the marine reserves where possible.

Tool Usage:

Depth Range: 20 – 50 m

Habitats: All habitat types

Data Collected:

	ROV Surveys?
Redfish Rocks	Yes
Otter Rock	No
Cape Perpetua	Yes
Cascade Head	Yes
Cape Falcon	No

Fishery Independent Tool

Hook and Line Surveys

We conduct fishery-independent hook and line surveys to obtain precise size structure data and catch per unit effort (CPUE) data for fishes inside the marine reserves and their associated comparison areas. We collect fish data through the help of volunteer anglers aboard chartered fishing boats, where we catch and sample, then release the fish. We divide our study areas into 500m x 500m grid cells. Local fishing knowledge helps ensure grid cells are placed in locations where fish are commonly caught in rocky habitats. On a survey day, five cells are randomly selected and anglers fish using standardized gear for a fixed amount of time. All fish caught by the volunteers are measured for length and then released. Hook and line surveys enable us to have fish in hand to take accurate length measurements. We will look at differences in average fish length before and after the reserve is closed to fishing, both inside the reserve and outside in the comparison areas (monitoring sites open to fishing). By sampling over time, we can determine whether fish sizes as well as catch rates (catch per unit effort) are changing due to cessation of fishing.

Hook-and-line surveys are conducted at four of the reserves and their associated comparison areas: Redfish Rocks, Cape Perpetua, Cascade Head, and Cape Falcon. The Otter Rock site is both too small and shallow to execute this survey type. At the Redfish Rocks site, our hook and line sampling is supplemented with longline sampling (see Huntington and Watson 2017).

Tool Usage:

Depth Range: 10 – 40 m

Habitats: Subtidal rock reef

Data Collected:

	Hook and Line Surveys?
Redfish Rocks	Yes
Otter Rock	No
Cape Perpetua	Yes
Cascade Head	Yes
Cape Falcon	Yes

2.E. Expanded Monitoring Through Collaborations

We work in collaboration with a variety of research partners to supplement and expand the ecological monitoring efforts of ODFW. Our research partners provide expertise, tools, methods, data, and personnel. Here we highlight the current collaborations that are directly contributing to the long-term monitoring of the reserves.

Oceanographic Monitoring

PISCO, Oregon State University

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) researchers at Oregon State University (OSU) have oceanographic moorings deployed in multiple locations along the Oregon coast. Some of these moorings are located within marine reserves or in nearby comparison areas. These data are available to help us understand oceanographic changes in the reserves over time. We are currently working with these researchers to understand how we can supplement the limited oceanographic data collected by ODFW with their longer term datasets.

Intertidal Monitoring

PISCO, MARINe, UC Santa Cruz, Oregon State University

PISCO and MARINe are the two largest rocky intertidal monitoring programs on the U.S. west coast. These programs have been monitoring community structure, abundances and sizes of intertidal species in Oregon for more than 20 years. They also record biodiversity hotspots, species-habitat associations and effects of oceanographic factors on intertidal communities. Some of the existing PISCO and MARINe long-term monitoring sites are located within marine reserves or comparison areas. Our MARINe collaborators at UC Santa Cruz also started long-term biodiversity and abundance sampling plots, beginning in July 2015, in the Otter Rock and Cascade Head reserves. These permanent plots are re-sampled through time every four to five years using the same methods to those being used at over 100 sites along the U.S. west coast. In addition, sea star wasting surveys are ongoing in these intertidal monitoring sites.

Juvenile Fish Recruitment Monitoring

Oregon State University

To maximize marine reserve conservation benefits and understanding of OR’s nearshore ecological communities, the marine reserve program partners with other interested researchers and community groups. Such collaboration is best exemplified by our current research with OSU to quantify abundance, diversity and settlement of juvenile fishes into OR's marine reserves (see section 4 for more details). In 2013, ODFW began a partnership with Dr. Kirsten Grorud-Colvert at Oregon State University (OSU) to study juvenile fish settlement and gain an understanding of how the marine reserves protect both juvenile and adult habitats from extractive activity. To survey juvenile fishes, we use standard monitoring units for the recruitment of fishes (SMURFs), which are devices attached to moorings that mimic available habitat for juvenile fish. Additionally we attach oceanographic sensors to each mooring to enhance our understanding of variations in temperature and salinity and their link to juvenile fish settlement. While monitoring fish settlement is still in its infancy along the Oregon coast, eventually this information can be used to inform managers how to best design, place, and manage these reserves into the future.

Additional Nearshore Research Collaborations

A list of additional research collaborations that are helping expand our understanding of Oregon's nearshore ecosystem, as well as support nearshore management and adaptive management of marine reserves, can be found in Section 6. Programmatic Analysis.

2.F. Defining Key Concepts

With an eye towards the 2023 evaluation, there is a need to clearly define several key concepts in relation to Oregon's marine reserve goals and objectives (OPAC 2008), and our six core research questions. The concepts most urgent to define are biodiversity, community structure, habitat, species-habitat correlations and change over time. These concepts have not been clearly defined and their definitions are pertinent to analysis of marine reserves data.

Biodiversity

The Ocean Policy Advisory Council (OPAC) provided a definition of biodiversity in its marine reserves policy guidelines (Table 2B). Biodiversity is a term meaning the diversity of life forms and communities that occur in a particular environment (OPAC 2008). OPAC is in agreement that there is no single way to define, measure or evaluate the diversity of life, but recognizes that there are four interrelated ways including species, ecological, genetic and functional diversity (OPAC 2008). Currently ODFW only has data to describe the species and ecological diversity of Oregon's marine reserves. Current efforts are underway to explore funding for a meta-genomics approach to quantifying marine biodiversity. Even if funded, it is currently not a long-term monitoring priority. There are many definitions of functional diversity (see Laureto et al. 2015), and with an austerity budget ODFW lacks the capacity to appropriately address exploring functional diversity in Oregon's marine reserves.

Table 2B: The four inter-related definitions of biodiversity according to OPAC, the type of data available from the Marine Reserves Ecological Monitoring Program.

Diversity	**Definition in OPAC 2008**	**Available data**
Species	Variety & abundance of species in an ecosystem	Species identification, Counts, & abundance
Ecological	Variety of types of biological communities found on earth	Species identification, counts, & abundance by habitat type
Genetic	Genetic variation that occurs among members of the same species	None
Functional	Variety of biological processes or functions characteristic of a particular ecosystem	None

Although it is not feasible for our program to measure all components of biodiversity, we can measure ones that involve species count and abundance data. There are numerous ways researchers' measure biodiversity including number of species (richness), evenness, rarity, abundance and diversity indices (Magurran 2004). It is generally known that no one single index can fully describe the biodiversity of a given area (Feest, 2006), and the measurement chosen can alter the interpretation of results (Morris et al. 2014) (Table 2C). Species richness is the most commonly used metric (Magurran 2004) in part because it is the simplest (Whittaker 1972), and species provide a focus for policy and legislation (Davies and Cadotte 2011). Species richness has shown to be a surrogate for unmeasured genetic and functional diversity (Cardinale et al. 2006, Worm et al 2006). However, relying strictly on species richness as a measure of biodiversity makes the assumption that we have complete information on species distributions and that population size and health of a given species are equivalent in each site (Davies and Cadotte 2011). Furthermore species counts are prone to sampling biases (MacKenzie et al. 2002, Kery and Schmidt 2008), which is especially true given challenges of detection in the marine environment (Issaris et al. 2012; Monk 2014).

We plan to initially report on the five biodiversity measures listed in Table 2C. This will serve two purposes: 1) generate new knowledge about marine biodiversity in Oregon's nearshore environment and 2) provide insight into the best way to determine if Oregon's marine reserves are effectively conserving biodiversity. Furthermore this supports previous descriptions of how to report on biodiversity given in the 2012 Ecological Monitoring Plan (ODFW 2012)

Table 2C: Common measurements of biodiversity, what they measure and their sensitivities.

Biodiversity Measure	What it Measures	Sensitivities	Reference
Berger Parker	Proportional abundance of most abundant species in the population	Sensitive to only the most abundant species	Berger and Parker 1970
Shannon's Diversity (Shannon-Wiener)	Represents the uncertainty in the system about the identity of an unknown individual; e.g. in a less diverse system dominated by few species, it is easier to predict the identity of unknown individuals	Equally sensitive to rare and abundant species	Shannon 1948
Simpson's Diversity	The probability that two randomly chosen individuals belong to different species	Sensitive to abundant species	Simpson 1949
Simpson's Evenness	The degree to which individuals are split among species	Sensitive to abundant species	Simpson 1949
Richness	Number of species present	Sensitive to rare species	Margurran 2004

Community Structure

Community structure is defined in the ecological literature as species diversity, richness and the abundance patterns of component species in a community (Margurran 2004). The Scientific and Technical Advisory Committee (STAC) supported this definition in their initial review of the draft marine reserve monitoring plan in 2010. We will focus our efforts to analyze community structure on multivariate techniques that compare similarity and distance in species assemblages. In order to compare variation in species abundance and composition among sampling units we will use an Analysis of Similarity (Anosim), which is a rank correlation between two distance matrices. Non-metric multidimensional scaling plots will enable us to view how sites (management areas, regions or years) cluster together if (when) they have similar species assemblages (Holland 2008). We will calculate a Bray-Curtis dissimilarity measure among sites (management areas, regions or years) and use similarity percentages (SIMPER) to determine which species contribute to the observed dissimilarity (Clark and Warwick 1994). These analyses are supported by the 2012 Ecological Monitoring Plan (ODFW 2012).

Habitat

OPAC defines four key types of habitats for Oregon's marine reserves: 1) rocky intertidal; 2) rocky subtidal with canopy forming kelp; 3) rocky subtidal without canopy forming kelp; 4) soft bottom subtidal (OPAC 2008). We currently focus our monitoring in intertidal areas, and rocky subtidal areas without canopy forming kelp. Although we do occasionally observe kelp in our scuba diver surveys or lander videos. Over the last seven years of monitoring it has been challenging to access rocky subtidal areas with canopy forming kelp, and kelp is only present in two of the reserves (Redfish Rocks and Otter Rock). Habitat consists of both non-living and living (i.e. biogenic) substrates. For this report we report on living substrate in terms of five different biogenic complexity categories (Lawrence et al. 2016). For definitions of our five biogenic complexity categories see Lawrence et al. 2016.

Species-Habitat Correlations

A species-habitat correlation exists when animals' presence or abundance vary, either directly or inversely with the presence or abundance of environmental components (Wiens 1976).

Detecting Change Over Time

Detecting change over time is a critical component of our marine reserves ecological monitoring approach. Our monitoring is designed to:

- Determine whether or not the marine reserve (prohibition of extractive activities) changes the environment over time;
- Determine which components of the environment are affected; and
- Estimate the magnitude of the effects.

In the literature there appear to be three basic approaches to measuring change over time inside and outside marine reserves. The first is to report pairwise comparisons through time, regardless of differences in initial values (Cote et al. 2001; Taggart et al. 2004; Russ et al. 2008). The second is to standardize initial values, and then evaluate the magnitude of the response through time (Babcock et al. 2010). The third method commonly used in the literature is to look at response ratios through time (Molloy et al. 2008; Horta e Costa et al. 2013; Fidler et al. 2017).

Similar to biodiversity, from now until 2021 we will explore the use of all three of these ways to evaluate change over time. This will serve two purposes: 1) generate new knowledge about marine biodiversity in Oregon's nearshore environment and 2) provide insight into the best way to evaluate change over time moving forward for long-term monitoring.

2.G. Spatial Scales of Analysis

Here we define our terminology for the three different spatial scales that we provide analyses at in this report.

Site – the smallest spatial scale to interpret data; each marine reserve is a site, each comparison area is a site.

Management Area – a middle spatial scale to interpret data; consists of generalizing and summarizing data from the marine reserve to all comparison areas combined together. This concept will be applied to the Redfish Rocks, Cascade Head and Cape Falcon locations only as these reserves have multiple comparison areas.

Region – the largest spatial scale to interpret data. Consists of generalizing and summarizing data from the marine reserve plus associated comparison areas together.

2.H. Focal Species

The Ecological Monitoring Plan (ODFW 2012) states that limitations of sampling gear, funding and staff dictate that reporting and analysis focus on a select group of species for each site. It suggests that focal species be chosen based on their ecological or economic importance, and their potential to show a response, or change within the marine reserve over time. However, to date focal species have not yet been chosen.

We conducted a literature review to identify the various methods used to select a core group of species for reporting and analysis. The literature also support the use of focal species for marine management and conservation of natural environments (Zacharias and Roff 2001; Margules et al. 2002), but the definition of a focal species is varied. Focal species may include indicator, keystone, umbrella, flagship, surrogate, charismatic, economically important or vulnerable species (King and Beazley 2005, Margules et al 2002). There are noted challenges with focal species in the literature including the lack of firm definitions, agreed standards for use and application, and the validity of the ecological theory behind the standards for their use and application are untested (Simberloff, 1998; Zacharias and Roff, 2001; Lindenmayer et al., 2002)

Focusing on marine environments, four studies have identified marine species and habitats for conservation (King and Beazley 2005; Zacharias and Roff 2001; McClure et al. 2016; The Nature Conservancy in Oregon 2013). There is also the Oregon Nearshore Strategy (ODFW 2012), which contains a list of Oregon species with notes on biology, threat status, stressors, and research needs. Taken together these studies contain several criteria we believe are important to consider when selecting focal species including biological and climate sensitivity, management importance, and likelihood to show a response to protection.

To identify habitat, macroalgae and invertebrate focal species, we consulted several academic and management experts for recommendations. We compared their recommended list against the recommendations from the Agency Analyses produced during the Phase I and Phase II marine reserves planning process (2008 and 2010) and found many of the species overlapped. Furthermore these recommended species also hit on many of the criteria mentioned in the four studies cited above focusing on marine environments.

To identify fish focal species, we started by generating a list of all the fish species observed by the program during the first seven years of data collection. Then we evaluated them against several biological, climate, management and response to protection criteria. We then selected the species with the highest scores (n=12) in each category to be our top priority species, which we call Tier 1. There were several species that scored highly in one or two of the categories, which became our Tier 2 species (n=9), meaning we would conduct analysis on them if time and data allowed. All other species (n=19), would be used in calculating species diversity at a site, but would not be expanded upon for additional analyses.

The results of this process are listed in Table 2D. These are the proposed focal species for our program and for the 2021 ecological monitoring synthesis for the evaluation.

Two points for further consideration are required before focal species can be finalized. First, the procedure described above does not take into account species of public interest, such as marine mammals or seabirds that may be of interest. Second, the species proposed are only ones that have been observed in the marine reserves to date. There may be value in waiting until 2021 to revisit this process, in case more species are identified, or others may become of particular interest because of an emerging issue.

Table 2D: Proposed focal species for the Oregon Marine Reserves Monitoring Program.

Habitat / Macroalgae		Invertebrates		Fish	
Intertidal	**Subtidal**	**Intertidal**	**Subtidal**	**Tier 1**	**Tier 2**
Saccharina (Brown Kelp)	*Nereocystis* (Bull Kelp)	*Mytilus californianus* (California Mussel)	Anemones	Kelp Greenling	Pile Perch
Bossiella plumose (Erect Coralline Algae)	*Pterygophora* (Northern Sea Palm)	*Pollicepes polymerus* (Gooseneck Barnacle)	Urchins	Lingcod	Tiger Rockfish
Pelvetiopsis limitata (Fucoid, Brown Algae)	*Pleurophycus* (Broad-Rib Kelp)	Pisaster (Ochre Sea Star)	Sea Stars	Striped Surfperch	Vermilion Rockfish
Postelsia (Sea Palm)	*L.setchelli/S.groenlandic* (Split-Blade Kelp)	*Katharina tunicata* (Black Chiton)	Abalone	Black Rockfish	Widow Rockfish
Phyllospadix (Surf Grass)	*Laminaria longipes*		Rock Scallop	Blue Rockfish	Yellowtail Rockfish
	Costaria (Five-Rib Kelp)		Sponges	Canary Rockfish	Buffalo Sculpin
	Desmarestia (Acid Weed)		Yellow Boring Sponge	China Rockfish	Red Irish Lord
	Alaria Sp. (Ribbon Kelp)		Gorgonians	Copper Rockfish	
			Sea Pens	Deacon Rockfish	
			Basket stars	Quillback Rockfish	
			Bryozoans	Yelloweye Rockfish	
			Tunicates	Cabezon	
			Tube-worms		

Section 3. Learning and Adapting

The ODFW Marine Reserves Program's ecological monitoring is the first ecosystem-focused, long-term monitoring program to be conducted in Oregon's nearshore marine environment. We have built upon advances in sampling technology and gear to design robust and contemporary survey tools that can function in Oregon's challenging nearshore environment. We have built research collaborations with scientists who have expertise and contribute to our long-term monitoring efforts.

During the development of this long-term monitoring program, we have made adaptations to our data collection based on tool and methods testing, lesson learned in the field and during data analyses, and advice from other scientific experts.

Here we highlight adaptations that have been made in our data collection during the first seven years. We also provide a brief discussion on possible future adaptions in our data collection and analytical approaches to address our six core research questions, which have arisen for consideration as part of developing of this report.

3.A. Adaptations in Data Collection

Here we highlight the adaptations in our data collection, both in terms of changes made to ODFW's core survey tools and building long-term monitoring collaborations. In some instances our initial research approaches did not yield robust data and have been dropped from our monitoring efforts, as reflected in Table 3A. Here we focus on ODFW's current core research tools and collaborations that contribute to long-term monitoring data.

ODFW Research Tools

Over the past seven year we refined, adjusted and adapted our four core research tools, based on methods testing and advances in technology. Here we highlight the most significant adaptations to our data collection for each of our four core monitoring tools. To document the evolution of our tools and sampling over time, ODFW created detailed methods documents that summarize our learning and adapting process. We reference these documents in our summaries below as they provide relevant detail about our process and decision-making.

SCUBA

Our SCUBA survey protocol has evolved over the years to be better adapted to conducting underwater visual census surveys in Oregon's nearshore environment. Nearshore ocean conditions in Oregon differ from those in California, where the methods originated, particularly in regards to water clarity and underwater visibility. We have made protocol modifications both for safety and data collection reasons. For example, fish surveys are no longer conducted at mid-water depths, and we are exploring the use of diver operated stereo video cameras to improve accuracy of fish size estimates. Furthermore we are still learning about the rocky reefs in each of Oregon's Marine Reserves and comparison areas. Some of this learning relates to the feasibility of returning to the same survey locations in each site, each year, which influences how we may analyze the data (e.g. repeated measure).

More details are available in the SCUBA methods document.

Video Lander

Since 2010, the video lander tool has been modified in configuration (Momma lander vs. Mini Lander), type of camera used (standard definition, high definition, lights) and in the drop duration (range from 3-8 minutes). Currently the lander consists of three GoPro™ cameras and housings and is deployed on a small, light-weight tripod shaped frame. It is restricted to depths < 30 m because of waterproof camera housing requirements. There are no lights or lasers, both to reduce the cost of the unit and ease of deployment and retrieval. The change to our current lander configuration occurred in 2014.

We are also continuing to learn about the viability of this tool to produce robust fish size data and contribute to future biodiversity and community structure analyses for our habitat, invertebrate and fish communities.

Details on changes and adaptations made to the video lander tool and discussions of potential confounding factors is provided in the video lander methods document. Changes and analytical applications are also presented in our journal publication (Watson and Huntington 2016) and in our ODFW Information Report (Lawrence et al. 2016).

ROV

Since 2010, the ROV has had changes in configuration (front camera only, front + downward facing cameras), camera type (total field of view, lens angle, lights) and transect size (lengths & widths). ROV surveys are intricate in the way they are executed, and decisions made about conditions during surveys, calibration of various instruments and advances in technology and data processing all factor into the evolution of ROV data. Ultimately, each of these considerations is appropriately factored into the calculation of species densities for each survey, with the goal of maintaining direct comparability of these densities among sites and years.

Recent effort focused on adding stereo video capacity to the ROV. At the cost of increased video processing time, this will allow the measurement of many more fish lengths, with greater precision, than was possible by comparison with the scaling lasers. Stereo video also opens possibilities for improved estimates of transect width, total area viewed, and observation distance for each measured fish (useful for calculating detection thresholds), among other potential applications.

More detailed information on adaptations to the ROV over time are provided in the ROV methods document.

Hook and Line

Hook and line surveys have undergone some adaptations based on methods testing and logistics. We have determined that diamond jigs are the standardized terminal gear to be used. We moved our sampling season from the summer months to spring and fall, and we added longline gear to supplement our hook and line surveys for the Redfish Rocks Marine Reserve.

More detailed information on adaptations and consideration of confounding factors is provided in our hook and line methods document, as well as in our journal publication (Huntington and Watson 2017).

Table 3A: Current ODFW monitoring tools, long-term collaborations and discontinued tools.

		Research Questions						
		Oceanographic Conditions	Habitat (+Algae)	Invertebrates	Fish	Species-Habitat Associations	Prohibition Human Activities & Community Structure	Patterns Across Reserves
Current ODFW Tools and Data Sources	SCUBA		X	X	X	X	X	X
	Video Lander		X	X	X	X	X	X
	ROV		X	X	X	X	X	X
	CTD	X				X		X
	Hobo, Odyssey, MK-9 sensors	X				X		X
	Hook & Line				X	X	X	X
	Longline				X	X	X	X
	Urchin Surveys			x				
	Fishery Dependent Data				X		X	X
	Human Dimensions Research				X		X	X
Long-term Collaborations	Oceanography	X					X	X
	Intertidal		X	X		X	X	X
	Juvenile Fish Recruitment (SMURFs)	X			X	X	X	X
	Seafloor Habitat Mapping Lab		X			X		X
Discontinued Tools and Surveys	Box Core		X	X				
	Benthic Extraction		X	X	X			
	Video Sled		X	X	X			
	Otolith Sampling				X			

Long-term Monitoring Collaborations

Here we highlight the development of our long-term monitoring collaborations. Our efforts to collaborate with other scientists both in Oregon and west-coast wide are best exemplified with our research in Oceanography, Intertidal Communities, and Juvenile Fish Recruitment.

Oceanography

A First Start: Data Collected by ODFW The initial monitoring plan (ODFW 2012) stated that temperature, salinity, chlorophyll, dissolved oxygen, and light data would be collected at each reserve for characterization of oceanographic conditions by ODFW. From 2010-2013, attempts were made with various instruments to collect these variables at the Redfish Rocks, Otter Rock, and Cascade Head Marine Reserves (see Table 4.2 & 4.3 in Section 4). These instruments were set out using one of two different platforms – either a mooring or a benthic oceanographic platform (BOP). After 2011, moorings were officially replaced with BOP's due to Oregon's high energy wave environment. Although data on light and chlorophyll were collected early on, they were difficult to interpret, and have not been analyzed. In 2014, our program began a new collaboration with Oregon State University (OSU) to study juvenile fish and placed temperature and conductivity sensors on the SMURF moorings in the Redfish Rocks and Otter Rock regions. In 2015 a decision was made to phase out oceanographic data collection at reserve sites once baseline data were completed (see Ecological Monitoring Report 2015). Since 2015, the only oceanographic data being collected by ODFW were from temperature and salinity sensors placed on SMURF moorings in the Otter Rock and Redfish Rocks regions.

Moving Forward: Collaborating with PISCO-OSU ODFW has started to work in collaboration with Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) researchers at OSU to augment physical oceanographic data collected by ODFW. The fruits of this initial collaboration are highlighted in this report. Through this collaboration, we are utilized PISCO's existing long-term oceanographic data streams from instrument moorings at the Cascade Head Cavalier Comparison Area (PISCO site "Lincoln Beach") and the Cape Perpetua Marine Reserve (PISCO site "Strawberry Hill"). Both these moorings also provide additional historic data for each of these sites (PISCO Lincoln Beach 1998-2013; Strawberry Hill moorings 1998 –present) (See Table 4.2 in Section 4). Some of these moorings have CTs that collect temperature, salinity, fluorescence, and dissolved oxygen as well as temperature from individual temperature sensors at multiple depths. PISCO additionally collects pH and pCO2 data and monitors nearshore oceanographic currents. It is worth noting that PISCO operates six separate moorings at "Strawberry Hill", hereon we refer only to two of the moorings, one equipped with a combination of CTs and temperature sensors, and another with only temperature sensors, as these both match the depths and variables of ODFW data in other locations. Both of these moorings are deployed at 15m water depth.

Intertidal Monitoring

As mentioned in Section 2, PISCO and MARINe are the two largest rocky intertidal monitoring programs on the U.S. west coast and had existing long-term monitoring sites established in Oregon, some of which fell close to or inside marine reserves. We initiated discussions with these groups after noticing sites were lacking in the Otter Rock Marine Reserve and Cascade Head Marine Reserve (Figures 3A, 3B). Of note, is that prior to 2015 the sites in Otter Rock and Cascade Head reserves were missing. In 2015, we contracted PISCO MARINe collaborators at UC Santa Cruz added long-term biodiversity and abundance sampling plots within the Otter Rock and Cascade Head Marine Reserve reserves. In addition, ODFW and The Nature Conservancy are conducting sea star wasting surveys that contribute to both PISCO and MARINe datasets in both of these reserves.

As we learned with oceanography, there is much value to exploring historical data collected by other scientists in the Pacific Northwest. As we continue to build on our initial collaborative efforts we hope to incorporate some of their long-term data from other Oregon sites to help us understand changes in our rocky intertidal communities in relation to marine reserves.

Juvenile Fish Recruitment (SMURFs)

In Section 2, we highlighted our collaborations with researchers at Oregon State University to survey juvenile fishes using standard monitoring units for the recruitment of fishes (SMURFs). SMURFs were first deployed in 2011 for the Otter Rock Marine Reserve. We did not start SMURF surveys at Redfish Rocks until 2014. Currently no other reserve sites have SMURF surveys being conducted, due to lack of funding and personnel.

3.B. How to Best Address Our Research Questions

For this report we've pulled from our existing monitoring data and run various summaries in an attempt to address our six research questions. Through this process we have learned more about the quantity and quality of data available from our efforts, and which tools are best suited for certain research questions. We've generated new ideas related to analytical approaches that are relevant to the discussions around the 2021 ecological monitoring synthesis. Based on this exercise, lessons learned, and feedback from STAC, we will continue to adapt our ecological monitoring program as we move forward with monitoring, data analysis and the 2021 synthesis report.

One area of learning best highlighted by the drafting of this report is in relation to our invertebrate survey tools. We collect data on invertebrates with three core tools (SCUBA diver, video lander, and ROV) and one collaboration (intertidal surveys). For this report, the intertidal and SCUBA diver datasets were unavailable for summarization beyond initial effort by site by year because there has been no development of data management for these datasets. In 2014-2016 there was a lot of effort focused on data management for the video lander, and therefore more data were available for reporting. However, we realized the utility of the video lander for collecting benthic invertebrate data was limited due to constraints of view, visibility and habitat type across sites and years. Very few species and individuals were observed, consistently less than 700 per year per site. The ROV surveys had a high utility for collecting benthic invertebrate data, as upwards of 40,000 individual was common and in Redfish Rocks in 2017 more than 100,000 total individual invertebrates were observed! This suggests perhaps our efforts may be better focused on tools other than the lander for observing and analyzing subtidal invertebrate communities.

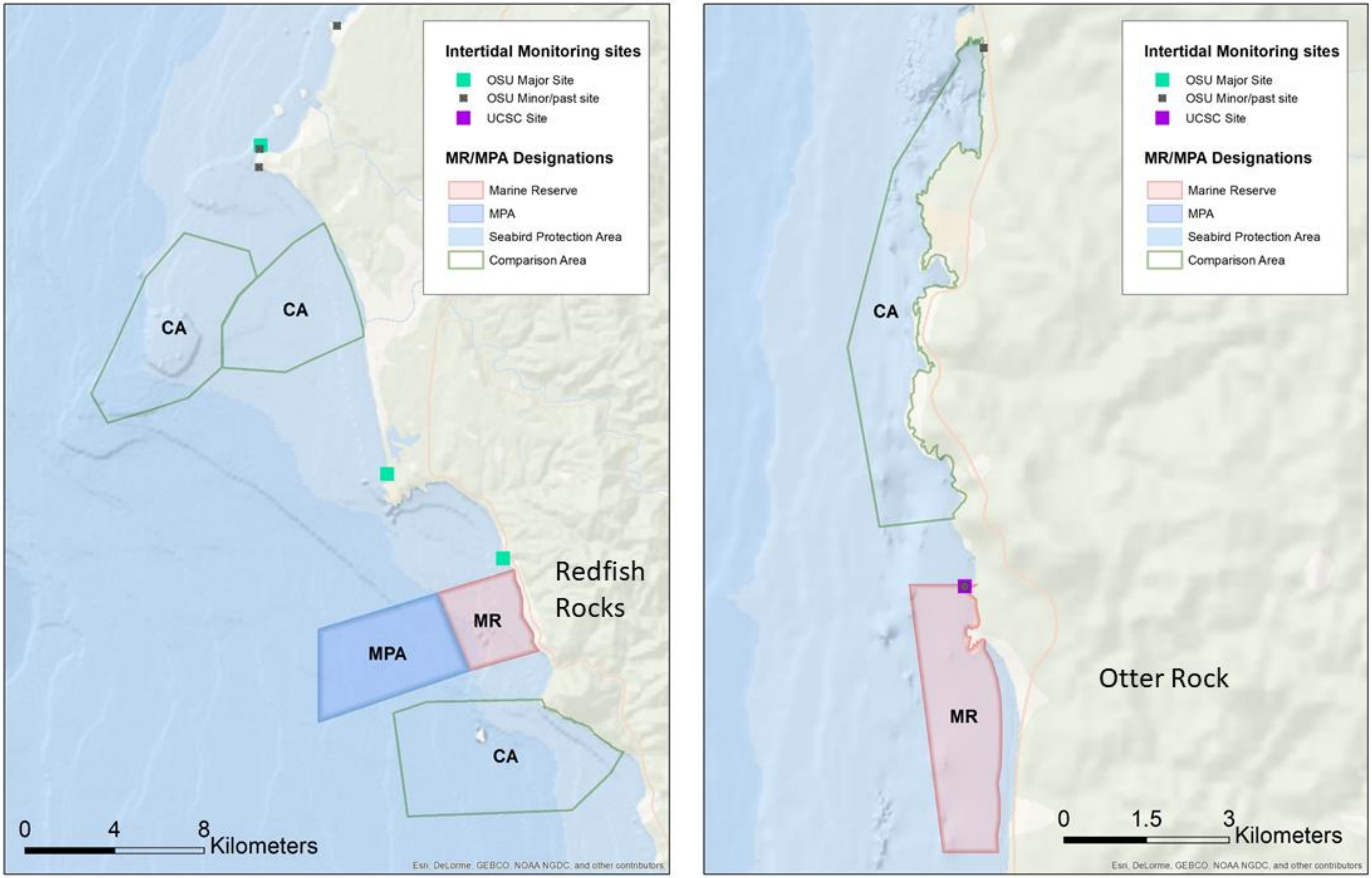


Figure 3A: Intertidal monitoring sites by PISCO OSU and PISCO UC Santa Cruz in relation to the Redfish Rocks and Otter Rock Marine Reserves and associated comparison areas. The UCSC site in the Otter Rock Marine Reserve represents the addition from ODFW to this long-term monitoring dataset.

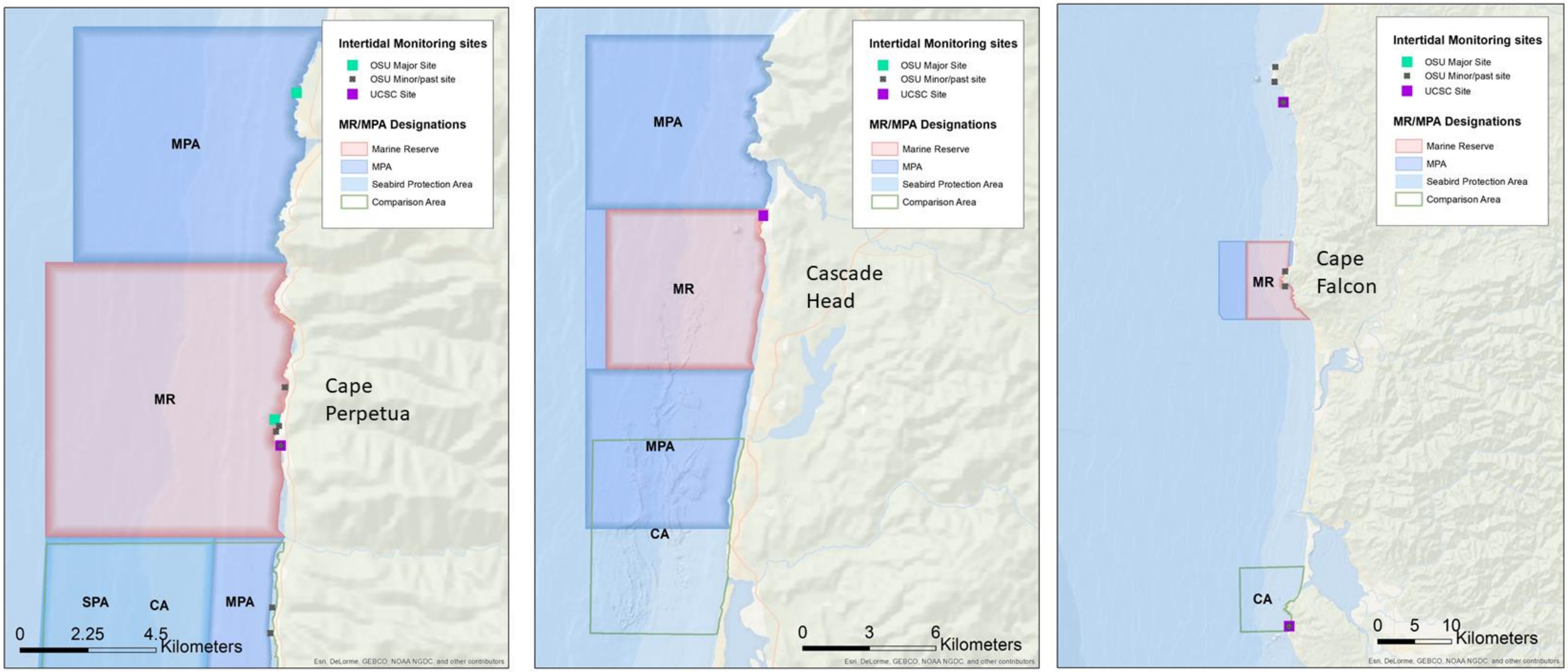


Figure 3B: Intertidal monitoring sites by PISCO and MARINe in relation to the Cape Perpetua, Cascade Head, and Cape Falcon reserves and associated comparison areas. The UCSC site in the Cascade Head Marine Reserve represents the addition from ODFW to this long-term monitoring datasets

Section 4. Available Data & Summaries

A discussion of the summaries we conducted to answer each research question, each described at three different spatial scales.

A question of scale

Throughout this document we refer to three spatial scales in relation to our data and summaries. The largest spatial scale is the region, e.g. Redfish Rocks Region, and is a summary of data for the marine reserve and associated comparison areas combined. The smallest spatial scale is that of the site, e.g. Redfish Rocks Marine Reserve. In between these scales is that of the management area, which is used to compare the marine reserve to all of its comparison areas combined.

Tools & Research Questions

We report a summary of the available data and analyses both by tool and by core research question. This is because several tools are used to provide data for core research questions such as characterizing the invertebrate and fish communities in the reserves and comparison areas. We wanted to provide a comprehensive understanding of how each tool provides data to our various research questions in an effort to evaluate the data collection efforts of the Marine Reserves Program overall. Every long-term monitoring program goes through a similar process of tool evaluation, data collection, data management, analysis, and reporting. Much of the focus of the Ecological Program has been on tool evaluation, and data collection, as such there has been limited time to devote to data management and the development of comprehensive analysis plans. We did focus data management efforts on the lander and hook and line survey tools in 2014-2016, and this is reflected in the quantity of information in these sections of the report. Therefore, in relation to some tools or research questions data management, data availability, and or analyses are limited. We report where this is relevant to highlight that a focus on data management and analyses are currently needed.

Four Core Monitoring Tools:

Scuba Diver Surveys

We are currently working to integrate our scuba diver collected data into a long-term database. Therefore, we only report diver effort by site and year where applicable for each core research question (Table 4.1).

Table 4.1: Dive survey effort for each of Oregon's Marine Reserves. The Cape Perpetua Marine Reserve is too deep to allow scuba diving surveys and is not included in this table. Survey efforts reflect surveys conducted both in the marine reserves and their associated comparison areas. For more details see the habitat, invertebrate and fish sections of this report.

Site	Transect type	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	UPC	24	28	---------	---------	7	48	---------	---------
	Algae	24	24	---------	---------	2	27	---------	---------
	Invert	24	24	---------	---------	5	46	---------	---------
	Fish	69	58	---------	---------	164	27	---------	---------
Otter Rock	UPC	4	34	---------	---------	---------	7	---------	27
	Algae	4	34	---------	---------	---------	0	---------	27
	Invert	4	34	---------	---------	---------	9	---------	27
	Fish	12	62	---------	---------	---------	45	---------	10
Cascade Head	UPC	---------	---------	---------	27	27	---------	---------	24
	Algae	---------	---------	---------	18	6	---------	---------	24
	Invert	---------	---------	---------	25	31	---------	---------	24
	Fish	---------	---------	---------	0	76	---------	---------	41
Cape Falcon	UPC	---------	---------	---------	---------	---------	---------	8	30
	Algae	---------	---------	---------	---------	---------	---------	0	30
	Invert	---------	---------	---------	---------	---------	---------	8	30
	Fish	---------	---------	---------	---------	---------	---------	27	3

Lander Surveys

Video lander surveys began prior to reserve closure at 4 of the 5 Oregon Marine Reserves and their associated comparison areas; no usable lander data was obtained from Cape Falcon prior to closure due to limited weather windows and poor visibility in 2014-15. Lander data contribute currently to research questions related to habitat, invertebrates, and fish.

Data Processing

All videos are reviewed to ensure they meet pre-determined conditions of visibility, view and rocky reef habitat (see Lander Methods Document for more details). They are then scored for relief, primary and secondary habitat type, species identification (of fish and invertebrate species), and a maximum relative abundance per species (MaxN). All fish and invertebrate species that can be positively identified are noted. Individuals unable to be positively identified to species are scored as 'unidentified' fish or invertebrates to the lowest functional form possible. Individuals of fish or invertebrates that could not be positively identified to species were tallied and excluded from subsequent analyses for all relevant research questions.

Data Summarization

Data streams collected by this tool are summarized in the following sections:

- Research Question 2: What habitats exist within each site? How do they change over time?

- Research Question 3A: What invertebrate species exist at each site?
- Research Question 3B: What fish species exist at each site?

Remotely Operated Vehicle (ROV) Surveys

ROV surveys were initiated prior to reserve closure at 3 of the 5 Oregon Marine Reserves and their associated comparison areas: Redfish Rocks, Cape Perpetua, and Cascade Head. The Otter Rock and Cape Falcon sites are both too small and shallow to execute this survey type.

Video transects are conducted with the ROV between 0.5 and 1.5 m above the bottom, depending on vertical relief of the substrate, at a target speed of 0.5–1 knot though speed varies as wind and seas affect the survey vessel. The resulting view angles produce a transect width of 1-4 m as the ROV navigates bottom features. The ROV is 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 are determined at 1 s intervals and subsequently smoothed using a 7-point moving average to minimize any positional artifacts. This equipment and processing typically yield a positional accuracy of ± 4 m.

Data Processing

All videos are reviewed to ensure they meet pre-determined conditions of visibility, view and rocky reef habitat (see ROV Methods Document for more details). They are then scored for primary and secondary habitat type, species identification (of fish and invertebrate species), species counts, and fish size for suitably-oriented individuals near the lasers. All fish and invertebrate species that can be positively identified are noted. Individuals unable to be positively identified to species are scored as 'unidentified' fish or invertebrates to the lowest functional form possible.

Data Summarization

Data streams collected by this tool are summarized in the following sections:

- Research Question 1: What is the oceanographic condition of each site? How does it change over time?
- Research Question 3A: What invertebrate species exist at each site?
- Research Question 3B: What fish species exist at each site?

Hook-and-Line Survey

Hook-and-line surveys were initiated prior to reserve closure at 4 of the 5 sites: Redfish Rocks, Cape Perpetua, Cascade Head, and Cape Falcon. The Otter Rock site is both too small and shallow to execute this survey type. Hook-and-line surveys contribute currently to the research question related to fish.

Data Collection

Hook-and-line surveys collect fish data through the help of volunteer anglers aboard chartered fishing boats. Study sites are devided into 500m x 500m grid cells. Local fishing knowledge helps ensure grid cells are placed in locations where fish are commonly caught in rocky habitats. On a survey day, five cells are randomly selected and volunteer anglers fish using standardized gear for a fixed amount of time. All fish caught by the volunteers are measured and released (see Hook-and-Line Methods Document for more details). Hook-and-line surveys enable us to have fish inhand to take accurate length measurements. We will look at differences in average fish length before and after the reserve is closed to fishing, both inside the reserve and outside in the comparison areas (monitoring sites open to fishing). By sampling overtime, we can determine whether fish sizes as well as catch rates (catch per unit effort) are changing due to cessation of fishing.

Data Summarization

Data streams collected by this tool are summarized in the following section:

- Research Question 3B: What fish species exist at each site?

Longline Survey

Longline surveys were piloted in 2015-16 and adopted in 2017 for the Redfish Rocks region (for more details see Huntington and Watson 2017).

Data Collection

Survey design mimicked that of the current hook-and-line survey by restricting longline deployment into the existing hook-and-line sampling cells whenever possible, though the captain was given the opportunity to select the deployment location. Sampling was conducted off a commercial longline fishing vessel which carries three ODFW scientists, a deckhand, and the captain with local fishing knowledge.

For the longline sampling the captain was asked to set longlines within the study area to target the colorful, demersal species valued in the live-fish fishery. The longline skate consists of a 138 m weighted ground line with 100, 12/0 hooks on 0.30 m long leaders spaced 1.37 m apart. Each ground line is anchored at the beginning and end of the line and with short lengths of chain at 20 hook intervals. Each hook is baited with squid. Spatial position, depth, and soak time are recorded for each longline set. Soak times are intentionally short (approx. two hrs) to aid in maintaining favorable fish condition for catch and release. Upon retrieval of the longline gear, the haul back time is recorded, as well as the hook number and associated catch (fish species, empty hook). Fish are identified to species, measured (fork length, cm), evaluated for condition (i.e. injury, barotrauma, mortality), and released. Fish are either released at the surface or at depth using a SeaQualizerTM if barotrauma symptoms are present. Six longline sets are completed in a typical sampling day resulting in approximately half of the at-sea time allocated to longline setting, rebaiting, and retrieval and the other half of the day allocated to hook-and-line sampling.

Data Summarization

Results from the pilot study can be found in Huntington and Watson 2017. As 2017 was the first year this method was implemented data will not be reported in this document at this time.

Collaborative Long-term Monitoring Efforts

Oceanography

Data streams collected by this tool are summarized in the following section:

- Research Question 1: What is the oceanographic condition of each site? How does it change over time?

Intertidal

We are currently working to integrate our intertidal data into a long-term database. Therefore, we only note effort by site and year where applicable from ODFW efforts and contracted work with PISCO UC Santa Cruz. We are also working with both PISCO OSU and PISCO UC Santa Cruz to identify their relevant long-term monitoring sites and survey dates that could provide valuable historical insight to changes in Oregon's rocky intertidal communities through time with regards to Oregon's marine reserves.

Juvenile Fish Research (SMURFs)

This research aims to quantify the community composition and abundance of settling temperate reef fishes to determine the value of designated marine reserve habitats for protecting early stages of fish ontogeny. In two pilot years (2011, 2012) at the Otter Rock site, Dr. Grorud Colvert began a project using Standard Monitoring Units for the Recruitment of Fishes- SMURFs (Ammann 2004) to successfully sample the relative abundance of larval and pelagic juvenile fish recruits in the reserve and adjacent area. In 2013, ODFW became a collaborative partner in this effort, along with the Oregon Coast Aquarium and the lab of Dr. Su Sponaugle (OSU, Hatfield Marine Science Center). In 2014, SMURFing was established at Redfish Rocks to add to the monitoring a second marine reserve, along with its associated comparison area at Humbug Mountain. Additional collaborations are also in development with Dr. Steve Rumrill (ODFW Shellfish Program Leader) and Dr. Aaron Galloway (OIMB) to use these SMURF moorings to sample larval invertebrates.

Data Collection

SMURFs were designed to sample settling larval and pelagic juvenile fishes that are often found in kelp habitats immediately post-settlement. Of the Oregon marine reserves, the Otter Rock and Redfish Rocks Marine Reserves are the primary target for this sampling due to the presence of kelp habitats in these reserves. In addition, these central and southern Oregon locations allow for comparison of larval and pelagic juvenile settlement dynamics above and below the biogeographic break at Cape Blanco.

The research design includes four SMURFs deployed at each reserve and comparison area site to balance replication, suitable habitats for settlement and benthic mooring placement, and spacing of ~ 300 meters between SMURFs (Figure 4.1). SMURF collectors consist of black polyvinyl chloride mesh folded inside a long (100 x 35 cm) cylinder of garden fencing, forming a 3-D structure that simulates natural settlement substrates such as a kelp canopy. These collectors provide an artificial refuge for settlement-size fishes high in the water column.

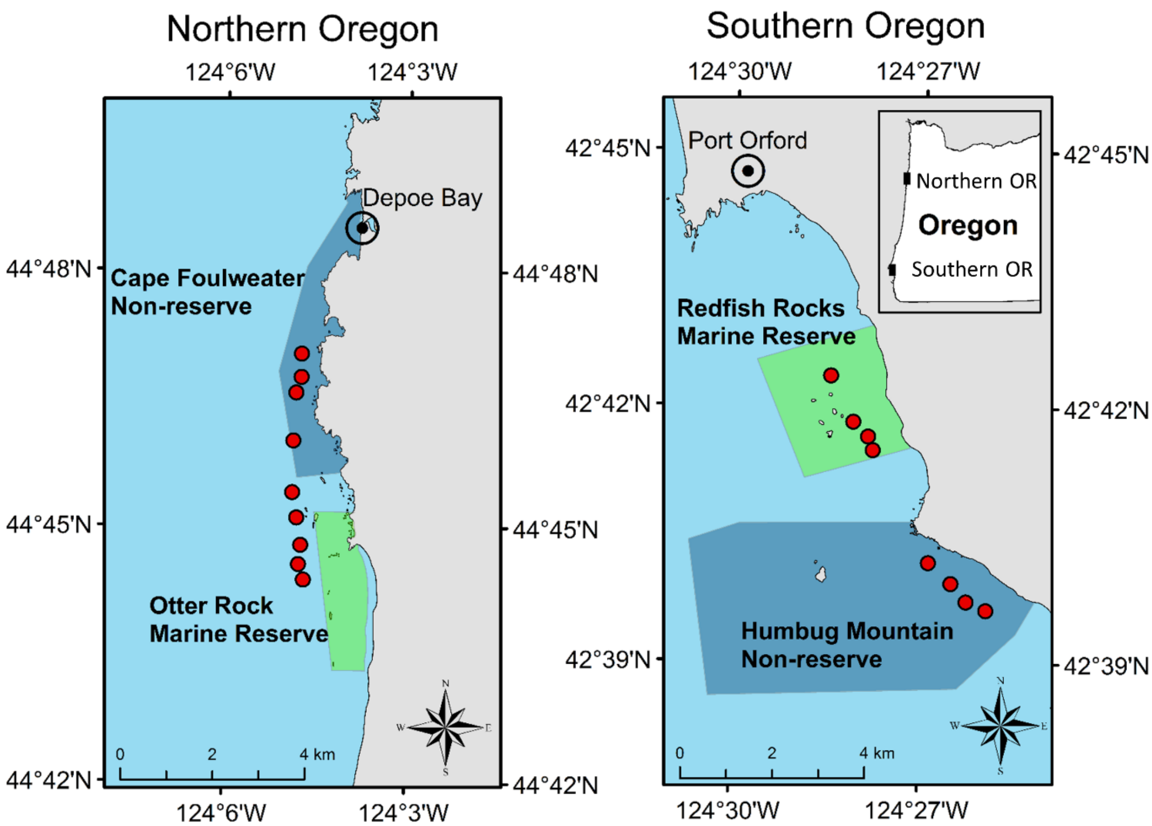


Figure 4.1: Sampling locations in two nearshore regions: northern (2012-16) and southern (2014-16) Oregon. Within each region, newly settled pelagic juveniles are sampled in replicate SMURFs grouped at either a marine reserve (green) or an unprotected comparison area (dark-blue). For Otter Rock Marine Reserve, SMURFs are located just seaward of the reserve to align with the 15-m bottom depth and remain offshore of settlement habitat. Red points indicate all the locations where SMURFs were deployed between 2011 and 2016. In 2012-13, one SMURF was located between the marine reserve and the non-reserve, but has been removed from analyses.

In each region, up to eight replicate SMURFs were deployed 1 m below the surface by attaching them to a mooring anchored in sandy substrates in ~15 m of water, 390-1,200 m from shore. The deployment locations were selected at a conservative distance offshore of underwater boulders and kelp canopy to ensure direct pelagic settlement of fish to SMURFs as opposed to movement from other surrounding substrates.

New fish settlers are collected every 2 wks during the summer settlement season (Love 2011), which starts in April-June (weather dependent) and tends to extend through September. Species identification is based on meristic characteristics; however, meristics are not always sufficient for the conclusive identification of some rockfish juveniles. The following species are conservatively grouped into three complexes: OYTB, which includes olive, yellowtail, and black rockfishes; QGBCC, which includes quillback, gopher, black-and-yellow, copper, and china rockfishes; and SR, which includes splitnose and redbanded rockfishes. The OYTB and QGBCC complexes are used to facilitate comparisons with previous research conducted off of California that used similar groupings (KGBC; Wilson et al. 2008, Caselle et al. 2010a; with the addition of china and quillback and omission of kelp rockfishes in Oregon).

Species presence within these complexes has been verified through genetic identification at the National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center in Santa Cruz, California. Additional species collected in the high numbers in these SMURFs are cabezon and tiger rockfish.

Data Summarization

Data streams collected by this tool are summarized in the following sections:

- Research Question 3B: What fish species exist at each site?

In this report we summarize the species observed to date for the two reserves where juvenile fish are collected. We also compare the average settlement rate per species across the years of study both within the associated reserve and comparison areas and across reserves. These results are reported under the Fish Section.

Research Question 1: What is the oceanographic condition of each site? How does it change over time?

To-date the ODFW Marine Reserves program has collected oceanographic data in three regions: Redfish Rocks, Otter Rock, and Cascade Head (Figure 4.2,

Table 4.2). PISCO moorings have collected data that contribute to the Cape Perpetua and Cascade Head regions (Figure 4.2). Data were collected in the Marine Reserves at these four regions, as well as at comparison areas of Humbug (for Redfish Rocks Region), Cape Foulweather (Otter Rock Region), and Cavalier (Cascade Head Region). Data collection to describe the initial oceanographic conditions for the Otter Rock, Redfish Rocks, Cascade Head and Cape Perpetua Marine Reserves began two years prior to implementation for each reserve (2010 for Otter Rock and Redfish Rocks regions, 2012 for Cascade Head and Cape Perpetua regions). Currently there have been no data collection efforts in the Cape Falcon Marine Reserve from the ODFW Marine Reserves Program.

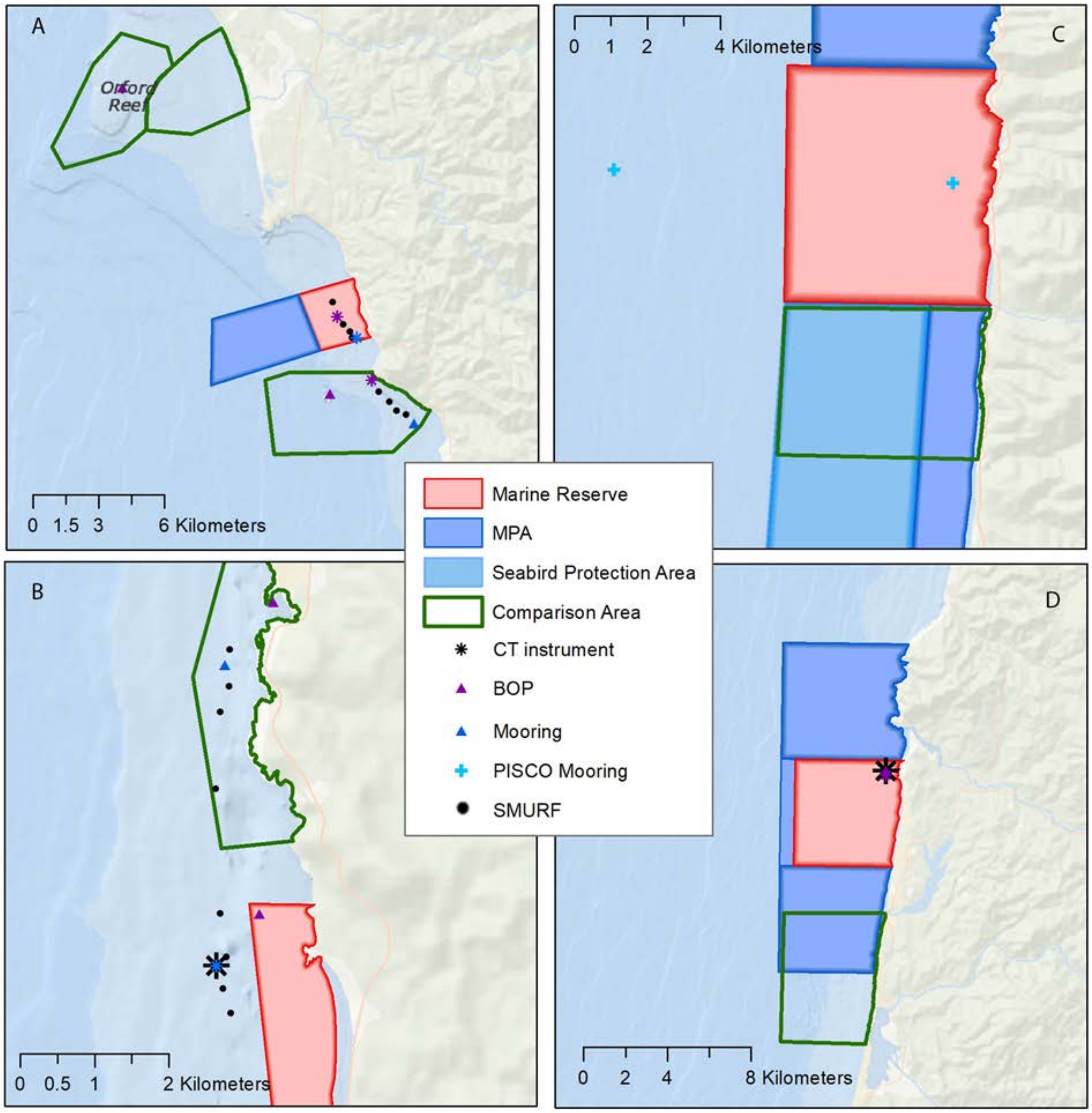


Figure 4.2: ODFW and PISCO oceanographic instruments and platforms near four of Oregon's marine reserves. A = Redfish Rocks Region, B = Otter Rock Region, C = Cascade Head Region , D = Cape Perpetua Region

*Table 4.2: Variables collected by year by ODFW and PISCO in Oregon's five marine reserve regions. O = ODFW data, P = PISCO data, *= includes intertidal data. Blank boxes indicate no data were collected.*

Site		Temperature	Salinity	DO	Chlorophyll	pH
Redfish Rocks (RR)	2010	O	O	O	O	
	2011	O	O	O	O	
	2012	O	O	O	O	
	2013	O	O	O	O	
	2014	O	O			

	2015	O	O			
	2016	O	O			
	2017	O	O			P*
Otter Rock (OR)	2010	O	O	O	O	
	2011	O	O	O	O	
	2012	O				
	2013	O	O			
	2014	O	O			
	2015	O	O			
	2016	O	O			
	2017	O	O			P*
Cascade Head (CH)	2012	P*	P	P	P	P
	2013	O, P*	O, P	O, P	O, P	P
	2014	O, P*	O, P	O, P	O, P	P
	2015					
	2016					
	2017					P*
Cape Perpetua (CP)	2012	P*	P	P	P	P
	2013	P*	P	P	P	P
	2014	P*	P	P	P	P
	2015	P*	P	P	P	P
	2016	P*	P	P	P	P
	2017	P*	P	P	P	P
Cape Falcon (CF)	2014					
	2015					
	2016					
	2017					P*

With both the ODFW and PISCO data, a variety of sensors were used to collect the physical oceanographic variables outlined in the monitoring plan: temperature, conductivity (hereon referred to as salinity), dissolved oxygen (DO), light, and fluorescence (hereon referred to as chlorophyll, Chl) (Table 4.3). These sensors were deployed on a mixture of moorings and benthic oceanographic platforms (BOPs) (Table 4.3). PISCO sensors additionally collect data on pH and carbonate (pCO2), and oceanographic currents (Table 4.4).

Table 4.3: Instruments used in oceanographic data collection along the Oregon coast by ODFW and PISCO.

ODFW

Instrument	*Data collected*	*Years used*	*Platform*
SeaBird 16-plus CT + WetStar Flourometer	Temperature, salinity, DO Chlorophyll	2010-2014	Mooring & BOP/CT cage
Odyssey CT	Temperature, salinity	2014-2017	SMURF moorings
Onset HOBO U22	Temperature	2010-2017	Mooring, BOP, SMURF

Wildlife Comp. MK9*	Light	2010-14	BOP

PISCO

Instrument	*Data collected*	*Years used*	*Platform*
SeaBird 16-plus CT	Temp, cond, DO	1998-2017	Mooring
+ WetStar Flourometer	Chlorophyll		
Sunburst SAMI	pH and pCO2	2011-2017	Mooring
RDI ADCP	Currents	2000-2017	Mooring
Onset HOBO U22	Temp	1998-2017	Mooring
+ Onset Tidbit v2			

Table 4.4: Sensor deployment locations and respective data collection teams for oceanographic data in Oregon's marine reserves. Depths are listed for each sensor as **S_S***: sensor in shallow (1-3m) location over shallow seabed (<25m);* **S_D***: sensor at/near seafloor in shallow seabed (<25m); sensor in shallow (1-3m),* **D_S***: location over deep seabed (25-75m);* **D_D***: sensor at/near seabed in deep seabed (25-75m); and* **I***: sensor located in the intertidal zone. Blanks indicate no data were collected.*

Site		Temperature					Salinity				Dissolved Oxygen				pH			Chl
		I	S_S	S_D	D_S	D_D	S_S	S_D	D_S	D_D	S_S	S_D	D_S	D_D	I	S_D	D_D	
Redfish Rocks	2010		O	O				O		O		O						O
	2011		O	O				O		O		O						O
	2012		O	O				O		O		O						O
	2013		O	O								O						O
	2014		O				O											
	2015		O				O											
	2016		O				O											
	2017		O				O								P			
Otter Rock	2010		O	O				O		O		O						O
	2011		O	O				O		O	O							O
	2012																	
	2013																	
	2014		O				O											
	2015		O				O											
	2016		O				O											
	2017		O				O								P			
Cascade Head	2010	P	P	P			P	P			P	P				P		P
	2011	P	P	P			P	P			P	P				P		P
	2012	P	P	P			P	P			P	P				P		P
	2013	P	O,P	O,P			P	O,P			P	O,P				P		O,P
	2014	P	O	O				O				O						O
	2015	P																
	2016	P																
	2017	P													P			
Cape Perpetua	2010	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2011	P	P	P	P	P	P	P		P	P	p		P		P	P	P
	2012	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2013	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2014	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2015	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2016	P	P	P	P	P	P	P		P	P	P		P		P	P	P
	2017	P	P	P	P	P	P	P		P	P	P		P	P	P	P	P
Cape Falcon	2017														P			

Data Processing

ODFW Marine Reserves oceanographic data were downloaded from the sensors and processed prior to summarization. Data were checked for instrument dropouts, erroneous readings, and other errors. Daily averages were obtained by running a function on the raw - data in Matlab using a low pass filter with a 40 hour cut-off frequency (K. Politano, J. Barth, *pers. comm*). This process smooths the data over tidal and diurnal cycles. Depending on the outputs, data were plotted in MatLab or Excel, and trends in data were visually analyzed for differences between the sampling areas and among sampling years. For data quality control, we plotted raw values for each parameter to ensure they were within known ranges for the Pacific Northwest.

Data Summarization

For each of our three most abundantly collected oceanographic parameters (temperature, salinity, and dissolved oxygen), we describe the conditions observed in several ways:

1. In the *deployment/effort table*, we describe the data collection effort across years and within the region. Since there is not enough funding or staff capacity to supply each reserve and comparison area with full instrumentation each year, efforts were made to collect data for two years prior to each reserve implementation using the CT and additional sensors. Additional data are available through collaborations with PISCO and other projects, such as SMURFs.

2. The data obtained prior to closure (and any additional) data from CT deployments are shown in the *CT Sensor Results* plots. Here, temperature (in degrees C), salinity (in Practical Salinity Units or PSU), and dissolved oxygen (in ml/L) are shown over the same time scale. Deployments of the CT were typically over the course of the summer months but some fall and winter, as well as 12-month deployments are shown as well.

3. Where available, surface (1-3m deep) temperature data collected with an Onset HOBO U22 sensor inside the reserve and in a nearby comparison area are shown over years in which both data sets were collected. These sensors were near the surface on moorings in 15-20m water depth.

4. For marine reserves that had over 3 years of shallow surface temperature data, a series of *climatology* plots are shown. Each plot shows the daily average temperature for a given year, the daily average over all years, and the standard deviation over all-years.

Research Question 2: What habitats exist within each site? How do they change over time?

The ODFW's ecological monitoring program is tasked with understanding what habitats exist within each site and how they change over time. Within the OPAC Marine Reserve Policy Recommendations the key types of marine habitats are rocky intertidal, rocky subtidal with canopy forming kelp, rocky subtidal without canopy forming kelp and soft bottom subtidal. All areas accept intertidal are further defined by depth (< 25 m = shallow, > 25 m = deep). There are six types of habitat data that are gathered by our monitoring tools (Table 4.5).

Table 4.5: Habitat data collected by monitoring tool for Oregon's marine reserves. Blank boxes indicate that no data were collected.

	Lander	RoV	Diver	Intertidal
Depth	X	X	X	N/A
Relief	X		X	N/A
Substrate type	X	X	X	N/A
Kelp	X		X	X
Macroalgae	X		X	X
Biogenic complexity	X	piloted		N/A

Data Collection

To date the ODFW Marine Reserves program has collected habitat data at all five Marine Reserves. We do not currently collect data targeting habitats with kelp or soft bottoms communities. All data collection efforts are either in intertidal or subtidal rocky habitats. We gather habitat data through scuba diver, landers, ROV, and intertidal surveys.

Data Summarization

Data are summarized first by reserve, and then by habitat type. Scuba and intertidal data are unavailable for summarization because their data management systems are under development. Reporting occurs for subtidal rocky habitats only. For the lander surveys we summarize data on both non-living and living substrate while ROV is only used to summaries non-living habitat.

For non-living substrates we report on depth, relief, and substrate type (see Lander Methods Document for more details) at the individual site, management, and regional spatial scales for each marine reserve and associated comparison areas. We report on the drops that were conducted at shallow (<25m) vs deep (>25m) depths, and on relief (low, moderate high) in terms of percentage of useable drops containing a given relief category by year. For depth we also summarize the depth range and mean drop depth covered by our useable lander drops. For lander and ROV data we also describe the relative frequency of each primary habitat observed.

In addition to data summaries for substrate type, we have also used our lander data to ground truth the habitat classifications from the SGH4 layer produced by the Goldfinger Lab at Oregon State University.

Many derived habitat traits are under development for analysis with species-habitat correlations and we wanted to verify its general accuracy in terms of habitat classifications. Specifically, SHG 4 habitat categories for Lith1 (Primary Habitat), Lith3 (Primary + Secondary), and IND (general category = Hard, Soft, Mixed) were used for comparison.

After ground truthing the derived habitat classifications, hard and soft habitat classifications were compared using the SGH4 habitat layer create by the Goldfinger lab at Oregon State University. For this comparison the IND (general category = Hard, Soft, Mixed) habitat classification was used to compare the available habitat classification available at the regional level (marine reserve +comparison areas), management area (marine reserve, comparison areas pooled), and the site (marine reserve, comparison area, comparison area).

For our living substrates, we have only lander data to report. We begin by reporting the percentage of drops that contain our five biogenic categories by year (see Lawrence et al 2016 and Lander Methods Document for more details). We also report on the percentage of drops that contained a given abundance index for the associated biogenic categories by year (see Lawrence et al 2016 and Lander Methods Document for more details).

Research Question 3A: What invertebrate species exist at each site?

ODFW's ecological monitoring program is tasked with identifying the invertebrate species and communities which exist within each site and how they change over time. Oregon's Marine Reserves have four main habitat types, but not all reserves have each habitat type (Table 4.6). To date survey efforts have focused on rocky hard bottom areas and we do not report on any subtidal soft bottom invertebrate communities. There are five main datasets that provide invertebrate information within Oregon's Marine Reserves (Table 4.7). We are working on data management for our scuba diver and intertidal surveys, therefore only effort summaries are reported by site by year.

Table 4.6:Habitat type by marine reserve. Blank boxes indicated no data were collected.

Marine Reserve	Intertidal	Shallow Rocky Subtidal	Deep Rocky Subtidal
Redfish Rocks		X	X
Otter Rock	X	X	
Cascade Head	X	X	X
Cape Perpetua	X		X
Cape Falcon	X	X	

Table 4.7: Marine reserve monitoring tools and partner datasets that provide information on invertebrate species found in Oregon's marine reserves. Blank boxes indicated no data were collected.

	Intertidal	Shallow Rocky Subtidal	Deep Rocky Subtidal
Diver		X	
Lander		X	
ROV			X
PISCO-OSU	X		
PISCO- UC Santa Cruz	X		

We report on the invertebrate communities by habitat type (rocky subtidal shallow, rocky subtidal deep) for each reserve. For rocky subtidal shallow habitats we only report data from our video lander surveys. While ROV data are only reported for rocky subtidal deep areas.

For our lander surveys, we first summarize the effort in terms of total useable drops per year. These are videos that meet our pre-determined conditions of visibility, view and rocky reef habitat. In 2015 we began noting out total effort of lander drops and from this year onwards we report on percentage of drops useable based on overall drops conducted. Then we summarize the percentage of drops yielding observations of invertebrates by species richness. We report on species observations by region and describe the sample size containing that species. The proportion of retained drops in which a given species was observed was calculated. A species that occurred in ≥20% of drops was considered common, while species occurring <20% were considered rare (Stobart et al. 2007). We also calculated a mean MaxN (maximum number of individuals), a common measure of reporting abundance for this tool (Watson and Huntington 2016), and also the total individuals of a given species observed. We provide a quick summary of total species richness and total number of individuals observed by year by site. Finally for invertebrates, we conclude by reporting mean MaxN by year for Sea Stars, one of our suggested focal species.

For the ROV surveys, we first summarize the number of transects conducted per year. Density calculations are made only using suitable "Non-gap" portions of data (see ROV Methods Document for more details). For the Redfish Rocks region only, we conclude with a summary comparison of total sea star counts by year by site, one of our suggested focal species.

Research Question 3B: What fish species exist at each site?

The ODFW's ecological monitoring program is tasked with understanding what fish species exist within each site and how they change over time. Oregon's Marine Reserves have four main habitat types, but not all reserves have each habitat type (Table 4.8). Therefore we report on the fish communities by habitat type for each reserve. There are six main datasets that provide information on fish in Oregon's marine reserves (Table 4.9). We believe these tools will allow us to report on relevant measures of biodiversity, abundance, community composition, size, sex, and life stage of fish in the future (Table 4.9). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. The scuba and longline data are unavailable for summarization to include in this report. Therefore, shallow subtidal rocky reefs are surveyed by both scuba surveys (restricted to depths < 20m), landers (post 2014 restricted to depths < 30m), and SMURFs. Since hook-and-line and longline surveys span the shallow (< 25m) and deep (> 25m) rocky reefs summaries are reported in a separate section which combines both depths. In the future, summaries and analyses will be partitioned by depth. Lastly, the deep rocky subtidal areas are also surveyed by the ROV which is restricted to depths > 20m.

Table 4.8: Marine reserve monitoring tools & partner datasets that provide information on fish species found in the marine reserves. Blank boxes indicated no data were collected.

	Rocky subtidal	
	Shallow	Deep
Scuba	X	
Lander	X	
ROV		X
Hook & Line	X	X
Longline	X	X
SMURF	X	

Table 4.9: Marine reserve monitoring tools & the potential analyses for each fish dataset. Sex is noted only for sexually dimorphic species. Blank boxes indicate that no data are available.

	Biodiversity				Abundance		Community Composition	Size	Life stage		Sex
	Richness	Evenness	Frequency of Occurrence	Index	Relative	Density			Juvenile	Adult	
Scuba	X	X	X	X	X	X	X	X		X	X
Lander	X	X	X	X	X		X			X	X
ROV	X	X	X	X	X	X	X	X		X	X
Hook & Line	X		X		X		X	X		X	X
Longline	X		X		X		X	X		X	X
SMURF	X		X		X		X		X		

For our lander surveys, we first summarize the effort in terms of total useable drops per year. These are videos that meet our pre-determined conditions of visibility, view and rocky reef habitat (see Lander Methods Document for more details). In 2015 we began noting out total effort of lander drops and from this year onwards we report on percentage of drops useable based on overall drops conducted. Then we summarize the percentage of drops yielding observations of invertebrates by species richness. We report on species observations by region and describe the sample size containing that species. The proportion of retained drops in which a given species was observed was calculated. A species that occurred in ≥20% of drops was considered common, while species occurring <20% were considered rare (Stobart et al. 2007). We also calculated a mean MaxN (maximum number of individuals), a common measure of reporting abundance for this tool (Watson and Huntington 2016), and also the total individuals of a given species observed. We provide a quick summary of total species richness and total number of individuals observed by year by site.

For the ROV surveys, we first summarize the number of transects conducted per year. In this report, data for fish species with very few ROV observations (generally <10) are excluded from graphics, but are incorporated into metrics such as species richness and calculations of percent of total observations. Density calculations are made only using suitable “Non-gap” portions of data (see ROV Methods document), but species-habitat association graphics and total abundance tables are based on all observations. This may induce some visual discrepancy between these portions of the report, particularly because the two typically most-prominent fish (Black Rockfish and Blue/Deacon Rockfish) are semi-pelagic and are very frequently observed during midwater "Gaps". Gaps can occur when the ROV is far off the bottom while transiting high relief substrates. In these gaps, the background substrate is not in view, the transect width is not defined, and therefore fish density calculations are not made.

Fish density calculations for ROV data in this report are made using whole 500 m transects as sample units. While this choice incorporates a large amount of habitat heterogeneity within transects, it maximizes the degree of independence between sample units and therefore maximizes the reliability of statistical inferences drawn from the resulting data. Densities are the sum of individuals of each species observed in non-gap sections of each transect, divided by the total non-gap area viewed for each transect. The weighted mean and weighted SD are calculated using the total non-gap area viewed as the transect weight. Area viewed is calculated for all 20-m segments along each transect by multiplying the non-gap segment length by the segment's mean transect width. The on-screen width of the 10 cm scaling lasers is measured at 30-second intervals, and the moving-average laser width is used in combination with the ROV's pitch data at each second to generate a transect width estimate for each 1-second interval.

We summarize our hook and line survey data by sampling effort in cells and report the percentage of sampling cells yielding observations of fish species. We describe species sample size, total individuals caught, representative % of total catch, and mean catch per unit effort (CPUE) in angler hours fished. We provide a quick summary of total species richness and total number of individuals observed by year by site.

For our collaborative juvenile fish research, we summarize the species observed to date for the two reserves where juvenile fish are collected. We also compare the average settlement rate per species across the years of study both within the associated reserve and comparison areas and across reserves.

Research Question 4: What are the species-habitat correlations at each site? How do they change over time

We are still learning about the species and habitats in Oregon's marine reserves, and therefore, are in the early stages of understanding species-habitat correlations. We are therefore providing an initial summary of observations, from the ROV, which describes the habitats where fish were observed in Redfish Rocks, Cascade Head, and Cape Perpetua marine reserves (Table 4.6). We present the data as percentage of fish observations by habitat type, tables of total observations by species, and graphics of primary habitat relative frequency at the given site or region. The goal is not to suggest that these are species-habitat correlations but to provide a few pieces of the larger species-habitat puzzle we will continue to explore over time.

Research Question 5: Does the prohibition of extractive activities change the community structure of the reserve?

Data collection

Data have been compiled from commercial fish tickets (1994-present), ODFW recreational boat sampling program (1994-present), and RecFIN (2001-present) from the ports most closely associated with each reserve (Table 4.10). For each region, this data has been used to classify the prior fishing pressure (Table 4.10). These data also provide information on species caught, landed catch (in pounds), average length, average weight, mortality, released fish, and general location (Figure 4.3;Table 4.11). The years that are relevant to comparison of effort prior and post marine reserve closure will be determined for future analyses.

Table 4.10: Oregon Marine Reserves, related ports and prior fishing pressure.

Reserve	Identified Ports	Prior Fishing Pressure
Redfish Rocks	Port Orford	High groundfish effort Moderate crab effort High urchin effort Low abalone effort
Otter Rock	Newport	Low groundfish effort Low crab effort Moderate urchin effort Moderate shoreside effort (surfperch)
Cascade Head	Depoe Bay Lincoln City Pacific City Salmon River	High groundfish effort Low crab effort Moderate salmon effort Moderate shoreside effort (crab, groundfish, surfperch, intertidal harvest)
Cape Perpetua	Newport Yachats Florence	Low groundfish effort High crab effort High salmon effort Low halibut effort High shoreside effort (groundfish, surfperch, intertidal harvest)
Cape Falcon	Nehalem Garibaldi	Low groundfish effort Moderate crab effort Low shoreside effort (crab, groundfish, surfperch, intertidal harvest)

Table 4.11: Fisheries data type, information and years available for ODFW Marine Reserve Program analysis.

Fisheries Data Available	Information	Years
Commercial Fish Tickets	Gear type Species Landed catch (in pounds)	1994-present
ODFW Recreational boat sampling (ORBS) program (sampled ports only)	Boat & trip type Species Landed catch Average length Average weight Estimated releases	1994-present
RecFIN (sampled by ORBS + unsampled ports)	Boat & trip type Species Landed catch Average length Average weight Estimated releases	2001 – present

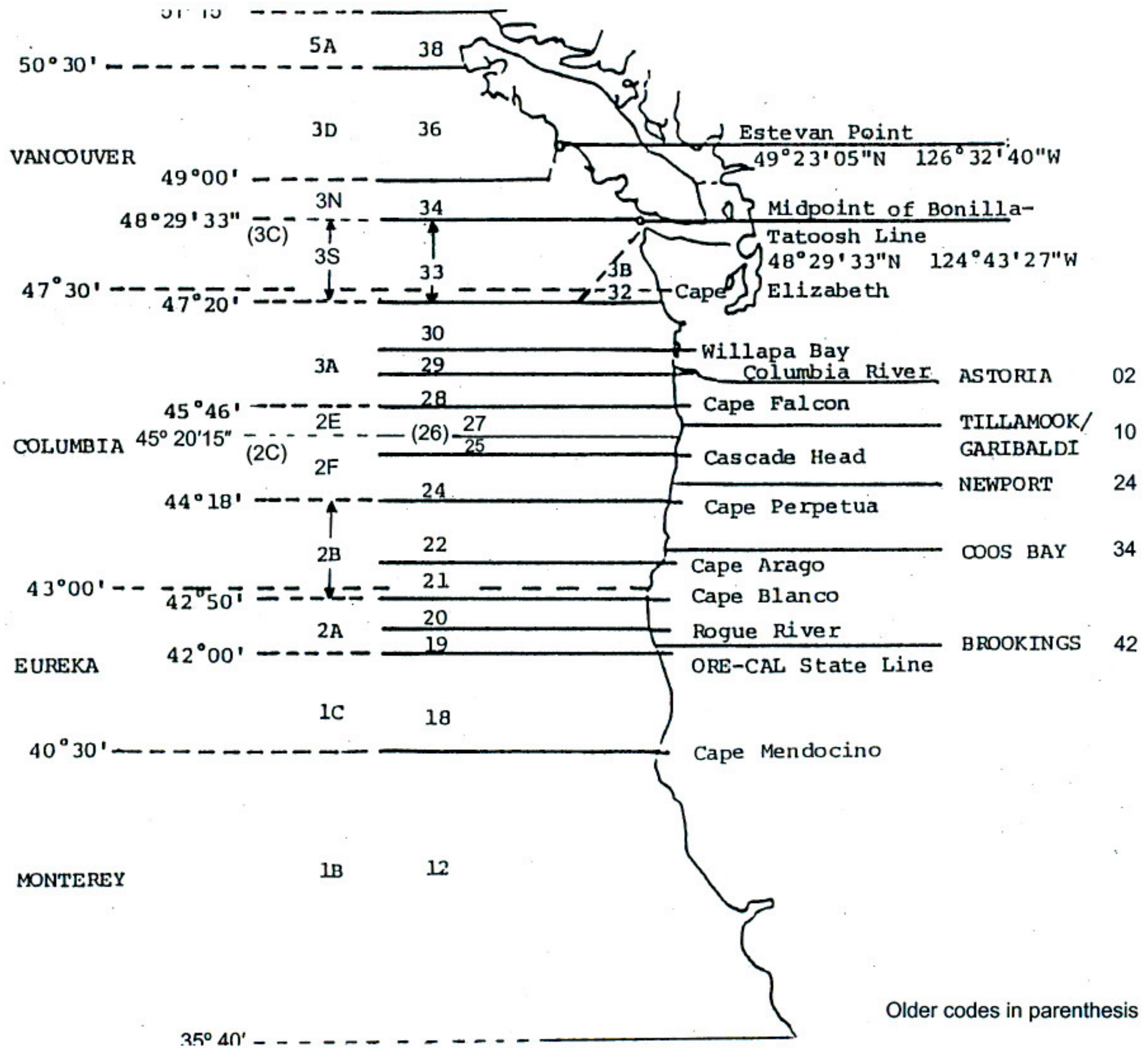


Figure 4.3: State area fisheries boundaries in the Pacific Northwest, and associated Oregon landmarks and dominant ports. The area is managed by state agencies, the Pacific Fisheries Management Council (PFMC), and the North Pacific Anadramous Fish Commission (INPFC). INPFC areas are Alaska (not shown), Vancouver, Columbia, Eureka, and Monterey. PFMC areas are listed as 1B-5A. State agency areas are listed as 12-38. Oregon data cover areas 12-33.

Data Summarization

Limited staff capacity has prevented us from summarizing available data for this report.

Research Question 6: Are patterns or changes within the marine reserve consistent throughout the marine reserve system?

We report on our progress addressing if the patterns or changes within the marine reserve are consistent throughout the marine reserve system. Our most advanced section is oceanography. For each location along the OR coast where temperature, salinity and dissolved oxygen data were collected (Figure 4.2) at similar depths (Table 4.4), we plotted daily mean values across years to determine if there were any regional patterns in oceanographic conditions through time. In addition to oceanography, we report on the juvenile recruitment patterns observed in the Redfish Rocks and Otter Rock Marine Reserves over time. For our collaborative juvenile fish research, we compare the average settlement rate per species across the years of study both within the associated reserve and comparison areas and across reserves. We are still working to characterize the initial conditions in many of the reserves and therefore all other areas of research where we may look for patterns are a work in progress.

Section 5: Fish

The ODFW's ecological monitoring program is tasked with understanding what fish species exist within each site and how they change over time. Oregon's Marine Reserves have four main habitat types, but not all reserves have each habitat type (Table 5.1). Therefore we report on the fish communities by habitat type for each reserve. There are six main datasets that provide information on fish in Oregon's Marine Reserves (Table 5.2).

Table 5.1: Marine reserve monitoring tools & partner datasets that provide information on fish species found in the marine reserves.

	Rocky subtidal	
	Shallow	Deep
Scuba	X	-
Lander	X	-
ROV	-	X
Hook & Line	X	X
Longline	X	X
SMURF	X	-

Table 5.2: Marine reserve monitoring tools & the potential analyses for each fish dataset. Sex is noted only for sexually dimorphic species.

	Biodiversity				Abundance		Community Composition	Size	Life stage		Sex
	Richness	Evenness	Frequency of Occurrence	Index	Relative	Density			Juvenile	Adult	
Scuba	X	X	X	X	X	X	X	X	-	X	X
Lander	X	X	X	X	X	-	X	-	-	X	X
ROV	X	X	X	X	X	X	X	X	-	X	X
Hook & Line	X	-	X	-	X	-	X	X	-	X	X
Longline	X	-	X	-	X	-	X	X	-	X	X
SMURF	X	-	X	-	X	-	X	-	X	-	-

Table 5.3: Habitats surveyed for fish at each marine reserve site by year. Blank boxes indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, H = Hook & Line, G = Longline, M = SMURF

		Year							
Site	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Shallow Rocky Subtidal	D, L	D, L, H	L, H	H	D, L, H, M	D, L, H, G, M	G, M,	H, G, M
	Deep Rocky Subtidal	R	H	H	H	H	H, G	R, H, G	H, G
Otter Rock	Shallow Rocky Subtidal	D	D, L, M	L, M	M	M	D, L, M	M	D,L, M
Cascade Head	Shallow Rocky Subtidal	-	-	L	D, L, H	D,L, H	H	L , H	D, L
	Deep Rocky Subtidal	-	-	R	R, H	H	R, H	H	R
Cape Perpetua	Deep Rocky Subtidal	R	R	R	H	H	R	H	R
Cape Falcon	Shallow Rocky Subtidal	-	-	-	-	H	H	D	D,L, H

Table 5.4: Marine Reserve focal fish species. Tier 1 are highest priority for data analysis; Tier 2 are as time and data allow.

Focal Fish Species	
Tier 1	Tier 2
Kelp Greenling	Pile Perch
Lingcod	Tiger Rockfish
Striped Surfperch	Vermilion Rockfish
Black Rockfish	Widow Rockfish
Blue Rockfish	Yellowtail Rockfish
Canary Rockfish	Buffalo Sculpin
China Rockfish	Red Irish Lord
Copper Rockfish	
Deacon Rockfish	
Quillback Rockfish	
Yelloweye Rockfish	
Cabezon	

Redfish Rocks

We have scuba, lander, hook-and-line, longline, SMURF, and ROV data to provide information on the fish species observed in rocky subtidal habitats in the Redfish Rocks Marine Reserve and associated comparison areas (Table 5.5). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. Therefore, shallow subtidal rocky reefs are surveyed by both scuba surveys (restricted to depths < 20m), landers (restricted to depths < 30m), and SMURFs. Since hook-and-line and longline surveys span the shallow (< 25m) and deep (> 25m) rocky reefs summaries are reported here in a separate section which combines both depths. In the future, summaries and analyses will be partitioned by depth. Lastly, the deep rocky subtidal areas are also surveyed by the ROV which is restricted to depths > 20m.

Table 5.5: Fish data collected by habitat type by year in the Redfish Rocks Marine Reserve and its three comparison areas by year. Blank boxes indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, H = Hook & Line, G = Longline, M = SMURF

			Year							
Site	Area	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Redfish Rocks MR	SMURFs	-	-	-	-	M	M	M	M
		Shallow Rocky Subtidal	D, L	D, L, H	L, H	H	D, L, H, M	D, L, H,G, M	G, H, M	H, G, M
		Deep Rocky Subtidal	R	H	H	H	H	H	R, H	H
	Orford Reef CA	SMURFs	-	-	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	-	-	-	L, H	L, H	-	H, G
		Deep Rocky Subtidal	R	-	-	-	H	H	R	H
	Humbug CA	SMURFs	-	-	-	-	M	M	M	M
		Shallow Rocky Subtidal	D, L	D, L, H	L, H	H	D, L, H, M	D, L, H, G, M	L, M, H, G	H, G, M
		Deep Rocky Subtidal	R	H	H	H	H	H	R	H

Shallow Rocky Subtidal

Scuba Diver Survey Effort

Scuba data are unavailable for analysis at this time, but effort by year by site can be found in Table 5.6.

Table 5.6: Scuba diver effort (number of transects) by year in the Redfish Rocks Marine Reserve and associated comparison areas for fish surveys.

		Year			
Region	Site	2010	2011	2014	2015
Redfish Rocks	Redfish Rocks MR	44	28	54	-
	Orford Reef CA	-	-	42	-
	Humbug CA	14	18	68	27
	All Sites Combined	58	46	164	27

Lander

Only a proportion of the lander drops were useable, given constraints of view, visibility and habitat type (Table 5.7). For any given year yield was never more than 35 useable drops (Table 5.7). We did not begin tracking total drops compared to useable drops until 2015. Even when we combine useable drops for all sites to look at sample size for the Redfish Rocks Region, the total drops are never greater than 75.

Table 5.7: Lander effort represented by total number of useable drops by year in the Redfish Rocks Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – represent where no data were recorded.

		Year					
Region	Site	2010	2011	2012	2014	2015	Total Useable Drops
Redfish Rocks	Redfish Rocks MR	15	16	22	35	25	113
	Orford Reef CA	-	-	17	16	-	33
	Humbug Mountain CA	13	7	6	24	32	82
	All Sites Combined	28	23	45	75	57	228
	Total Drops Conducted	NA	NA	NA	NA	93	
	% Useable Drops	NA	NA	NA	NA	62%	

Lander drops yielded low observations of fish species (Table 5.8). For four of the five years of lander drops, the vast majority of drops yielded observations of four different species (Table 5.8). Overall, it was rare to see more than four different species on any given drop in any given year. When looking across all years, the maximum number of different species observed in a single drop was six (n=1).

Table 5.8: The percentage of useable lander drops yielding observations of fish species for the Redfish Rocks region.

		Year				
Region	Species Richness Value	2010	2011	2012	2014	2015
Redfish Rocks	0	11%	26%	33%	22%	21%
	1	32%	39%	31%	19%	26%
	2	25%	9%	22%	29%	32%
	3	14%	9%	7%	11%	21%
	4	14%	4%	7%	17%	-
	5	4%	13%	-	1%	-
	6	-	-	-	1%	-
	Total Drops	28	23	45	75	57

Considering all useable drops, in all sites and years, fish were identified to species in 77% (n =176) of lander drops. Overall, fourteen species of fish were observed, across five families. Three species were classified as common with Black Rockfish being the most frequently observed (Table 5.9). Of the remaining eleven species that were classified as rare, Lingcod had the highest frequency of occurrence in useable drops at 14% (Table 5.9). When present, five (of 14) species exhibited mean MaxN values greater than one (Table 5.9).

Table 5.9: Of the drops that met condition of habitat, visibility, and view in the Redfish Rocks region (n =228), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and total individuals observed across drops.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Redfish Rocks Region	Black Rockfish	114	50%	Common	2.6	298
	Blue/Deacon Rockfish	72	32%	Common	3.8	270
	Cabezon	2	1%	Rare	1.0	2
	Canary Rockfish	18	8%	Rare	2.6	46
	China Rockfish	2	1%	Rare	1.0	2
	Kelp Greenling	107	47%	Common	1.1	123
	Lingcod	32	14%	Rare	1.0	33
	Pile Perch	3	1%	Rare	1.0	3
	Quillback Rockfish	1	0%	Rare	1.0	1
	Striped Surfperch	19	8%	Rare	1.7	32
	Vermilion Rockfish	1	0%	Rare	1.0	1
	Wolf Eel	1	0%	Rare	1.0	1
	Yelloweye Rockfish	4	2%	Rare	1.0	4
	Yellowtail Rockfish	5	2%	Rare	1.2	6

When comparing across individual sites by year, species richness is consistently under ten (Table 5.10). Even when combining richness for all sites, the maximum value of species richness is thirteen. The

Redfish Rocks Marine Reserve has similar species richness across all years to the Humbug Comparison Area. Orford reef had low species richness and few total individuals observed compared to all other locations. 2014 stands out as a year where many more total individuals were observed in both the Redfish Rocks Marine Reserve and Humbug comparison area. However, increased effort during this year may be linked to both more total individuals and higher species richness.

*Table 5.10: Lander survey richness by counts by year at the Redfish Rocks Marine Reserve and surrounding comparison areas. * = Change in lander configuration, camera type, and drop duration to current methods(Mini GoPro camera, 8 min drops) Total species richness, total # individuals observed in the lander invertebrate datasets by year at the Redfish Rocks Marine Reserve & associated comparison areas. - represent where no data was collected.*

			Year				
	Site	Metric	2010	2011	2012	2014*	2015*
Redfish Rocks Region	Redfish Rocks MR	Total species richness	5	8	6	10	4
		Total # individuals observed	79	81	66	127	54
	Orford Reef CA	Total species richness	-	-	4	5	-
		Total # individuals observed	-	-	65	27	-
	Humbug CA	Total species richness	6	2	5	8	7
		Total # individuals observed	42	4	24	124	129
	All Areas Combined	Total species richness	6	8	6	13	7
		Total # individuals observed	121	85	155	278	183

Juvenile Fish Research

With the exception of cabezon, settlement of most sampled taxa has been highly variable across years, with annual means ranging 0-1.5 fish SMURF-1 day-1 in some taxa in both the Redfish Rocks Marine Reserve (Fig 5.1) and Humbug Comparison Area (Fig 5.2).

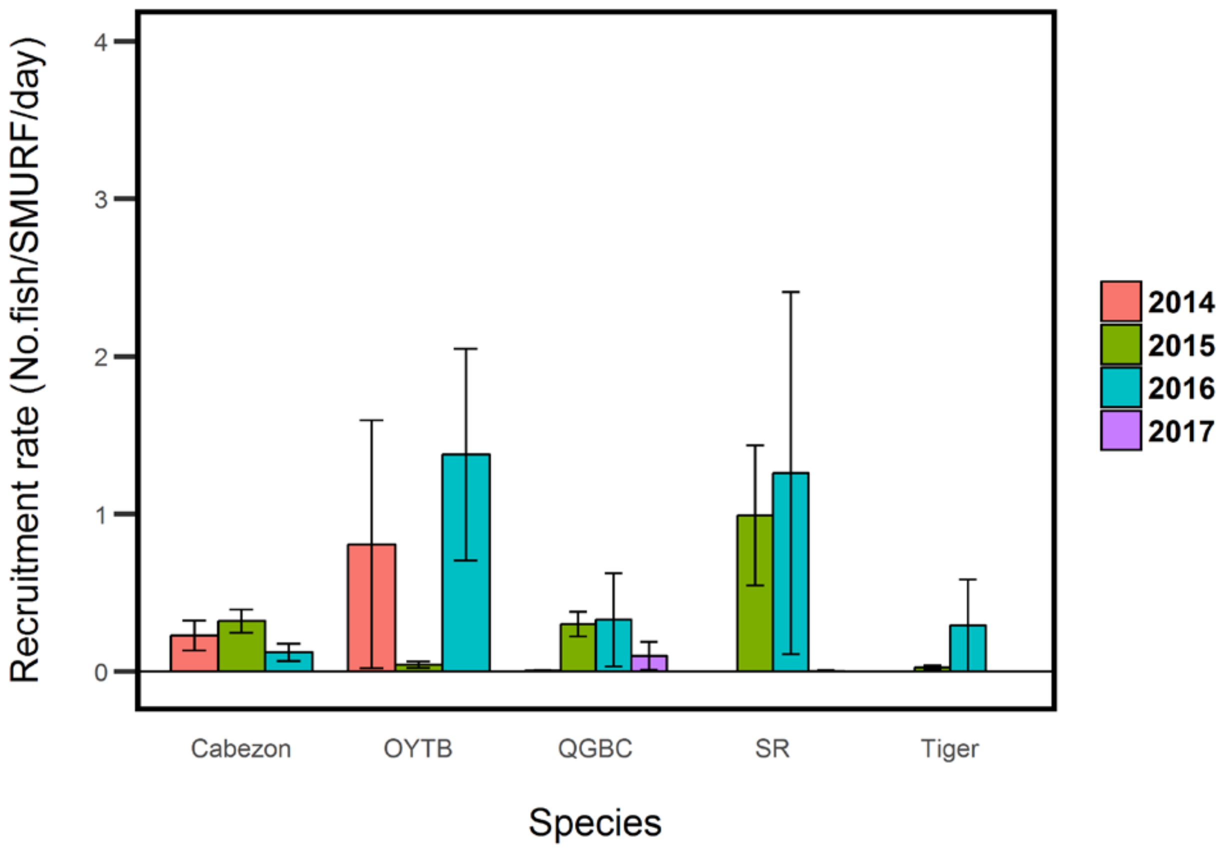


*Figure 5.1 Annual recruitment (settlement) of five fish taxa to Redfish Rocks Marine Reserve. Recruitment rate (N fish SMURF^{-1} day^{-1}) is averaged over all the replicate SMURFs within each region per year. Data are available from 2014-2017 for southern Oregon, when sampling began. Error bars indicate standard error. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

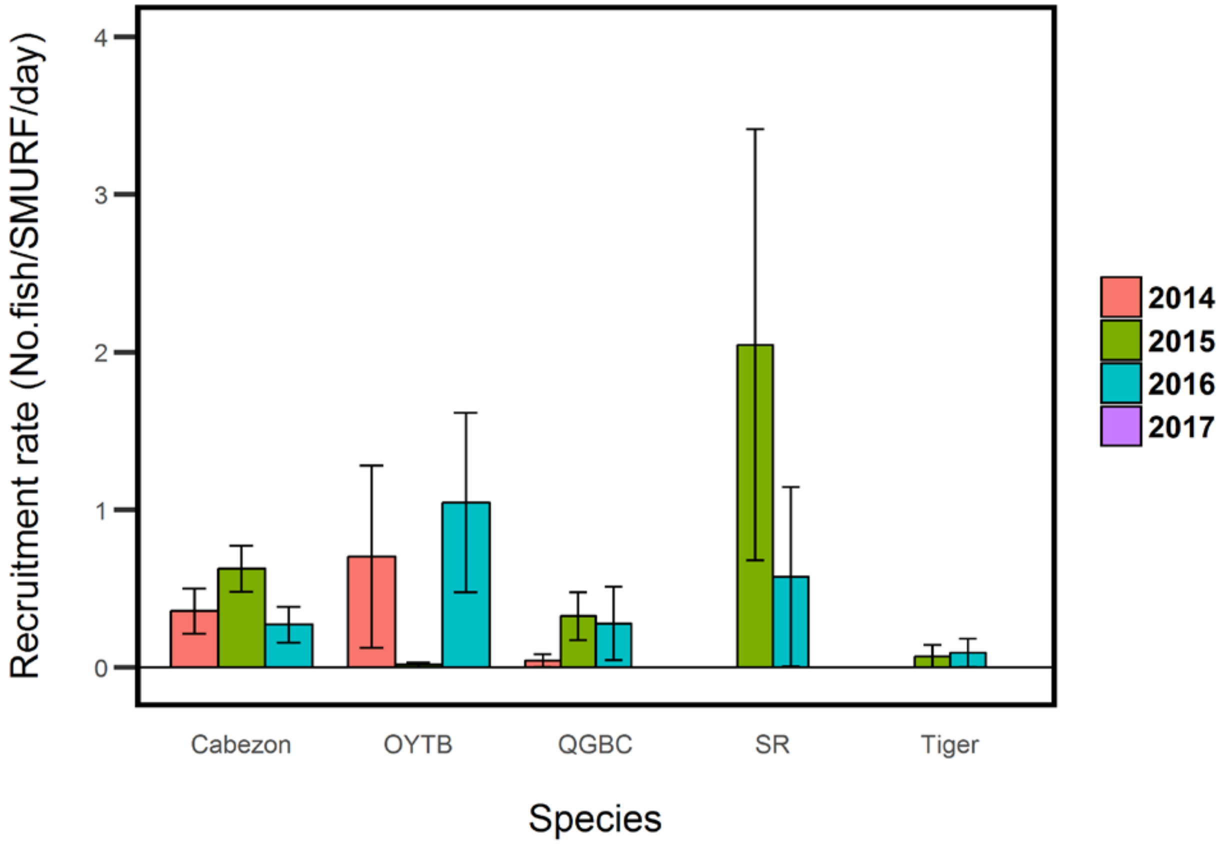


*Figure 5.2 Annual recruitment (settlement) of five fish taxa to Humbug Mountain Comparison Area. Recruitment rate (N fish SMURF^{-1} day^{-1}) is averaged over all the replicate SMURFs within each region per year. Data are available from 2014-2017 for southern Oregon, when sampling began. Error bars indicate standard error. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

OYTB exhibit greater settlement to marine reserves than to unprotected comparison areas (Fig. 5.2). Cabezon exhibit the opposite trend, with greater settlement to the unprotected area than to the marine reserve. Settlement of the remaining taxa do not appear to differ between reserves and non-reserve areas.

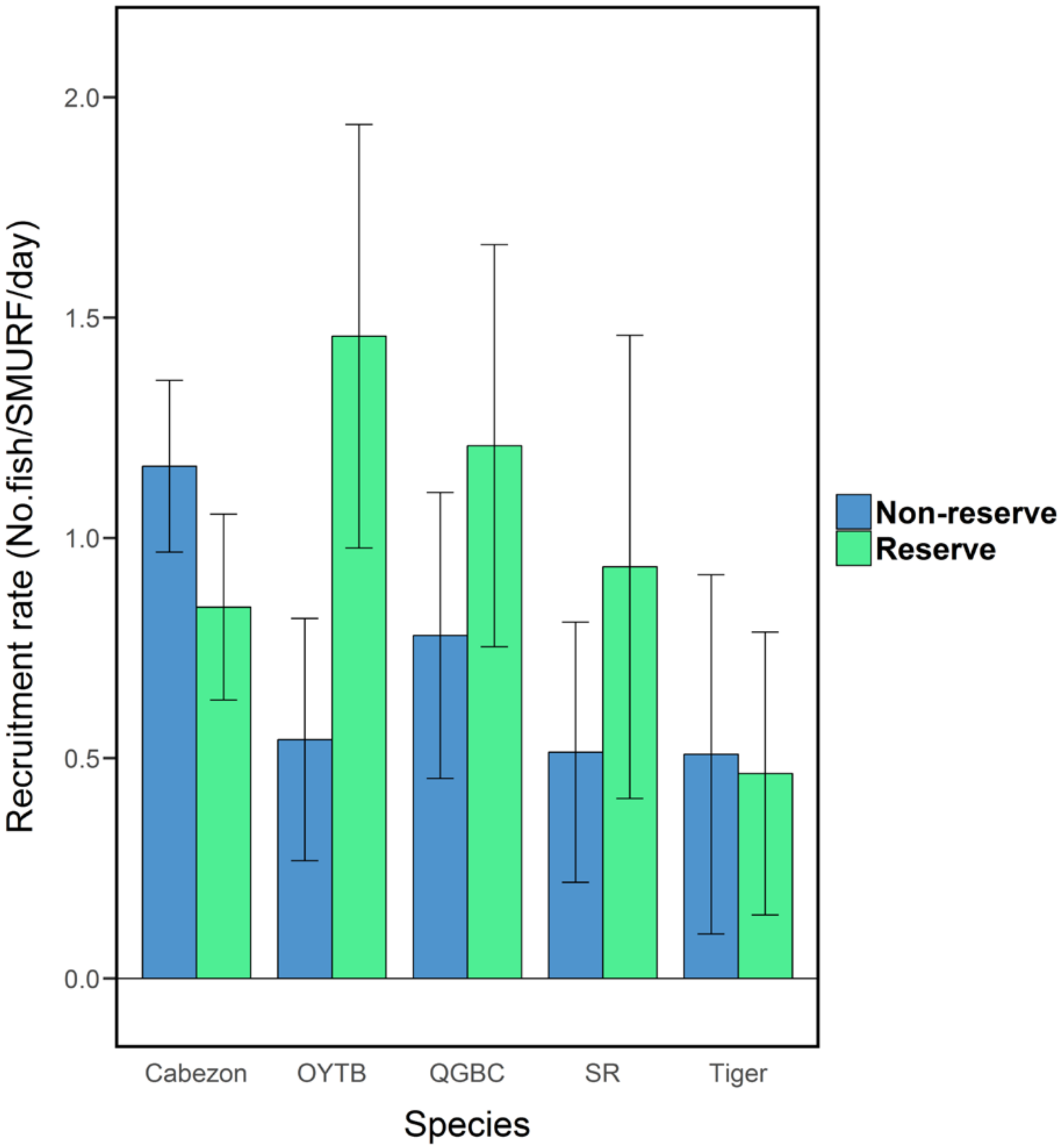


*Figure 5.3 Recruitment (settlement) rate of OYTB is greater in the Redfish Rocks Marine Reserve (green) when compared to the Humbug Mountain Comparison Area (blue) over 2012-2017. Settlement rate (N fish SMURF^{-1} day^{-1}) was averaged over all the replicate SMURFs within site and normalized by the annual mean settlement from each region to account for the year random effect. Error bars indicate standard error. Number of sampling collections shown under bars. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

Shallow and Deep Rocky Subtidal

Hook- and –Line Surveys

A total of 338 cells were sampled in Redfish Rocks region from 2011-2017. Of these completed cells 323 (96%) encountered fish (Table 5.11) .

Table 5.11: Hook-and-Line effort represented by total number of cells completed by year in the Redfish Rocks Marine Reserve and associated comparison areas for fish surveys."–" represent where no data were recorded.

		Year						
Region	Site	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Redfish Rocks MR	39	42	14	20	28	4	20
	Orford Reef CA	-	-	-	14	9	-	17
	Humbug Mountain CA	26	37	14	12	20	3	19
	All Sites Combined	65	79	28	46	57	7	56

Hook-and-line sampling yielded moderate observations of fish species (Table 5.12). For five of the seven years sampling cells produced seven or more species (Table 5.12). As a general pattern most sampling cells across all years produced three to five species (Table 5.12). When looking across all years the maximum species richness observed per cell at the Redfish Rocks region was 12 with a mean richness per cell of 3.99 (±0.13SE).

Table 5.12: The percentage of sampling cells yielding observations of fish species for the Redfish Rocks region.

		Year						
Region	Species Richness Value	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	0	3%	11%	-	2%	2%	-	4%
	1	14%	22%	-	2%	9%	-	5%
	2	15%	30%	-	13%	12%	57%	7%
	3	17%	14%	14%	11%	16%	-	5%
	4	18%	14%	18%	17%	7%	29%	25%
	5	11%	6%	14%	22%	21%	-	14%
	6	14%	3%	14%	13%	10%	14%	18%
	7	3%	-	18%	7%	10%	-	11%
	8	5%	-	11%	7%	7%	-	7%
	9	-	-	11%	2%	4%	-	4%
	10	-	-	-	2%	2%	-	-
	11	-	-	-	-	-	-	-
	12	-	-	-	2%	-	-	-
	Total Cells Sampled	65	79	28	46	57	7	56

Overall, a total of 5,132 individual fish representing 22 species from four families were caught in the Redfish Rocks region. Ninety-one percent of the catch at the Redfish Rocks region was made up of seven species including Black Rockfish, Lingcod, Kelp Greenling, Blue/Deacon Rockfish, Canary Rockfish, Yellowtail Rockfish, and Deacon Rockfish (Table 5.13). Note that Blue/Deacon, Blue, and Deacon Rockfish are reported separately because prior to 2013 there was confusion in species identification. When present five species exhibited mean CPUE (expressed as angler hour) values greater than one (Table 5.13).

Table 5.13: Of the cells that were surveyed in the in the Redfish Rocks region from 2011-2017 (n = 338), species sample size (N), total number of individuals caught, percentage of total catch that each species represents, and mean CPUE (SE) (angler hour) for each species is represented.

	Species	N	Total Individuals Caught	% of Total Catch	Mean CPUE (SE) (angler hour)
Redfish Rocks	Black Rockfish	286	2527	49%	3.85(±0.25)
	Blue Rockfish	12	16	0%	0.55(±0.14)
	Blue/Deacon Rockfish	69	231	5%	1.54(±0.21)
	Brown Irish Lord	2	2	0%	0.36(±0.1)
	Buffalo Sculpin	7	7	0%	0.33(±0.04)
	Cabezon	76	121	2%	0.59(±0.04)
	Canary Rockfish	119	262	5%	0.92(±0.08)
	China Rockfish	86	125	2%	0.57(±0.04)
	Copper Rockfish	21	26	1%	0.4(±0.04)
	Deacon Rockfish	72	217	4%	1.12(±0.1)
	Gopher Rockfish	1	1	0%	0.33
	Kelp Greenling	160	397	8%	0.95(±0.06)
	Lingcod	232	765	15%	1.25(±0.05)
	Quillback Rockfish	64	99	2%	0.59(±0.04)
	Red Irish Lord	8	9	0%	0.42(±0.12)
	Rosy Rockfish	1	1	0%	0.33
	Tiger Rockfish	2	2	0%	0.24(±0.08)
	Vermilion Rockfish	28	28	1%	0.41(±0.06)
	Widow Rockfish	1	1	0%	0.44
	Wolf Eel	1	1	0%	0.27
	Yelloweye Rockfish	35	46	1%	0.44(±0.04)
	Yellowtail Rockfish	67	248	5%	1.76(±0.32)

When comparing across individual sites by year, species richness is consistently above 8 (Table 5.14). Overall when combining richness across all sites the maximum is seventeen. The Redfish Rocks Marine Reserve has similar species richness across all years compared to the associated comparison areas of Humbug and Orford Reef (Table 5.14). Across all years more individual fish were caught in the Redfish Rocks Marine Reserve compared to the associated comparison areas (Table 5.14). 2016 stands out as a year where many fewer total individuals were observed in both the Redfish Rocks Marine Reserve and Humbug Comparison Area, which is attributed to the decreased sampling effort that year.

Table 5.14: Hook-and-line survey species richness and total individuals caught by year at the Redfish Rocks Marine Reserve and associated comparison areas. - represent where no data was collected.

			Year						
	Site	Metric	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks Region	Redfish Rocks MR	Total species richness	12	11	14	14	14	8	13
		Total # individuals caught	543	295	525	526	762	53	266
	Orford Reef CA	Total species richness	-	-	-	14	13	-	12
		Total # individuals caught	-	-	-	197	130	-	183
	Humbug CA	Total species richness	14	11	13	10	13	8	11
		Total # individuals caught	367	267	334	192	243	15	234
	All Sites Combined	Total species richness	15	12	15	17	15	11	13
		Total # individuals caught	910	562	859	915	1135	68	683

Longline Surveys

Longline data are unavailable for summary at this time because of limited staff capacity.

Deep Rocky Subtidal

ROV

Table 5.15 Number of transects conducted by the ROV by year for the Redfish Rocks Marine Reserve and Associated Comparison Areas.

	2010	2016
Redfish Rocks Marine Reserve	42	35
Orford Reef	40	23
Humbug Comparison Area	35	13
All Sites	117	71

Redfish Rocks 2010

A total of 20 species were observed on ROV surveys in the Redfish Rocks region in 2010 (Table 5.9) Of these all Tier 1 focal species were observed and two tier 2 focal species were observed. Kelp Greenling, Blue/Deacon Rockfish and Black Rockfish were the species with the highest weighted mean density on all transects (Figure 5.1). There was high variability in the observations for each species amongst the transects.

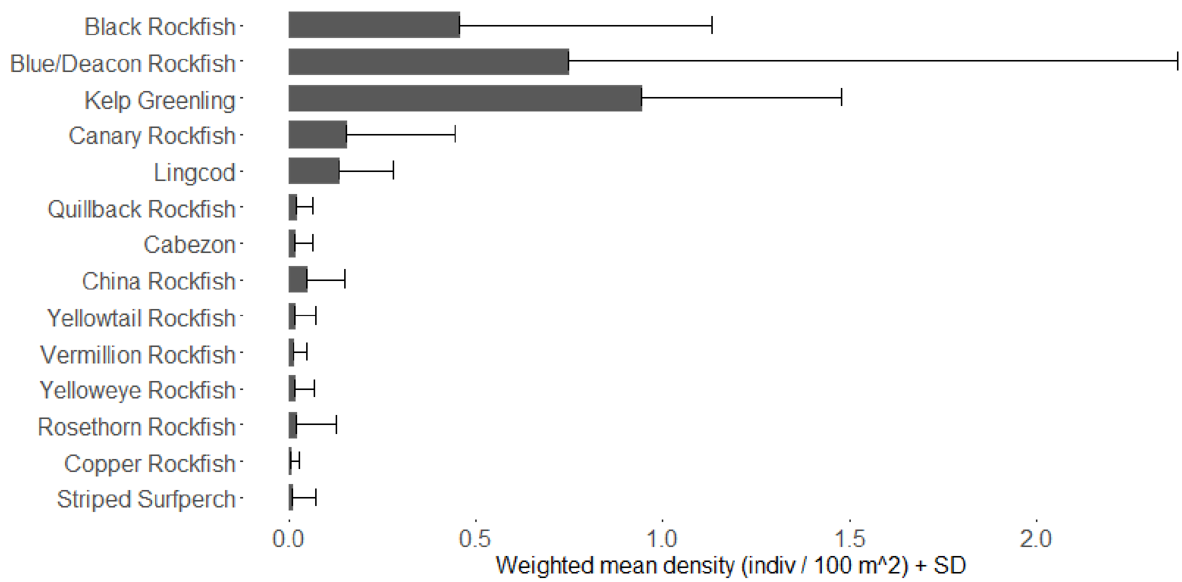


Figure 5.4 Redfish Rocks region 2010 weighted mean fish density (individuals per 100 m^2) + weighted standard deviations. N = 118 transects.

Not all species were observed at all sites (Figure 5.2, 5.3). Fourteen species were observed in the Redfish Rocks Marine Reserve (all but Rosethorn Rockfish and Striped Surfperch). Eighteen species were observed at the Orford Reef (missing Striped Surfperch) Comparison Area, and 16 at the Humbug (missing Rosethorn Rockfish) Comparison Areas. Kelp Greenling, Blue/Deacon Rockfish and Black Rockfish were the species with the highest weighted mean density on all transects at all sites (Figure 5.2). There was high variability in the observations for each species amongst all transects at all sites.

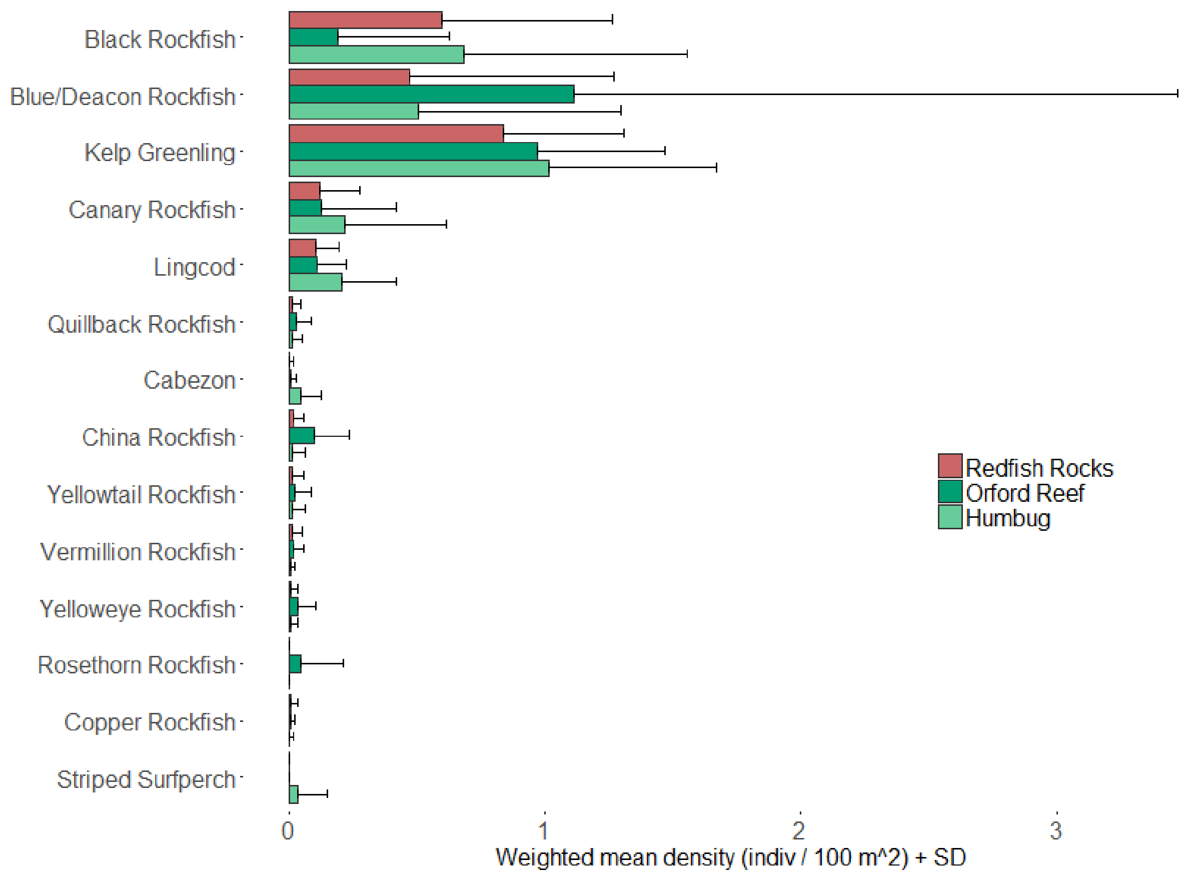


Figure 5.5 Redfish Rocks region 2010 weighted mean fish density by site (individuals per 100 m²) + weighted SD. Redfish Rocks n = 42; Orford CA n= 40; Humbug CA n = 36.

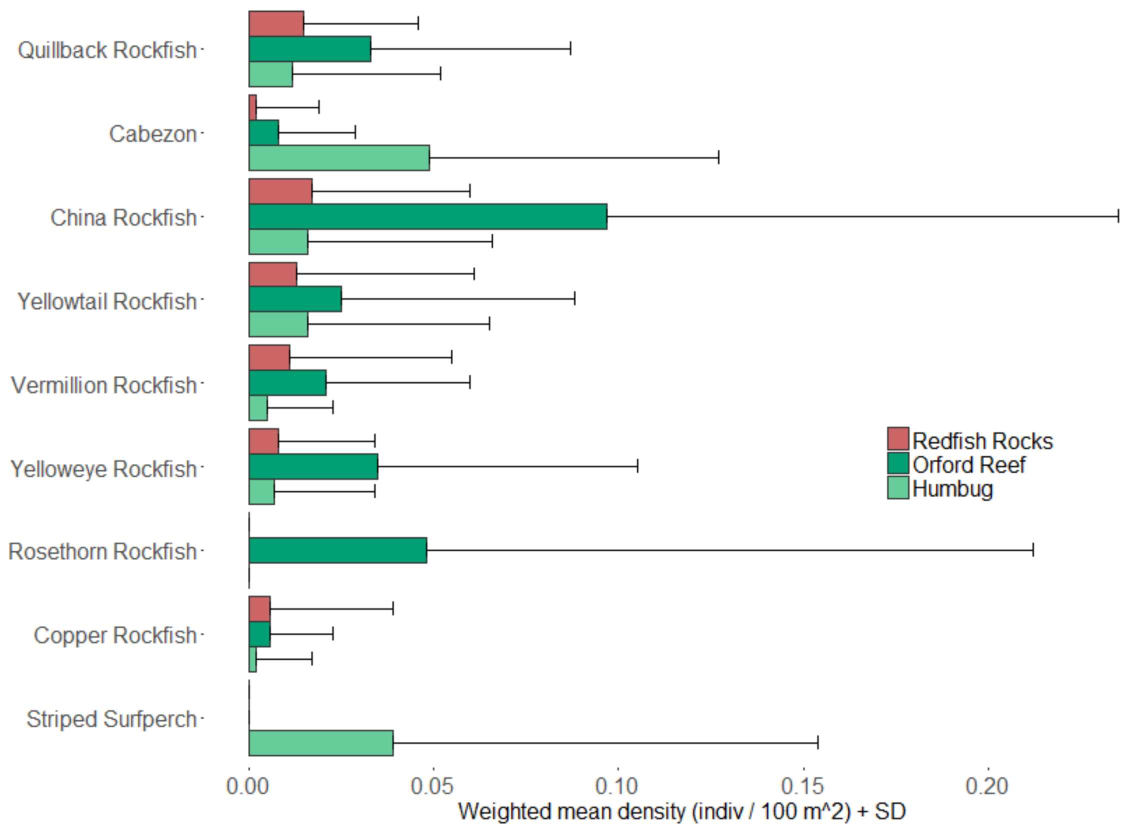


Figure 5.6 Same as above; zoomed for less abundant species. Redfish Rocks region 2010 weighted mean fish density by site (individuals per 100 m2) + weighted SD. Redfish Rocks n = 42; Orford CA n= 40; Humbug CA n = 36.

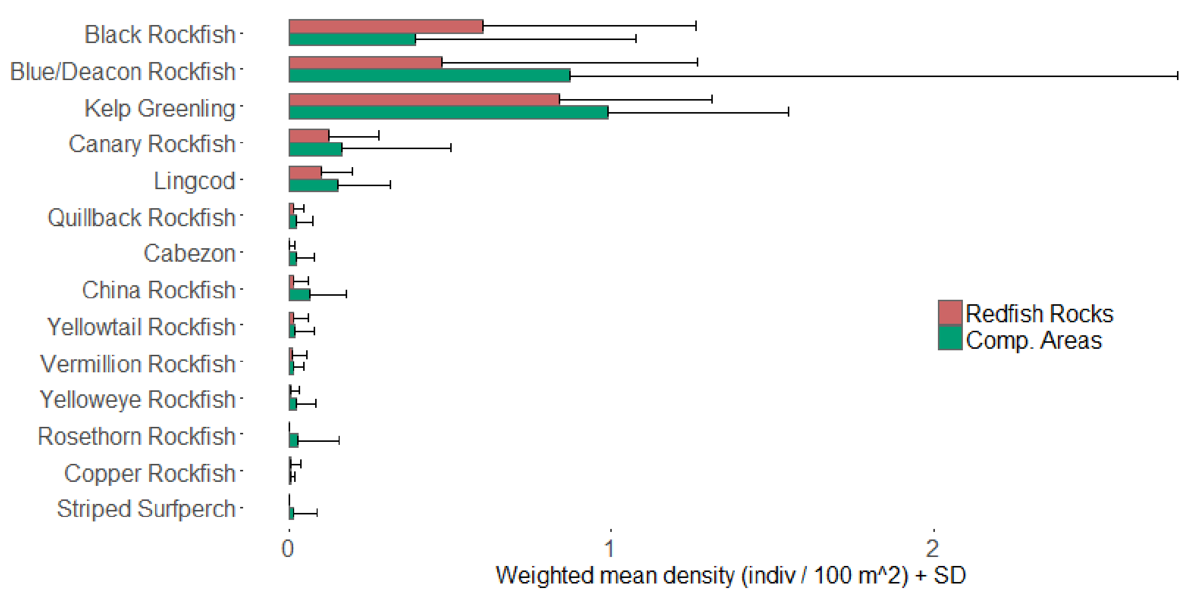


Figure 5.7 2010 Redfish Rocks Marine Reserve (n = 42 transects) compared with both comparison areas combined (n = 76 transects).

If we compare the Redfish Rocks Marine Reserve to both Comparison Areas combined, we see similar results in terms of total species observed and the species with the highest weighted mean density on all transects (Figure 5.7)

Table 5.16 Species richness, total # individuals observed and top two dominant species in the ROV fish datasets from 2010 and 2016 at the Redfish Rocks Marine Reserve & associated comparison areas.

		2010	2016
Redfish Rocks Marine Reserve	Species richness	14	15
	Total # individuals observed	3,686	1,726
	Top 2 dominant species (% observations)	Blue/Deacon (49.1%)	Black Rockfish (39.2%)
		Black Rockfish (25%)	Blue / Deacon Rockfish (21.9%)
Orford Reef Comparison Area	Species richness	18	16
	Total # individuals observed	3,107	1,834
	Top 2 dominant species (% observations)	Blue/Deacon (55.1%)	Blue / Deacon Rockfish (54.2%)
		Kelp Greenling (23%)	Black Rockfish (16%)
Humbug Comparison Area	Species richness	16	16
	Total # individuals observed	3,136	1,078
	Top 2 dominant species (% observations)	Blue / Deacon Rockfish (33%)	Black Rockfish (32.4%)
		Black Rockfish (32%)	Blue / Deacon Rockfish (24.8%)
All Sites Combined	Species richness	20	19
	Total # individuals observed	9,929	4,638
	Top 2 dominant species (% observations)	Blue / Deacon Rockfish (45.9%)	Blue / Deacon Rockfish (35.4%)
		Black Rockfish (21.6%)	Black Rockfish (28.4%)

Redfish Rocks 2016

A total of 14 species were observed on ROV surveys in the Redfish Rocks region in 2016 (Figure 5.8) . Of these all Tier 1 focal species were observed and two tier 2 focal species were observed. Kelp Greenling, Blue/Deacon Rockfish and Black Rockfish were the species with the highest weighted mean density on all transects (Figure 5.8). There was high variability in the observations for each species amongst the transects.

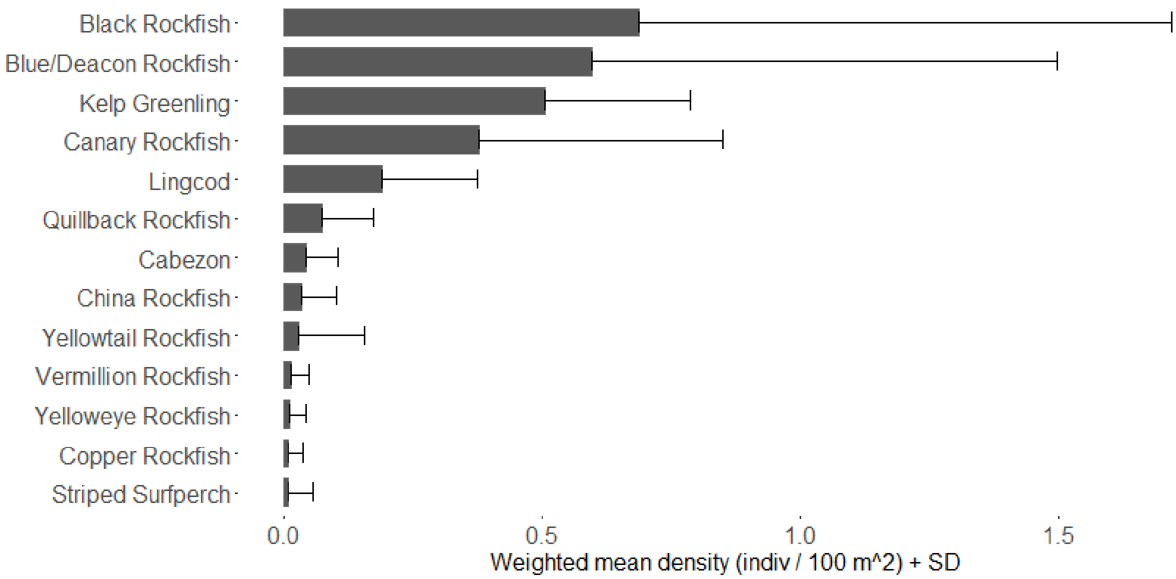


Figure 5.8 Redfish Rocks region 2016 weighted mean fish density (individuals per 100 m²) + weighted SD. N = 73 transects.

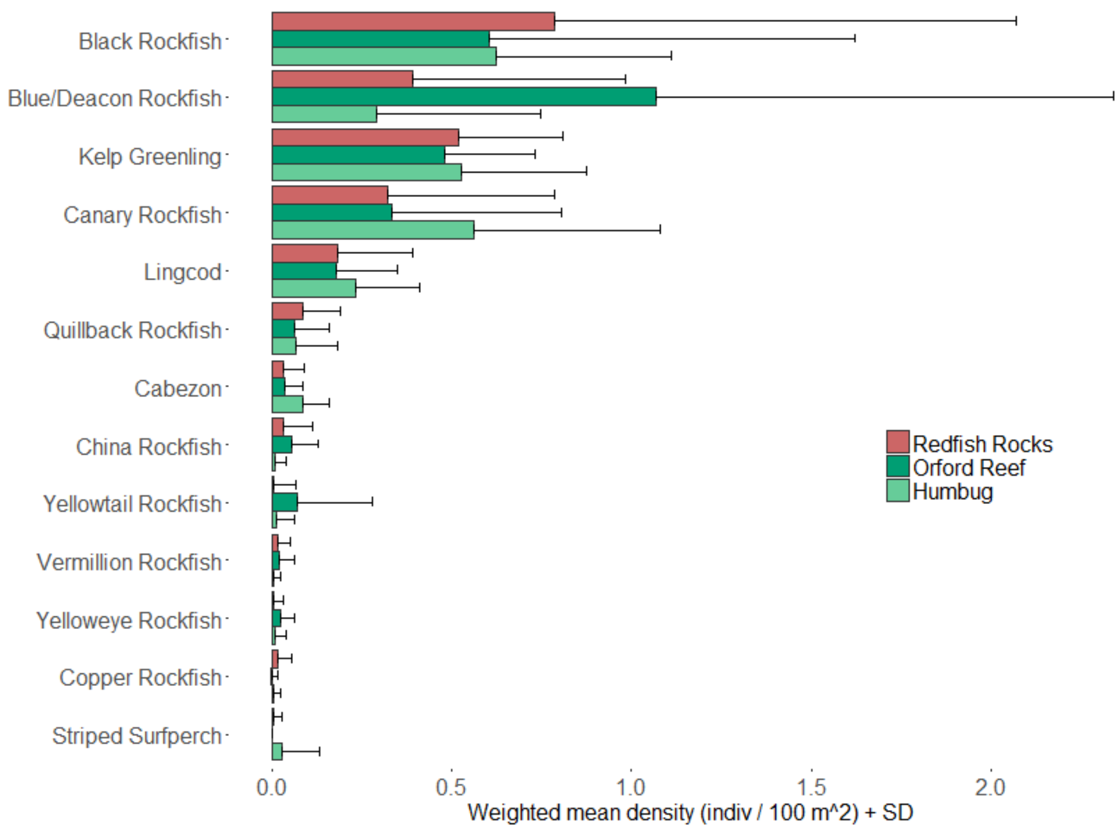


Figure 5.9 Redfish Rocks region 2016 weighted mean fish density by site (individuals per 100 m²) + weighted SD. Redfish Rocks n = 34; Orford CA n= 23; Humbug CA n = 16.

Not all species were observed at all sites (Figure 5.9 Figure 5.10). Fifteen species were observed in the Redfish Rocks Marine Reserve and 16 at the Orford Reef and Humbug Comparison Areas. Kelp Greenling, Blue/Deacon Rockfish and Black Rockfish were the species with the highest weighted mean density on all transects at all sites (Figure 5.9). There was high variability in the observations for each species amongst all transects at all sites.

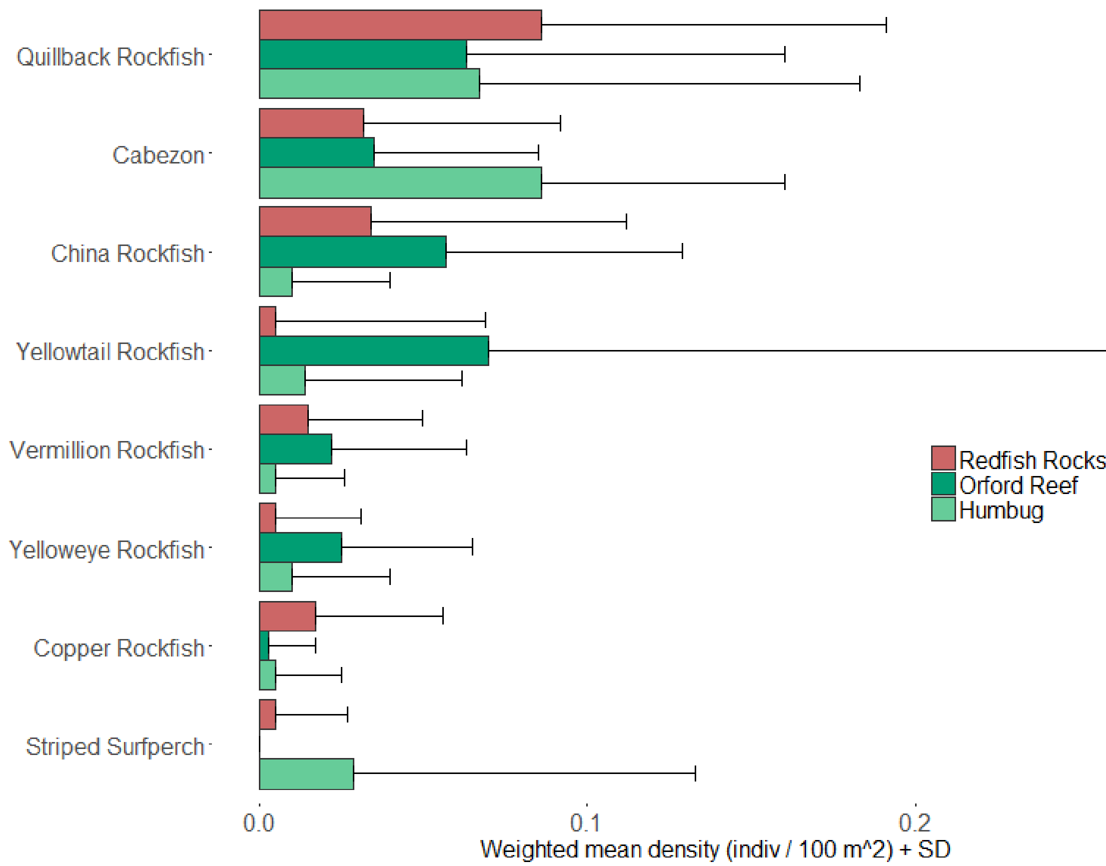


Figure 5.10 Same as previous; zoomed for less abundant species.

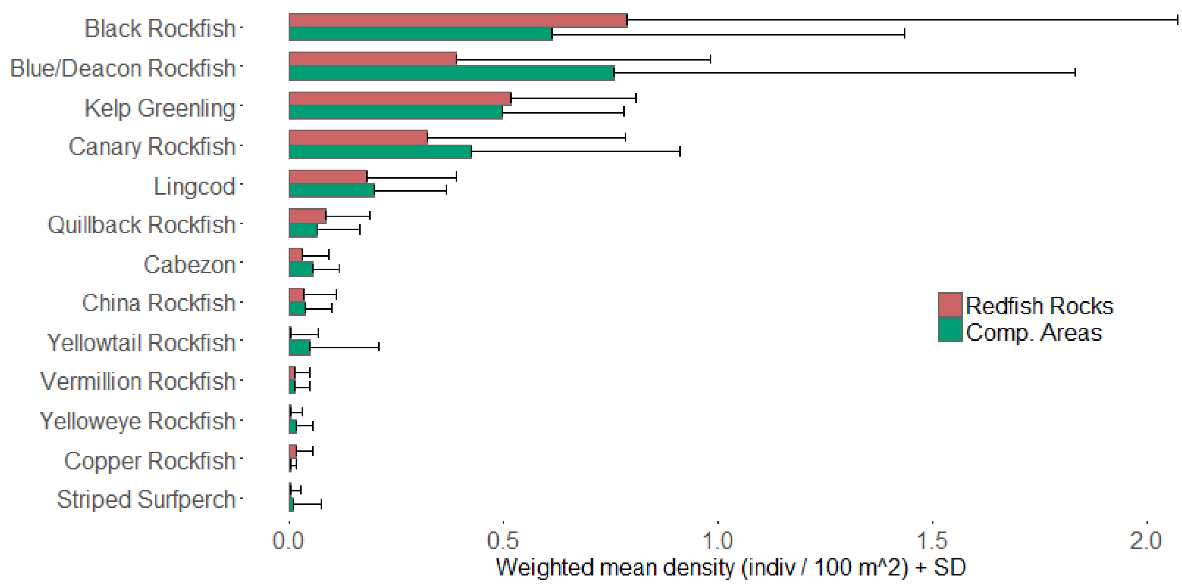


Figure 5.11 Redfish Rocks Marine Reserve (n = 34 transects) compared with both comparison areas combined (n = 39 transects).

If we compare the Redfish Rocks Marine Reserve to both Comparison Areas combined, we see similar results in terms of total species observed (Figure 5.11). However the species with the highest weighted mean density is black rockfish for the Redfish Rocks Marine Reserve and Blue/Deacon Rockfish for the Comparison Areas.

Otter Rock

We have scuba, lander, and SMURF data to provide information on the fish species observed in rocky subtidal habitats in the Otter Rock Marine Reserve and associated comparison areas (Table 5.17). Since the Otter Rock region rocky reef is restricted to shallow depths (< 25m), hook-and-line and ROV surveys are not conducted in this region.

Table 5.17: Fish data collected by year in the Otter Rock Marine Reserve and Cape Foulweather Comparison Area by year. - boxes indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, H = Hook & Line, G = Longline, M = SMURF

			Year							
Region	Site	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Otter Rock	Otter Rock MR	SMURFs	-	-	M	M	M	M	M	M
		Shallow Rocky Subtidal	D, L	D, L	L	-	-	D, L	-	D,L
	Cape Foulweather CA	SMURFs	-	-	M	M	M	M	M	M
		Deep Rocky Subtidal	L	L	L	-	-	L	L	D,L

Shallow Rocky Subtidal

Scuba Surveys

Scuba data are unavailable for analysis at this time, but effort by year by site can be found in Table 5.18.

Table 5.18: Scuba diver effort (number of transects) by year in the Otter Rock Marine Reserve and associated comparison areas for fish surveys.

		Year			
Region	Site	2010	2011	2015	2017
Otter Rock	Otter Rock MR	12	28	45	3
	Cape Foulweather CA	-	-	-	7
	All Sites Combined	12	28	45	10

Lander

Only a proportion of the lander drops are useable, given constraints of view, visibility and habitat type (Table 5.19). For five of the six years of data we any we were never able to yield more than 19 useable drops, even when we combine drops for Otter Rock Marine Reserve and Cape Foulweather (Table 5.19). In 2015, we had the most useable drops at both the Otter Rock Marine Reserve and Cape Foulweather. We did not begin tracking total drops compared to useable drops until 2015. Since then our percentage of useable drops have ranged from 46-66%. When we combine useable drops for all sites to look at sample size for the Otter Rocks Region, the largest sample size was in 2015 with 151 useable drops.

Table 5.19: Lander effort represented by total number of useable drops by year in the Otter Rock Marine Reserve and Associated Comparison Areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year					
Region	Site	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	4	3	7	84	-	6
	Cape Foulweather CA	10	16	8	67	17	10
	All Sites	14	19	15	151	17	16
	Total Drops Conducted	NA	NA	NA	228	34	35
	% Useable Drops	NA	NA	NA	66%	50%	46%

Lander drops yielded low observations of fish species (Table 5.20). For five of the six years of lander drops, the vast majority of drops yielded observations of two different species (Table 5.20). Overall, it was rare to see more than three different species on any given drop in any given year. When looking across all years, the maximum number of different species observed in a single drop was six (n=1).

Table 5.20: The percentage of useable lander drops yielding observations of fish species for the Otter Rock Region.

		Year					
Region	Species Richness Value	2010	2011	2012	2015	2016	2017
Otter Rock	0	57%	31%	40%	16%	47%	32%
	1	43%	37%	47%	24%	23%	19%
	2	-	21%	13%	26%	12%	31%
	3	-	11%	-	19%	12%	6%
	4	-	-	-	11%	-	6%
	5	-	-	-	3%	6%	6%
	6	-	-	-	1%	-	-
	Total Drops	14	19	15	151	17	16

Considering all useable drops, in all sites and years, fish were identified to species in 76% (n =176) of lander drops. Overall, eight species of fish were observed, across four families. Four species were classified as common with Kelp Greenling being the most frequently observed (Table 5.21). Of the remaining four species that were classified as rare, Pile Perch had the highest frequency of occurrence in useable drops at 16% (Table 5.21). When present, six (of 8) species exhibited mean MaxN values greater than one (Table 5.21).

Table 5.21: Of the drops that met condition of habitat, visibility, and view in the Otter Rock Region (n =232), species sample size (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and total individuals observed across drops.

	Species	N	Frequency	Occurrence	Mean MaxN when present	Total Individuals Observed
Otter Rock	Black Rockfish	94	41%	Common	2.5	236
	Blue/Deacon Rockfish	20	9%	Rare	2.1	42
	Buffalo Sculpin	1	0%	Rare	1.0	1
	Cabezon	4	2%	Rare	1.0	4
	Kelp Greenling	104	45%	Common	1.2	124
	Lingcod	47	20%	Common	1.1	54
	Pile Perch	36	16%	Rare	1.5	53
	Striped Surfperch	78	34%	Common	2.1	165

When comparing across individual sites by year, species richness was consistently under six (Table 5.22). Even when combining richness for all sites, the maximum value of species richness is eight. The Otter Rock Marine Reserve has similar species richness across all years to the Cape Foulweather Comparison Area (Table 5.22). 2015 stands out as a year where many more total individuals were observed in both the Otter Rock Marine Reserve and Cape Foulweather Comparison Area which is mostly likely due to the increase in sample sizes for that year.

Table 5.22: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Otter Rock Marine Reserve & associated comparison areas. - represent where no data were collected.

			Year					
Region	Site	Metric	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	Total species richness	1	3	2	8	-	4
		Total # individuals observed	1	17	8	348	-	8
	Cape Foulweather CA	Total species richness	2	4	2	7	6	6
		Total # individuals observed	6	25	19	155	44	48
	All Areas Combined	Total species richness	2	4	2	8	6	6
		Total # individuals observed	7	42	27	503	44	56

Juvenile Fish Research

With the exception of cabezon, settlement of most sampled taxa has been highly variable across years, with annual means ranging 0-1.5 fish SMURF-1 day-1 in some taxa (Figure 5.12, Figure 5.13). Settlement rates do not appear to differ for OYTB, QGBCC, and SR.

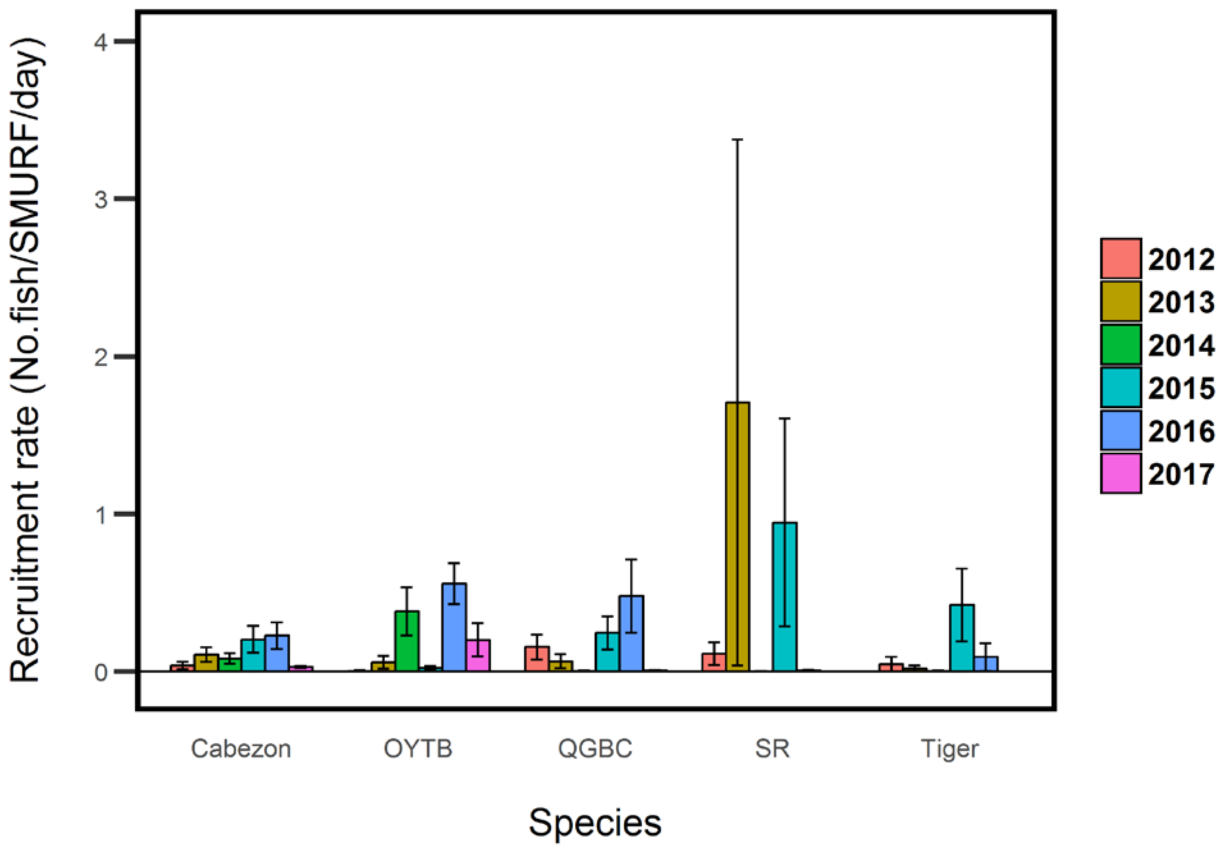


*Figure 5.12 Annual recruitment (settlement) of five fish taxa to Otter Rock Marine Reserve. Recruitment rate (N fish SMURF^{-1} day^{-1}) is averaged over all the replicate SMURFs within each region per year. Data are available from 2012-2017 for central Oregon, when sampling began. Error bars indicate standard error. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

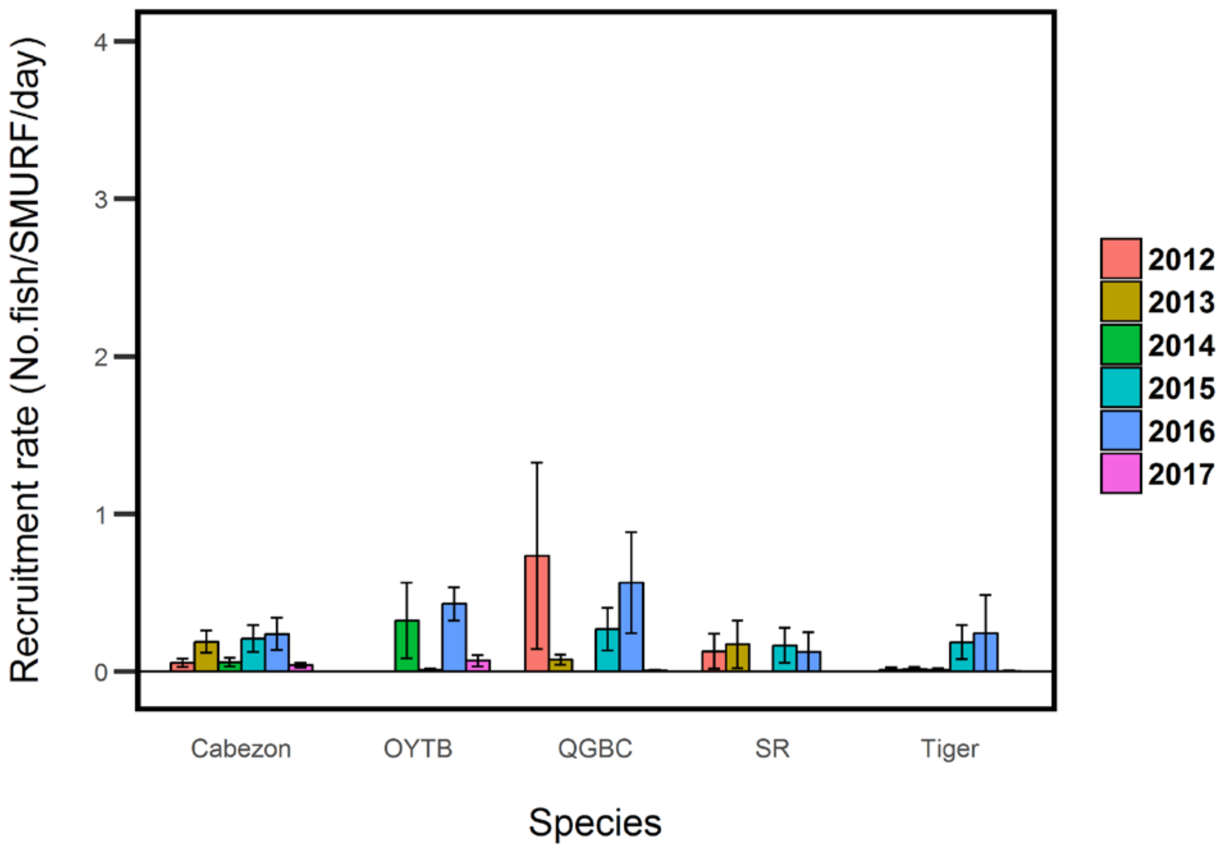


*Figure 5.13 Recruitment rate (N fish SMURF^{-1} day^{-1}) is averaged over all the replicate SMURFs within each region per year. Data are available from 2012-2017 for central Oregon, when sampling began. Error bars indicate standard error. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

OYTB and Splitnose / Redband rockfishes exhibit greater settlement to marine reserves than to unprotected comparison areas (Figure 5.14). Tiger Rockfish exhibit the opposite trend, with greater settlement to the unprotected area than to the marine reserve. Settlement of the remaining taxa do not appear to differ between reserves and non-reserve areas.

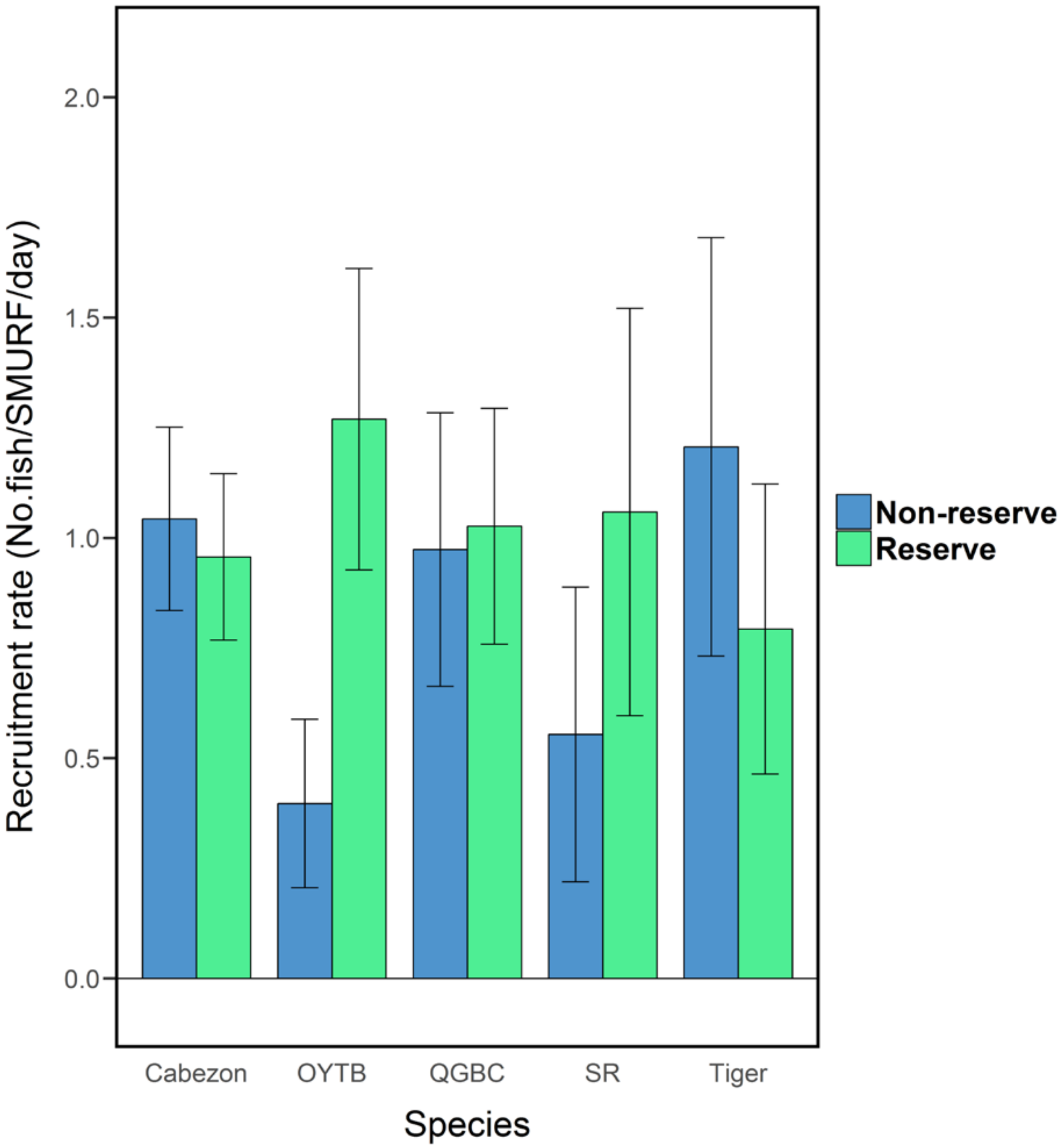


*Figure 5.14 Recruitment (settlement) rate of OYTB is greater in the Otter Rock Marine Reserve (green) when compared to the Cape Foulweather Comparison Area (blue) over 2012-2017. Settlement rate (N fish SMURF^{-1} day^{-1}) was averaged over all the replicate SMURFs within site and normalized by the annual mean settlement from each region to account for the year random effect. Error bars indicate standard error. Number of sampling collections shown under bars. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.*

Cascade Head

We have scuba, lander, hook-and-line, and ROV data to provide information on the fish species observed in rocky subtidal habitats in the Cascade Head Marine Reserve and associated comparison areas (Table 5.23). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. Therefore, shallow subtidal rocky reefs are surveyed by both scuba surveys (restricted to depths < 20m) and landers (restricted to depths < 30m). Since hook-and-line surveys span the shallow (< 25m) and deep (> 25m) rocky reefs summaries are reported here in a separate section which combines both depths. In the future, summaries and analyses will be partitioned by depth. Lastly, the deep rocky subtidal areas are also surveyed by the ROV which is restricted to depths > 20m.

*Table 5.23: Fish data collected by year in the Cascade Head Marine Reserve and its three comparison areas by year. Blank boxes indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, H = Hook & Line, G = Longline, M = SMURF. * indicates that this comparison area will only be summarized for hook-and-line in this section.*

			Year					
Region	Site	Habitat	2012	2013	2014	2015	2016	2017
Cascade Head	Cascade Head MR	SMURFs	-	-	-	-	-	-
		Shallow Rocky Subtidal	L	D	D,L	-	-	D, L
		Deep Rocky Subtidal	R, L	R	-	R	-	R, L
	Schooner Creek CA	SMURFs	-	-	-	-	-	-
		Shallow Rocky Subtidal	L	L	D	-	L	D, L
		Deep Rocky Subtidal	L	R,L	-	R	R, L	R, L
	Cavalier CA	SMURFs	-	-	-	-	-	-
		Shallow Rocky Subtidal	L	D, L	-	-	L	D
		Deep Rocky Subtidal	R, L	L	-	-	R, L	R
	Cape Foulweather CA*	SMURFs	M	M	M	M	M	M
		Shallow Rocky Subtidal	L	-	-	L, H	L, H	D,L

Shallow Rocky Subtidal

Scuba Diver Survey Effort

Scuba data are unavailable for analysis at this time, but effort by year by site can be found in Table 5.24.

Table 5.24: Scuba diver effort (number of transects) by year in the Cascade Head Marine Reserve and associated comparison areas for fish surveys.

		Year		
Region	Site	2013	2014	2017
Cascade Head	Cascade Head MR	-	40	21
	Schooner Creek CA	-	36	11
	Cavalier CA	-	-	9
	Cape Foulweather CA	-	-	7
	All Sites Combined	-	76	48

Lander

Only a proportion of the lander drops are useable for data collection, given constraints of view, visibility and habitat type (Table 5.25). Tracking total drops compared to useable drops was not calculated until 2015. Since then the percentage of useable drops has never been higher than 54%.

Table 5.25: Lander effort represented by total number of useable drops by year in the Cascade Head Marine Reserve and associated comparison areas for fish surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year				
Region	Site	2012	2013	2014	2016	2017
Cascade Head	Cascade Head MR	55	-	6	-	12
	Cavalier CA	43	9	-	21	-
	Schooner Creek CA	55	56	-	28	9
	All Sites	153	65	6	49	21
	Total Drops Conducted	NA	NA	NA	111	39
	% Useable Drops	NA	NA	NA	44%	54%

Lander drops yielded low observations of fish species (Table 5.26). For four of the five years of lander drops, the vast majority of drops yielded observations of two different species (Table 5.26). Overall, it was rare to see more than four different species on any given drop in any given year. When looking across all years, the maximum number of different species observed in a single drop was seven (n=1).

Table 5.26: The percentage of useable lander drops yielding observations of fish species for the Cascade Head region.

		Year				
Site	Species Richness Value	2012	2013	2014	2016	2017
Cascade Head	0	51%	24%	-	27%	23%
	1	22%	37%	17%	18%	48%
	2	13%	17%	-	25%	19%
	3	9%	15%	50%	8%	10%
	4	3%	5%	33%	10%	-
	5	2%	2%	-	6%	-
	6	-	-	-	4%	-
	7	-	-	-	2%	-
	Total Drops	153	65	6	49	21

Considering all useable drops, in all sites and years, fish were identified to species in 62% (n =182) of lander drops. Overall, fifteen species of fish were observed, across six families. Three species were classified as common with Black Rockfish being the most frequently observed (Table 5.27). Of the remaining twelve species that were classified as rare, Blue/Deacon Rockfish had the highest frequency of occurrence in useable drops at 13% (Table 5.27). When present, eleven (of 15) species exhibited mean MaxN values greater than one (Table 5.27).

Table 5.27: Of the drops that met condition of habitat, visibility, and view in the Cascade Head region (n =294), species sample (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and total individuals observed across drops.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Cascade Head	Black Rockfish	91	31%	Common	5.2	471
	Blue/Deacon Rockfish	37	13%	Rare	5.3	197
	Cabezon	3	1%	Rare	1.0	3
	Canary Rockfish	33	11%	Rare	3.4	112
	China Rockfish	1	0%	Rare	1.0	1
	Copper Rockfish	6	2%	Rare	1.5	9
	Kelp Greenling	79	27%	Common	1.1	87
	Lingcod	66	22%	Common	1.2	81
	Northern Ronquil	8	3%	Rare	1.1	9
	Pile Perch	22	7%	Rare	1.7	38
	Quillback Rockfish	9	3%	Rare	1.1	10
	Striped Surfperch	9	3%	Rare	2.4	22
	Wolf Eel	1	0%	Rare	1.0	1
	Yelloweye Rockfish	6	2%	Rare	1.0	6
	Yellowtail Rockfish	10	3%	Rare	1.7	17

When comparing across individual sites by year, species richness was consistently under eight (Table 5.28). Even when combining richness for all sites, the maximum value of species richness is twelve. The Cascade Head Marine Reserve has similar species richness across all years to the Cavalier Comparison Area. Schooner Creek Comparison Area had consistently higher species richness and more total individuals observed compared to all other locations.

*Table 5.28: Lander survey effort by year at the Cascade Head Marine Reserve and surrounding comparison areas. * = Change in lander configuration, camera type, and drop duration to current methods(Mini GoPro camera, 8 min drops) Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Redfish Rocks Marine Reserve & associated comparison areas. - represent where no data was collected.*

			Year				
Region	Site	Metric	2012	2013	2014*	2016*	2017*
Cascade Head	Cascade Head	Total species richness	8	-	6	-	5
		Total # individuals observed	155	-	88	-	69
	Cavalier CA	Total species richness	8	3	-	9	-
		Total # individuals observed	68	10	-	152	-
	Schooner Creek CA	Total species richness	12	11	-	7	4
		Total # individuals observed	181	238	-	70	33
	All Sites Combined	Total species richness	12	11	6	9	5
		Total # individuals observed	404	248	88	222	102

Shallow and Deep Rocky Subtidal

Hook- and –Line Surveys

A total of 200 sampling cells were conducted in Cascade Head region from 2013-2017. Of these completed cells, 198 (99%) of cells encountered fish (Table 5.29).

Table 5.29: Hook-and-Line effort represented by total number of cells sampled by year in the Cascade Head Marine Reserve and associated comparison areas for fish surveys.– represent where no data were recorded.

		Year				
Region	Site	2013	2014	2015	2016	2017
Cascade Head	Cascade Head MR	17	27	27	18	-
	Schooner Creek CA	13	16	17	23	-
	Cavalier CA	5	-	7	17	-
	Cape Foulweather CA	-	-	8	5	-
	Total Cells Sampled	35	43	59	63	-

Hook-and-line sampling cells yielded moderate observations of fish species (Table 5.30). For two of the four years sampled cells produced seven or more species (Table 5.30). As a general pattern most sampled cells across all years produced nine to ten species (Table 5.30). Across all years up to eight species were observed with most cells per year yielding three to six species. When looking across all years the maximum species richness observed per cell at the Redfish Rocks region was 10 with a mean richness per cell of 4.14 (±0.13SE).

Table 5.30: The percentage of sampled cells yielding observations of fish species for the Cascade Head region.

		Year			
Region	Species Richness Value	2013	2014	2015	2016
Cascade Head	0	-	-	-	3%
	1	8%	3%	2%	21%
	2	3%	5%	8%	10%
	3	20%	14%	29%	17%
	4	20%	28%	27%	25%
	5	14%	16%	12%	8%
	6	17%	23%	14%	6%
	7	9%	7%	3%	8%
	8	9%	2%	3%	2%
	9	-	2%	-	-
	10	-	-	2%	-
	Total Cells Sampled	35	43	59	63

Overall of 5,943 individual fish representing 19 species and from three families were caught in the Cascade Head region. Ninety-one percent of the catch at the Cascade Head region was made up of five species including Black Rockfish, Lingcod, Deacon Rockfish, Canary Rockfish, and Kelp Greenling (Table 5.31). When present three species exhibited mean CPUE (expressed as angler hour) values greater than one (Table 5.31).

Table 5.31: Of the cells that were surveyed in the in the Cascade Head region from 2013-2016 (n = 200), species sample size (N), total number of individuals caught, percentage of the total catch that each species represents, and mean CPUE (SE) (angler hour) for each species is represented.

	Species	N	Total Individuals Caught	% of Total Catch	Mean CPUE (SE) (angler hour)
Cascade Head	Black Rockfish	177	3751	63%	4.04(±0.38)
	Blue Rockfish	12	63	1%	1.41(±0.39)
	Buffalo Sculpin	1	1	0%	0.23
	Cabezon	57	119	2%	0.37(±0.04)
	Canary Rockfish	79	255	4%	0.62(±0.06)
	China Rockfish	10	14	0%	0.23(±0.03)
	Copper Rockfish	23	32	1%	0.26(±0.04)
	Deacon Rockfish	67	313	5%	0.96(±0.15)
	Kelp Greenling	103	217	4%	0.42(±0.03)
	Lingcod	157	867	15%	1.03(±0.06)
	Pacific Staghorn	6	9	0%	0.26(±0.07)
	Quillback Rockfish	32	41	1%	0.22(±0.02)
	Red Irish Lord	6	6	0%	0.18(±0.03)
	Tiger Rockfish	7	9	0%	0.29(±0.08)
	UNID Juvenile Rockfish	1	1	0%	0.28
	Vermilion Rockfish	4	4	0%	0.19(±0.03)
	Widow Rockfish	2	2	0%	0.36(±0.22)
	Yelloweye Rockfish	23	39	1%	0.31(±0.04)
	Yellowtail Rockfish	60	200	3%	0.58(±0.08)

When comparing across individual sites by year, species richness is consistently above 9 for all the areas except Cape Foulweather Comparison Area (Table 5.32). Overall when combining richness across all sites the maximum is seventeen. The Cascade Head Marine Reserve has similar species richness across all years compared to the associated comparison areas of Cavalier and Schooner Creek (Table 5.32). Across all years more individual fish were caught in the Cascade Head Marine Reserve compared to the associated comparison areas (Table 5.32). 2014 stands out as a year where many more total individuals were caught in both the Cascade Head Marine Reserve and associated comparison areas.

Table 5.32: Hook-and-line survey effort by year at the Cascade Head Marine Reserve and associated comparison areas. Total species richness, total # individuals observed in the hook-and-line fish datasets by year at the Cascade Head Marine Reserve & associated comparison areas. - represent where no data was collected.

			Year				
	Site	Metric	2013	2014	2015	2016	2017
Cascade Head	Cascade Head MR	Total species richness	13	15	11	10	-
		Total # individuals caught	387	1676	1121	964	-
	Cavalier CA	Total species richness	13	-	9	14	-
		Total # individuals caught	49	-	67	247	-
	Schooner Creek CA	Total species richness	13	12	12	11	-
		Total # individuals caught	271	419	320	278	-
	Cape Foulweather CA	Total species richness	-	-	6	4	-
		Total # individuals caught	-	-	78	66	-
	All Sites Combined	Total species richness	17	16	14	14	-
		Total # individuals caught	707	2095	1586	1555	-

Deep Rocky Subtidal

ROV

Table 5.33: Number of transects conducted by the ROV by year for the Cascade Head Marine Reserve and Associated Comparison Areas.

Site	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Cascade Head	16	10	----	4	3	11
Schooner Creek	0	10	----	4	4	15
Cavalier	16	0	----	0	4	14
All Sites Combined	32	20	----	8	11	40

In 2012 and 2013, the acoustic USBL tracking system that calculates the ROV's position suffered from problems that created an apparent, unrealistically wandering, ROV path, thereby degrading the accuracy of estimates of the total area viewed. These issues were resolved in subsequent surveys, but attempts to correct the 2012-2013 data have not been completed at this time. Satisfactory estimates of viewed area for these years, albeit with larger confidence intervals than for most surveys, are anticipated with additional effort. At this time, we present total abundance of fish for these years (Table 5.33).

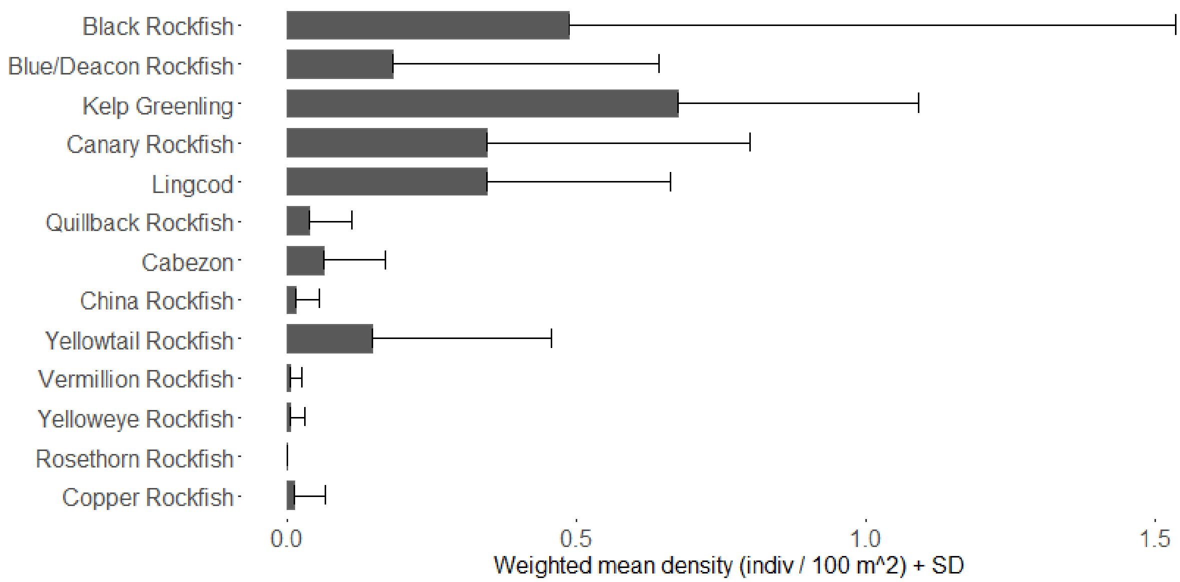


Figure 5.15: Cascade Head region 2017 weighted mean fish density (individuals per 100 m^2) + weighted SD. N = 37 transects.

A total of 16 species were observed on ROV surveys in the Cascade Head region in 2017 (Table 5.33). Of these eleven Tier 1 focal species were observed and two tier 2 focal species were observed. Kelp Greenling and Black Rockfish were the species with the highest weighted mean density on all transects (Figure 5.15). There was high variability in the observations for each species amongst the transects.

Not all species were observed at all sites (Figure 5.16, Figure 5.17). Ten species were observed in the Cascade Head Marine Reserve. Fourteen species were observed at the Cavalier and 16 at the Schooner Creek Comparison Areas. Kelp Greenling and Black Rockfish were the species with the highest weighted mean density on all transects at the Cascade Head Marine Reserve and Cavalier Comparison Area (Figure 5.16). Kelp Greenling and Lingcod had the highest mean density at the Schooner Creek Comparison Area. There was high variability in the observations for each species amongst all transects at all sites.

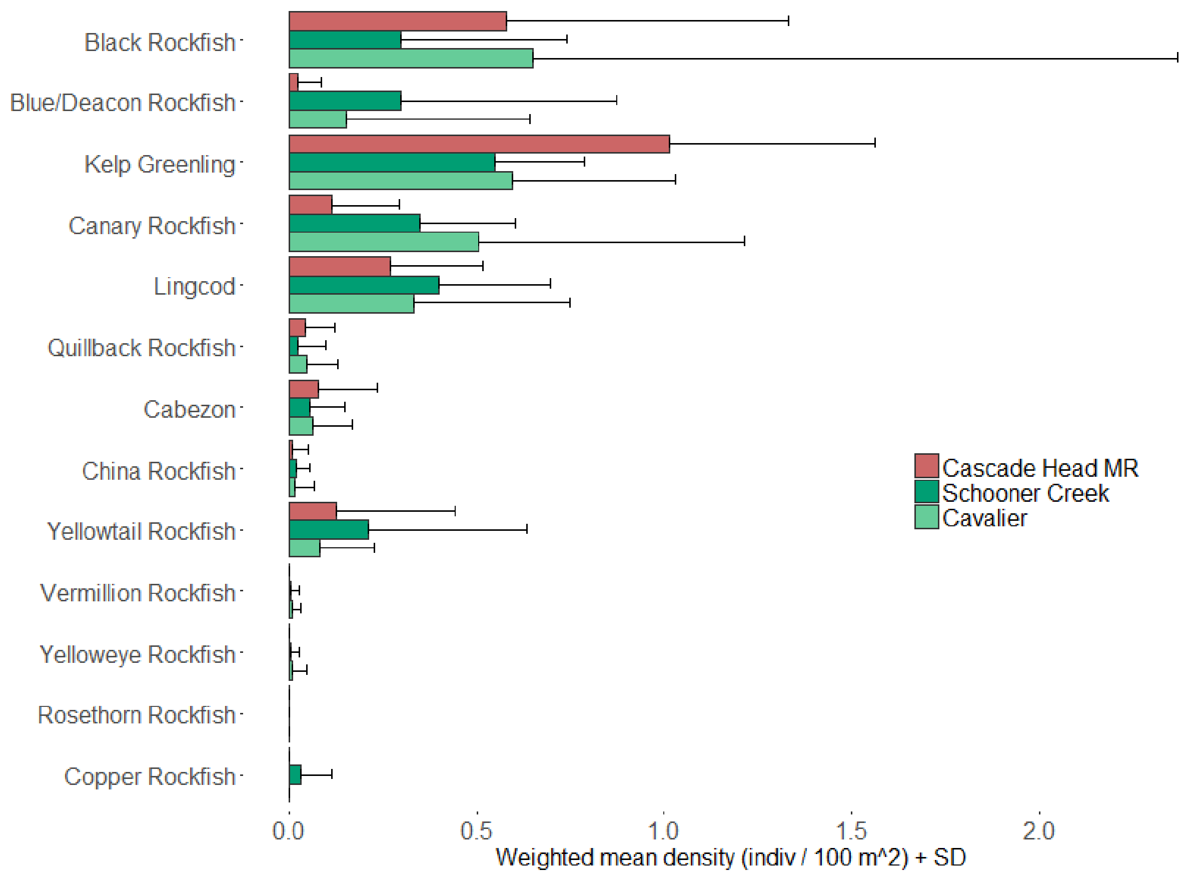


Figure 5.16: Cascade Head region 2017 weighted mean fish density by site (individuals per 100 m^2) + weighted SD. Cascade Head MR n = 12; Schooner Creek CA n= 12; Cavalier CA n = 13.

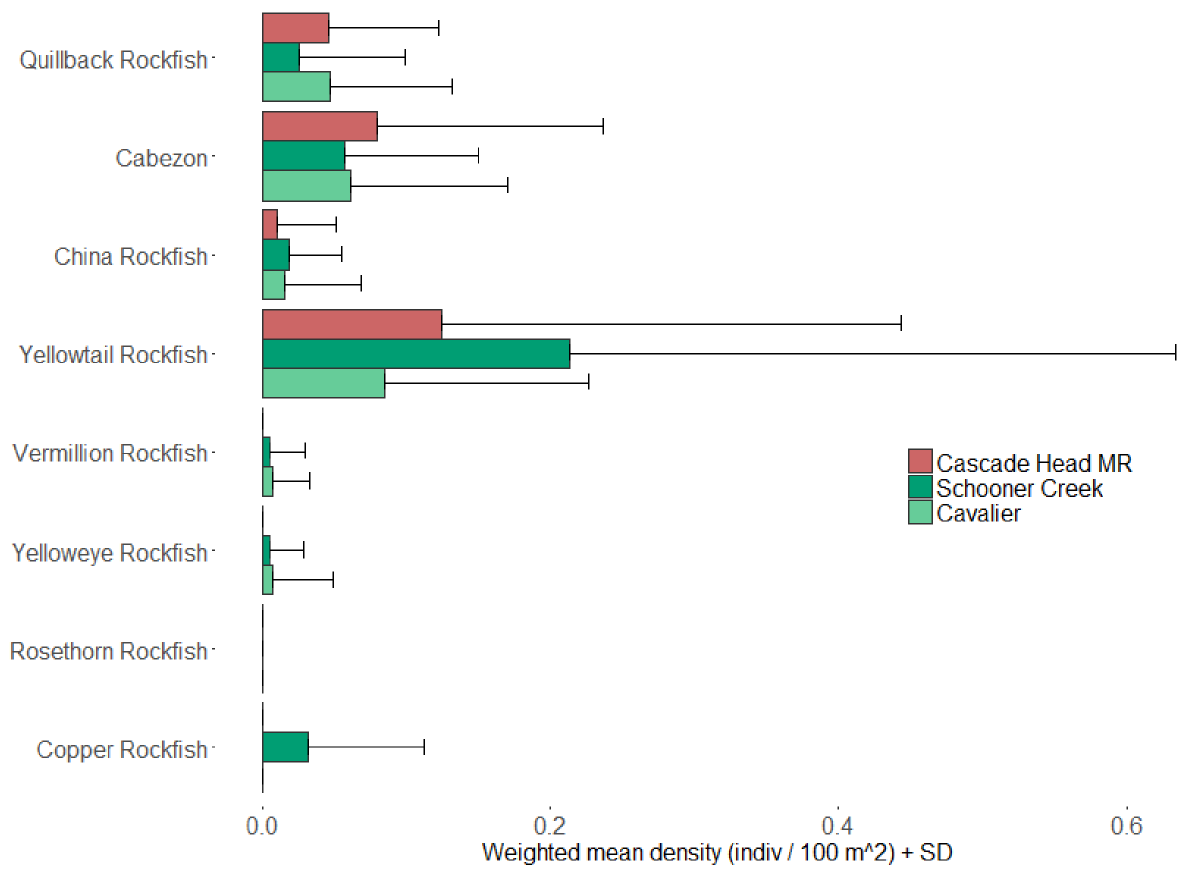


Figure 5.17: Same as previous; zoomed for less abundant species.

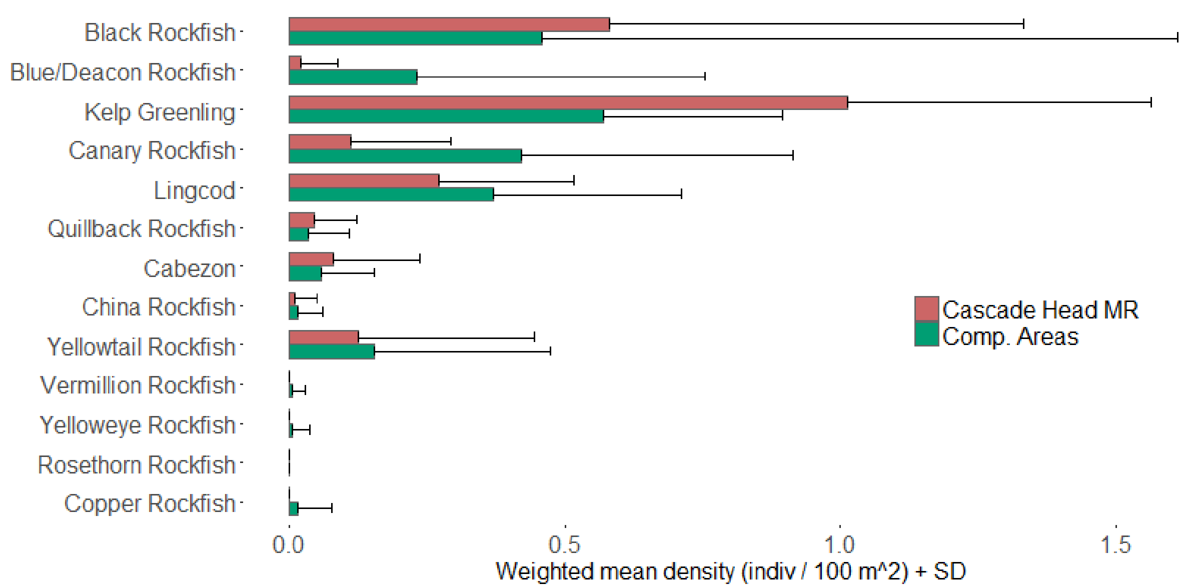


Figure 5.18: Cascade Head Marine Reserve 2017 (n = 12 transects) compared with both comparison areas combined (n = 25 transects).

If we compare the Cascade Head Marine Reserve to both Comparison Areas combined, we see similar results in terms of total species observed and the species with the highest weighted mean density on all transects (Figure 5.18)

Table 5.34: Species richness, total # individuals observed and top two dominant species in the ROV fish datasets by year at the Cascade Head Marine Reserve & associated comparison areas.

		2012	2013	2017
Cascade Head Marine Reserve	Species richness	13	11	10
	Total # individuals observed	1,002	638	391
	Top 2 dominant species (% observations)	Black Rockfish (44.4%)	Black Rockfish (61.9%)	Black Rockfish (34.5%)
		Blue/Deacon Rockfish (22.7%)	Blue/Deacon Rockfish (7.7%)	Kelp Greenling (33.2%)
Schooner Creek	Species richness	N/A	16	16
	Total # individuals observed	N/A	682	795
	Top 2 dominant species (% observations)	N/A	Blue/Deacon Rockfish (46.9%)	Blue/Deacon Rockfish (39.4%)
		N/A	Black Rockfish (15.2%)	Kelp Greenling (14.5%)
Cavalier	Species richness	13	N/A	14
	Total # individuals observed	1,202	N/A	688
	Top 2 dominant species (% observations)	Blue/Deacon Rockfish (38.4%)	N/A	Black Rockfish (43.5%)
		Black Rockfish (37.3%)	N/A	Kelp Greenling (15.4%)
All Sites	Species richness	15	17	16
	Total # individuals observed	2,204	1,320	1,874
	Top 2 dominant species (% observations)	Black Rockfish (40.5%)	Black Rockfish (37.8%)	Black Rockfish (27.7%)
		Blue/Deacon Rockfish (31.3%)	Blue/Deacon Rockfish (27.9%)	Blue/Deacon Rockfish (21%)

Cape Perpetua

We have lander, hook-and-line, and ROV data to provide information on the fish species observed in rocky subtidal habitats in the Cape Perpetua Marine Reserve and associated comparison areas (Table 5.5). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. Since hook-and-line and longline surveys span the shallow (< 25m) and deep (> 25m) rocky reefs summaries are reported here in a separate section which combines both depths. In the future, summaries and analyses will be partitioned by depth. Lastly, the deep rocky subtidal areas are also surveyed by the ROV which is restricted to depths > 20m and the lander which prior to 2014 was not restricted by depth.

Table 5.35: Fish data collected by habitat type by year in the Cape Perpetua Marine Reserve and its three comparison areas by year. Blank boxes indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, H = Hook & Line, M = SMURF

			Year					
Region	Site	Habitat	2012	2013	2014	2015	2016	2017
Cape Perpetua	Cape Perpetua MR	SMURFs	-	-	-	-	-	-
		Deep Rocky Subtidal	L, R	H, R	H	R	H	R
	Postage Stamp CA	SMURFs	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	H	H	-	H	-
		Deep Rocky Subtidal	L	H	L, H	-	H	-
	CA Outside Cape Perpetua MR	SMURFs	-	-	-	-	-	-
		Deep Rocky Subtidal	-	-	-	-	H	-

Shallow and Deep Rocky Subtidal

Hook- and –Line Surveys

A total of 110 sampled cells were conducted in Cape Perpetua region from 2013-2017. Of these completed cells 108 (98%) encountered fish.

Table 5.36: Hook-and-Line effort represented by total number of cells sampled by year in the Cape Perpetua Marine Reserve and associated comparison areas for fish surveys.– represent where no data were recorded.

		Year				
Region	Site	2013	2014	2015	2016	2017
Cape Perpetua	Cape Perpetua MR	11	16	-	15	-
	Postage Stamp CA	23	18	-	25	-
	CA Outside Cape Perpetua MR	-	-	-	2	-
	Total Cells Sampled	34	34	-	42	-

Hook-and-line cells yielded moderate observation of fish species (Table 5.37). As a general pattern most cells across all years produced three to five species (Table 5.37). When looking across all years the maximum species richness observed per cell at the Redfish Rocks region was 10 with a mean richness per cell of 3.93 (±0.20SE).

Table 5.37: The percentage of cells yielding observations of fish species for the Cape Perpetua region.

		Year		
Region	Species Richness Value	2013	2014	2016
Cape Perpetua	0	3%	-	2%
	1	12%	-	14%
	2	35%	9%	19%
	3	15%	15%	14%
	4	9%	17%	12%
	5	17%	21%	10%
	6	6%	17%	17%
	7	-	15%	10%
	8	3%	3%	2%
	9	-	-	-
	10	-	3%	-
	Total Cells Sampled	34	34	42

Overall, a total of 4,206 individual fish representing 18 species from four families were caught in the Cape Perpetua region. Ninety-one percent of the catch at the Cape Perpetua region is made up of four species including Black Rockfish, Canary Rockfish, Lingcod, and Yellowtail Rockfish (Table 5.38). When present two species exhibited mean CPUE (expressed as angler hour) values greater than one (Table 5.38).

Table 5.38: Of the cells that were surveyed in the in the Cape Perpetua region from 2013-2016 (n = 110), species sample size (N), total number of individuals caught, percentage of the total catch that each species represents, and mean CPUE (SE) (angler hour) for each species is represented.

	Species	N	Total Individuals Caught	% of Total Catch	Mean CPUE (SE) (angler hour)
Cape Perpetua	Black Rockfish	105	2965	70%	5.91(±0.62)
	Blue Rockfish	5	12	0%	0.66(±0.29)
	Boccacio	1	1	0%	0.16
	Brown Irish Lord	1	1	0%	0.3
	Brown Rockfish	5	7	0%	0.25(±0.05)
	Buffalo Sculpin	21	41	1%	0.33(±0.06)
	Cabezon	13	24	1%	0.36(±0.08)
	Canary Rockfish	47	366	9%	1.48(±0.22)
	Copper Rockfish	22	42	1%	0.4(±0.06)
	Deacon Rockfish	18	31	1%	0.36(±0.06)
	Kelp Greenling	28	68	2%	0.4(±0.05)
	Lingcod	80	367	9%	0.89(±0.11)
	Pacific Staghorn	2	2	0%	0.25(±0.06)
	Quillback Rockfish	32	94	2%	0.61(±0.11)
	Spotted Ratfish	1	1	0%	0.27
	Tiger Rockfish	1	1	0%	0.24
	Yelloweye Rockfish	12	37	1%	0.59(±0.06)
	Yellowtail Rockfish	38	146	3%	0.81(±0.16)

When comparing across individual sites by year, species richness is consistently above 11 (Table 5.39). Overall when combining richness across all sites the maximum is seventeen. The Cape Perpetua Marine Reserve has similar species richness across all years compared to the associated comparison areas (Table 5.39). Across all years more individual fish were caught in the Cape Perpetua Marine Reserve compared to the associated comparison areas (

Table 5.39). 2014 stands out as a year where many more total individuals were observed in both the Cape Perpetua Marine Reserve and associated comparison areas.

Table 5.39: Hook-and-line survey effort by year at the Cape Perpetua Marine Reserve and associated comparison areas. Total species richness, total # individuals observed in the hook-and-line fish datasets by year at the Cape Perpetua Marine Reserve & associated comparison areas. - represent where no data was collected.

			Year				
	Site	Metric	2013	2014	2015	2016	2017
Cape Perpetua	Cape Perpetua MR	Total species richness	11	12	-	11	-
		Total # individuals caught	293	1090	-	796	-
	Postage Stamp CA	Total species richness	12	12	-	7	-
		Total # individuals caught	668	853	-	416	-
	CA Outside Cape Perpetua MR	Total species richness	-	-	-	8	-
		Total # individuals caught	-	-	-	90	-
	All Sites Combined	Total species richness	17	15	-	12	-
		Total # individuals caught	961	1943	-	1302	-

Deep Rocky Subtidal

Lander

Only two years of data were collected in the Cape Perpetua Marine Reserve (Table 5.40). We did not begin tracking total drops compared to useable drops until 2015.

Table 5.40: Lander effort represented by total number of useable drops by year in the Cape Perpetua Marine Reserve and associated comparison area for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. - indicate that no data were collected.

		Year	
Region	Site	2012	2014
Cape Perpetua	Cape Perpetua MR	4	-
	Postage Stamp CA	1	4
	All Sites	5	4
	Total Drops Conducted	NA	NA
	% Useable Drops	NA	NA

Lander drops yielded a range of observations of fish species (Table 5.41). For 2014 higher species richness was observed compared to 2012 (Table 5.41). When looking across all years, the maximum number of different species observed in a single drop was eight (n=1).

Table 5.41: The percentage of useable lander drops yielding observations of fish species for the Cape Perpetua Region.

		Year	
Region	Species Richness Value	2012	2014
Cape Perpetua	0	20%	-
	1	40%	-
	2	-	-
	3	20%	-
	4	-	-
	5	-	25%
	6	-	25%
	7	20%	25%
	8	-	25%
	Total Useable Drops	5	4

Considering all useable drops, in all sites and years, fish were identified to species in 89% (n =8) of lander drops. Overall, twelve species of fish were observed, across three families. Eight species were classified as common with Black Rockfish being the most frequently observed (Table 5.42). Of the remaining four species that were classified as rare all had similar frequency of occurrence in useable drops at 11% (Table 5.42). When present, six (of 12) species exhibited mean MaxN values greater than one (Table 5.42).

Table 5.42: Of the drops that met condition of habitat, visibility, and view in the Cape Perpetua Region (n =9), species sample size (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and total individuals observed across drops.

	Species	N	Frequency	Occurrence	Mean MaxN when present	Total Individuals Observed
Cape Perpetua	Black Rockfish	7	78%	Common	12.0	84
	Blue/Deacon Rockfish	5	56%	Common	7.8	39
	Canary Rockfish	5	56%	Common	6.0	30
	Copper Rockfish	1	11%	Rare	1.0	1
	Kelp Greenling	4	44%	Common	1.0	4
	Lingcod	5	56%	Common	1.8	9
	Pile Perch	2	22%	Common	1.5	3
	Quillback Rockfish	4	44%	Common	1.3	5
	Striped Surfperch	1	11%	Rare	1.0	1
	Tiger Rockfish	1	11%	Rare	1.0	1
	Yelloweye Rockfish	2	22%	Common	1.0	2
	Yellowtail Rockfish	1	11%	Rare	1.0	1

When comparing across individual sites by year, species richness varied due to low sample sizes (Table 5.10). 2011 had the highest species richness and total number of individuals that were caught compared to all other years.

Table 5.43: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Cape Perpetua Marine Reserve & associated comparison areas. – represent where no data were collected.

Region	Site	Metric	Year 2012	Year 2014
Cape Perpetua	Cape Perpetua CA	Total species richness	8	-
		Total # individuals observed	44	-
	Postage Stamp CA	Total species richness	1	11
		Total # individuals observed	14	122
	All Sites Combined	Total species richness	8	11
		Total # individuals observed	58	122

ROV

ROV fish data has been collected over several years at the Cape Perpetua Marine Reserve by the ODFW Habitat team (Table 5.35). However only 2017 data are available for summary in this report.

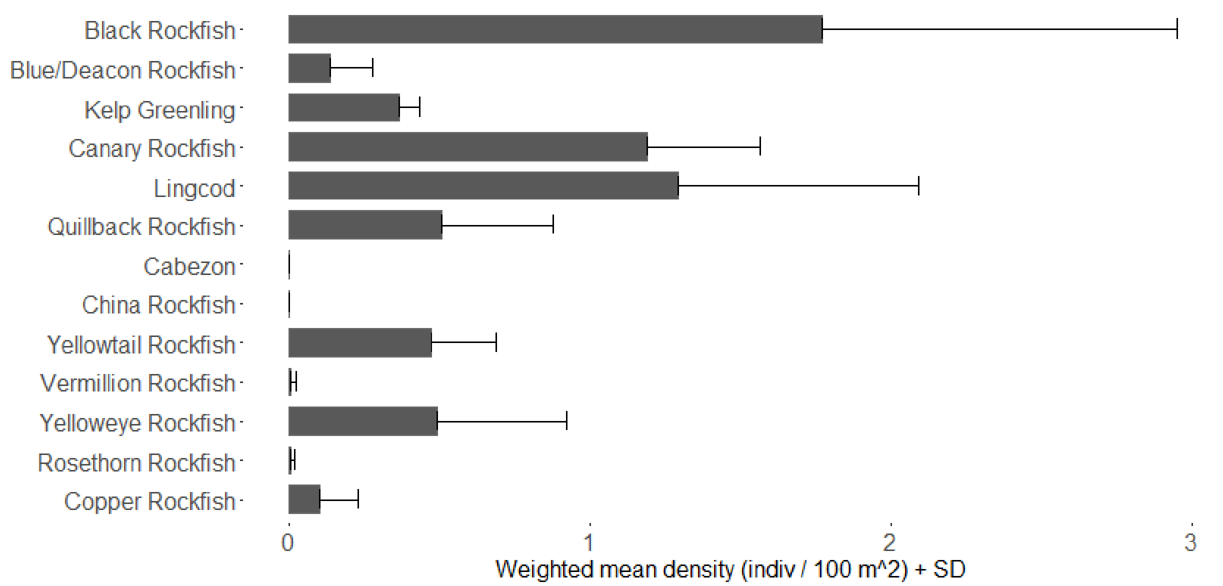


Figure 5.19: Cape Perpetua 2017 weighted mean fish density (individuals per 100 m^2) + weighted SD. N = 2 transects. These transects are both 3-4 times longer than standard 500 m transects used at other sites. Future analyses will likely subset the Cape Perpetua transects into smaller discrete sample units.

A total of 11 species were observed on ROV surveys in the Cape Perpetua Marine Reserve in 2011 (Figure 5.19). Of these eight Tier 1 focal species were observed and two tier 2 focal species were observed. Kelp Greenling and Lingcod were the species with the highest weighted mean density on all transects (Figure 5.19). There was high variability in the observations for each species amongst the transects. There is no comparison area for ROV at Cape Perpetua Marine Reserve.

Cape Falcon

We have scuba, lander, and hook-and-line data to provide information on the fish species observed in rocky subtidal habitats in the Cape Falcon Marine Reserve and associated comparison areas (Table 5.44). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. Therefore, shallow subtidal rocky reefs are surveyed by both scuba surveys (restricted to depths < 20m), and landers (restricted to depths < 30m. Since hook-and-line and longline surveys span the shallow (< 25m) and deep (> 25m) rocky reefs summaries are reported here in a separate section which combines both depths. In the future, summaries and analyses will be partitioned by depth.

Table 5.44: Fish data collected by habitat type by year in the Cape Falcon Marine Reserve and its associated comparison areas by year. Blank boxes indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, H = Hook & Line, G = Longline, M = SMURF

			Year							
Region	Site	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Cape Falcon	Cape Falcon MR	SMURFs	-	-	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	-	-	-	H	H	D, L	D, L ,H
	Cape Meares CA	SMURFs	-	-	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	-	-	-	H	H	-	D, L ,H
	Comparison Areas with varied fishing pressure	SMURFs	-	-	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	-	-	-	H	H	L	D, L ,H

Shallow Rocky Subtidal

Scuba Diver Survey Efforts

Scuba data are unavailable for analysis at this time, but effort by year by site can be found in

Table 5.6

Table 5.45: Scuba diver effort (number of transects) by year in the Redfish Rocks Marine Reserve and associated comparison areas for fish surveys.

		Year	
Region	Site	2016	2017
Cape Falcon	Cape Falcon MR	20	-
	Cape Meares CA	-	-
	Comparison Areas with varied fishing pressure	7	3
	All Sites Combined	27	3

Lander

Only a proportion of the lander drops are useable, given constraints of view, visibility and habitat type (Table 5.46). Two years of lander surveys yielded limited useable drops (Table 5.46). The majority of useable drops were for the Cape Falcon Marine Reserve in 2016 and from the comparison areas with varied fishing pressure in 2017. The percentage of useable drops has never been higher than 45%.

Table 5.46: Lander effort represented by total number of useable drops by year in the Cape Falcon Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicated where no data were collected.

		Year	
Region	Site	2016	2017
Cape Falcon	Cape Falcon MR	11	4
	Cape Meares CA	-	1
	Comparison Areas with varied fishing pressure	2	7
	All Sites Combined	13	12
	Total Drops Conducted	29	54
	% Useable Drops	45%	22%

Lander drops yielded low observations of fish species (Table 5.47). Overall, it was rare to see more than one species on any given drop in any given year. When looking across all years, the maximum number of different species observed in a single drop was two (n=1).

Table 5.47: The percentage of useable lander drops yielding observations of fish species for the Cape Falcon region.

		Year	
Region	Species Richness Value	2016	2017
Cape Falcon	0	85%	75%
	1	15%	17%
	2	-	8%
	3	-	-
	4	-	-
	5	-	-
	6	-	-
	7	-	-
	8	-	-
	Total Drops	13	12

Considering all useable drops, in all sites and years, fish were identified to species in 20% (n =5) of lander drops. Overall, four species of fish were observed, across three families. No species were classified as common (Table 5.9). Of the those species classified as rare, Black Rockfish had the highest frequency of occurrence in useable drops at 12% (Table 5.9). When present, two of the species exhibited mean MaxN values greater than one (Table 5.9).

Table 5.48: Of the drops that met condition of habitat, visibility, and view in the Cape Falcon region (n =25), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and total individuals observed across drops.

	Species	N	Frequency	Occurrence	Mean MaxN when present	Total Individuals Observed
Cape Falcon	Black Rockfish	3	12%	Rare	6.3	19
	Lingcod	1	4%	Rare	1.0	1
	Pile Perch	1	4%	Rare	3.0	3
	Striped Surfperch	1	4%	Rare	1.0	1

When comparing across individual sites by year, species richness was consistently under two (Table 5.10). Even when combining richness for all sites, the maximum value of species richness is three. The comparison areas adjacent to the Cape Falcon Marine Reserve observed higher species richness and total individuals. However, these results are effected by low sample sizes.

Table 5.49: Total species richness, total # individuals observed in the lander invertebrate datasets by year at the Cape Falcon Marine Reserve & associated comparison areas. – represent where no data were collected.

			Year	
Region	Site	Metric	2016	2017
Cape Falcon	Cape Falcon MR	Total species richness	1	-
		Total # individuals observed	1	-
	Cape Meares CA	Total species richness	-	-
		Total # individuals observed	-	-
	Comparison Areas with Varied Fishing Pressure	Total species richness	1	3
		Total # individuals observed	15	8
	All Areas Combined	Total species richness	2	3
		Total # individuals observed	16	8

Shallow and Deep Rocky Subtidal

Hook- and –Line Surveys

A total of 116 cells were sampled in Cape Falcon region from 2014-2017. Of these sampled cells 105 (91%) encountered fish.

Table 5.50: Hook-and-Line effort represented by total number of cells sampled by year in the Cape Falcon Marine Reserve and associated comparison areas for fish surveys.– represent where no data were recorded.

		Year			
Region	Site	2014	2015	2016	2017
Cape Falcon	Cape Falcon MR	8	20	-	18
	Cape Meares CA	6	5	-	14
	Comparison Areas with Varied Fishing Pressure	4	26	-	15
	Total Cells Sampled	18	51	-	47

The max species richness observed per replicate (cell) at the Cape Falcon region was 7 with a mean richness per cell of 2.57 (±0.15SE).

Table 5.51: The percentage of cells yielding observations of fish species for the Cape Perpetua region.

		Year		
Region	Species Richness Value	2014	2015	2017
Cape Falcon	0	11%	10%	8%
	1	5%	23%	17%
	2	39%	16%	19%
	3	28%	23%	28%
	4	11%	18%	13%
	5	-	4%	13%
	6	6%	4%	2%
	7	-	2%	-
	Total Cells Sampled	18	51	47

A total of 2,427 individual fish representing 16 species from three families were caught in the Cape Falcon region. 90% of the catch at the Cape Falcon region is made up of three species including Black Rockfish, Lingcod, and Kelp Greenling.

Table 5.52: Of the cells sampled in the in the Cape Falcon region from 2013-2016 (n = 116), species sample size (N), total number of individuals caught, percentage of the total catch that each species represents, and mean CPUE (SE) (angler hour) for each species is represented.

	Species	N	Total Individuals Caught	% of Total Catch	Mean CPUE (SE) (angler hour)
Cape Falcon	Black Rockfish	73	1834	76%	4.85(±0.7)
	Blue Rockfish	1	2	0%	0.25
	Buffalo Sculpin	40	89	4%	0.5(±0.09)
	Cabezon	27	72	3%	0.56(±0.11)
	Canary Rockfish	9	22	1%	0.4(±0.07)
	China Rockfish	2	2	0%	0.24(±0)
	Deacon Rockfish	3	3	0%	0.16(±0.04)
	Kelp Greenling	52	145	6%	0.56(±0.09)
	Lingcod	57	203	8%	0.6(±0.1)
	Pacific Staghorn	5	7	0%	0.64(±0.2)
	Quillback Rockfish	4	5	0%	0.22(±0.05)
	Red Irish Lord	8	10	0%	0.16(±0.03)
	Shiner Perch	2	2	0%	0.15(±0.02)
	Tiger Rockfish	2	3	0%	0.26(±0.11)
	Yelloweye Rockfish	7	16	1%	0.36(±0.17)
	Yellowtail Rockfish	6	12	1%	0.28(±0.05)

When comparing across individual sites by year, species richness is variable (Table 5.53). Overall when combining richness across all sites the maximum is 14. The Cape Falcon Marine Reserve has similar species richness across all years compared to the Cape Meares Comparison Area (Table 5.53). Across all years more individual fish were caught in the Comparison Areas with varied fishing pressure compared to the other sites (Table 5.53). 2017 stands out as a year where many more total individuals were observed in both the Cape Falcon Marine Reserve and associated comparison areas.

Table 5.53: Hook-and-line survey effort by year at the Cape Falcon Marine Reserve and associated comparison areas. Total species richness, total # individuals observed in the hook-and-line fish datasets by year at the Cape Falcon Marine Reserve & associated comparison areas. - represent where no data was collected.

			Year			
	Site	Metric	2014	2015	2016	2017
Cape Falcon	Cape Falcon MR	Total species richness	5	7	-	8
		Total # individuals caught	107	234	-	272
	Cape Meares CA	Total species richness	6	8	-	5
		Total # individuals caught	128	122	-	181
	Comparison Areas with Varied Fishing Pressure	Total species richness	6	13	-	13
		Total # individuals caught	237	516	-	630
	All Areas Combined	Total species richness	9	14	-	14
		Total # individuals caught	472	872	-	1083

Section 5: What habitats exist within each site? How do they change over time?

To date the ODFW Marine Reserves program has collected habitat data at all five Marine Reserves. We do not currently collect data targeting habitats with kelp or soft bottoms communities. All data collection efforts are either in intertidal or subtidal rocky habitats. We gather habitat data through scuba diver, landers, ROV, and intertidal surveys (Table 1). Data are summarized first by reserve, and then by habitat type, and tool. Scuba and intertidal data are unavailable for summarization because their data management systems are under development. Reporting occurs for subtidal rocky habitats only. For the lander surveys we summarize data on both non-living and living substrate while ROV is only used to summaries non-living habitat.

Table 1 Habitat variables collected at each marine reserve site by year. Blank boxes indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, I = intertidal

Site		2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Depth	D, L, R	D, L	L		D, L	D, L	R	
	Relief	D, L	D, L	L		D, L	D, L		
	Substrate Type	D, L, R	D, L	L		D, L	D, L	R	
	Kelp	D, L	D, L	L		D, L	D, L		
	Macroalgae	D, L	D, L	L		D, L	D, L		
	Biogenic complexity	L	L	L		L	L		
Otter Rock	Depth	D, L	D, L	L			D, L		D, L
	Relief	D, L	D, L	L			D, L, I		D, L
	Substrate Type	D, L	D, L	L			D, L, I		D, L
	Kelp	D, L	D, L	L			D, L, I		D, L
	Macroalgae	D, L	D, L	L			D, L, I		D, L
	Biogenic complexity	L	L	L			L		L
Cascade Head	Depth			L, R	L, R	D, L	R	L, R	D, L, R
	Relief			L	L	D, L	I	L	D, L
	Substrate Type			L, R	L, R	D, L	R, I	L, R	D, L, R
	Kelp			L	L	D, L	I	L	D, L
	Macroalgae			L	L	D, L	I	L	D, L
	Biogenic complexity			L	L	L		L	L
Cape Perpetua	Depth	R	R	L, R		L	R		R
	Relief			L		L			
	Substrate Type	R	R	L, R		L	R		R
	Kelp			L		L			
	Macroalgae			L		L			
	Biogenic complexity			L		L			
Cape Falcon	Depth							D, L	D, L
	Relief							D, L	D, L
	Substrate Type							D, L	D, L
	Kelp							D, L	D, L
	Macroalgae							D, L	D, L
	Biogenic complexity							L	L

Redfish Rocks

Habitat data were collected using landers, scuba divers and the ROV since monitoring began in 2010 (Table 2).

Table 2: Habitat variables collected at the Redfish Rocks Marine Reserve, and associated comparison areas by year. - indicate that no data were collected. Pilot indicates a test to see if reliable data were collected. D = Scuba diver, L = Lander, R = ROV, I = intertidal

				Year						
Region	Site	Metric	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Redfish Rocks	Redfish Rocks MR	Depth	D, L, R	D, L	L	-	D, L	D, L	R	-
		Relief	D, L	D, L	L	-	D, L	D, L		-
		Substrate Type	D, L, R	D, L	L	-	L	L	R	-
		Kelp	D, L	D, L	L	-	D, L	D, L	-	-
		Macroalgae	D, L	D, L	L	-	D, L	D, L	-	-
		Biogenic complexity	L, R(pilot)	L	L	-	L	L	-	-
	Orford Reef CA	Depth	R	-	-	-	L	L	R	-
		Relief	-	-	-	-	L	L	-	-
		Substrate Type	R	-	-	-	L	L	R	-
		Kelp	-	-	-	-	L	L	-	-
		Macroalgae	-	-	-	-	L	L	-	-
		Biogenic complexity	R (pilot)	-	-	-	L	L	-	-
	Humbug CA	Depth	D, R, L	D, L	L	-	D, L	D, L	R	-
		Relief	D, L	D, L	L	-	D, L	D, L	-	-
		Substrate Type	D, R, L	D, L	L	-	D, L	D, L	R	-
		Kelp	D, R(pilot), L	D, L	L	-	D, L	D, L	-	-
		Macroalgae	D, R(pilot), L	D, L	L	-	D, L	D, L	-	-
		Biogenic complexity	R-(pilot, L	, L	L	-	L	L	-	-

Rocky Subtidal: Shallow

Scuba Diver Survey Effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 3.

Table 3: Scuba diver survey effort (number of transects) by year in the Redfish Rocks Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Algae= algal swath counts of specific macroalgaes

		Year							
		2010		2011		2014		2015	
Region	Site	UPC	Algae	UPC	Algae	UPC	Algae	UPC	Algae
Redfish Rocks	Redfish Rocks MR	15	15	16	16	1	-	30	24
	Orford Reef CA	-	-	-	-	-	-	-	-
	Humbug CA	5	5	8	8	6	2	18	3
	All Sites Combined	20	20	24	24	7	2	48	27

Lander

The utility of the video lander for collecting benthic habitat data was limited due to constraints of view, visibility and habitat type (Table 4). For any given year the yield was never more than 35 useable drops per site (Table 4). Even combined, the sample size of useable drops are never greater than 75 for the Redfish Rocks Region for any year. In 2015, the first year we recorded total drops compared to useable drops, only 62% of the total lander drops were useable for invertebrate data collection (Table 4).

Table 4: Lander effort by year in the Redfish Rocks Marine Reserve and associated comparison areas for habitat surveys. - indicate that no data were collected, NA indicate that no data were recorded.

		Year					
Region	Site	2010	2011	2012	2014	2015	Total Useable Drops
Redfish Rocks	Redfish Rocks MR	15	16	22	35	25	113
	Orford Reef, CA	-	-	17	16	-	33
	Humbug, CA	13	7	6	24	32	82
	Total Useable	28	23	45	75	57	228
	Overall Drops Conducted	NA	NA	NA	NA	93	
	Percentage of Drops Useable	NA	NA	NA	NA	80%	

Non-living Substrate

Depth

A total of 228 drops were completed in the Redfish Rocks region from 2010-2017 (Table 5). Drops were conducted at depths ranging from 7.1m – 53.4m, with a mean depth of 18.3 (±0.41SE). Of the 228 drops that were completed in the Redfish Rocks Region 113 were completed in the Redfish Rocks Marine Reserve (RRMR) (Table 5). The depths for which these drops were conducted ranged from 7.1m – 34.9m, with a mean depth of 19.47m (±0.59SE). The remaining 115 drops were conducted in Redfish Rocks associated comparison areas (Table 5). When comparing the depths surveyed for each of the comparison areas independently the depths for which the 82 lander drops were conducted in the Humbug Comparison Area ranged from 7.1m – 53.9m, with a mean depth of 17.29m (±0.73SE) (Table 5). While the 33 drops conducted at the Orford Reef Comparison Area ranged from 9.6m – 23m, with a mean depth of 16.8m (±0.53SE).

Overall, 200 of these drops were conducted in shallow depths (<25m) while the remaining 28 were conducted in deep (>25m) depths. Thus, for future analysis lander drops will be used to only classify shallow rocky reef communities for the Redfish Rocks region.

Table 5: Depth range and mean depth surveyed each year in the Redfish Rocks Marine Reserve and associated comparison areas by the lander with associated lander effort represented by total drops. – indicate where no data were collected.

			Year				
Region	Site	Metric	2010	2011	2012	2014	2015
Redfish Rocks	Humbug CA	Depth Range	10.2 - 22.8m	15.1 - 25m	20.1 - 53.4m	9.6 - 22m	7.1 - 22m
		Mean Depth (±SE)	16.92m (±1.14)	22.71m (±1.31)	30.35m (±5.08)	15.52m (±0.92)	15.13m (±0.73)
		Total Drops	13	7	6	24	32
	Orford Reef CA	Depth Range	-	-	9.6 - 21.7m	14.2- 23m	-
		Mean Depth (±SE)	-	-	16.19m (±0.85)	17.44m (±0.61)	-
		Total Drops	-	-	17	16	-
	Redfish Rocks MR	Depth Range	10.6- 34.7m	15.7 - 34.9m	7.1 - 32.3m	13 - 33.1m	11.1 - 25m
		Mean Depth (±SE)	20.17m (±1.82)	25.44m (±1.58)	20.01m (±1.64)	18.61m (±0.70)	15.49m (±0.77)
		Total Drops	15	16	22	35	25
	All sites Combined	Depth Range	10.2 - 34.7m	15.1 - 34.9m	7.1 - 53.4m	9.6 - 33.1m	7.1 - 25m
		Mean Depth (±SE)	18.66m (±1.14)	24.61m (±1.18)	19.95m (±1.25)	17.37m (±0.48)	15.49m (±0.53)
		Total Drops	28	23	45	75	57

Relief

Table 6: Percentage of scored drops assigned a relief category by year for the Redfish Rocks Marine Reserve and associated comparison areas as well as the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year				
Region	Site	Relief Code	2010	2011	2012	2014	2015
Redfish Rocks	Redfish Rocks MR	Low	40%	12%	5%	-	20%
		Mod	33%	44%	50%	49%	44%
		High	27%	44%	45%	51%	36%
		Total Drops	15	16	22	35	25
	Humbug CA	Low	8%	-	17%	-	22%
		Mod	69%	14%	-	37%	34%
		High	23%	86%	83%	63%	44%
		Total Drops	13	7	6	24	32
	Orford Reef	Low	-	-	-	12%	-
		Mod	-	-	12%	44%	-
		High	-	-	88%	44%	-
		Total Drops	-	-	17	16	-
	All Sites Combined	Low	25%	9%	4%	3%	21%
		Mod	50%	35%	29%	44%	39%
		High	25%	56%	67%	53%	40%
		Total Drops	28	23	45	75	57

Substrate Type

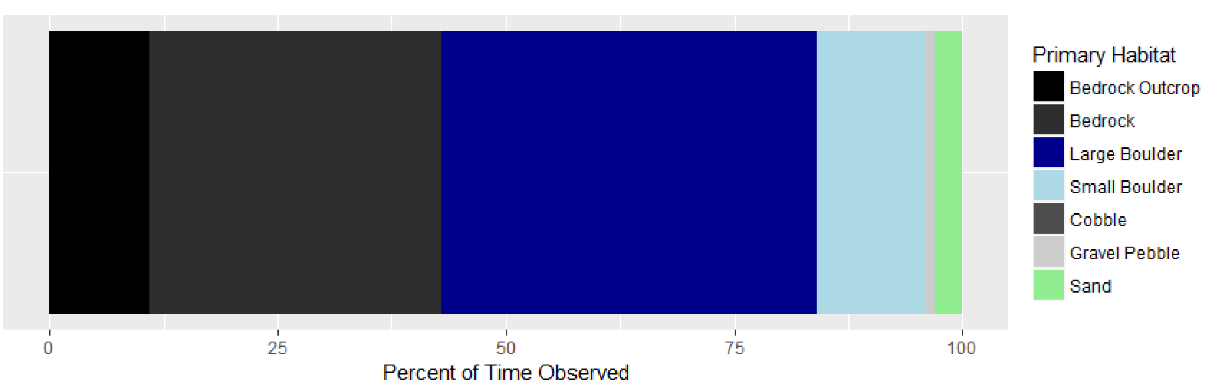


Figure 1: Relative frequency of each primary habitat observed from lander drops at the Redfish Rocks Region. The Redfish Rocks Marine Reserve site includes the Redfish Rocks Marine Reserve, Orford Reef Comparison Area and Humbug Comparison Area.

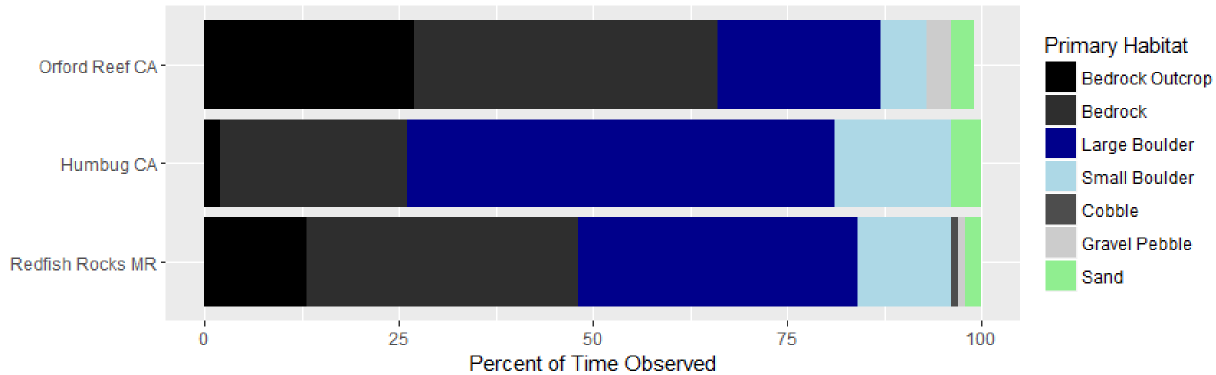


Figure 2: Relative frequency of each primary habitat observed on lander drops in the Redfish Rocks Marine Reserve, Orford and Humbug Comparison Areas.

Ground Truthing Derived Habitat Classification

In the Redfish Rocks Region, pooling across all sites, a total of 281 drops were used for comparison. Seventy-four percent of the drops showed agreement between the in situ and derived habitat classifications of the primary + secondary (Lith3) and general (IND) habitat (Figure 3). However, 91% showed agreement when compared to the derived classification of primary (Lith1) habitat (Figure 3).

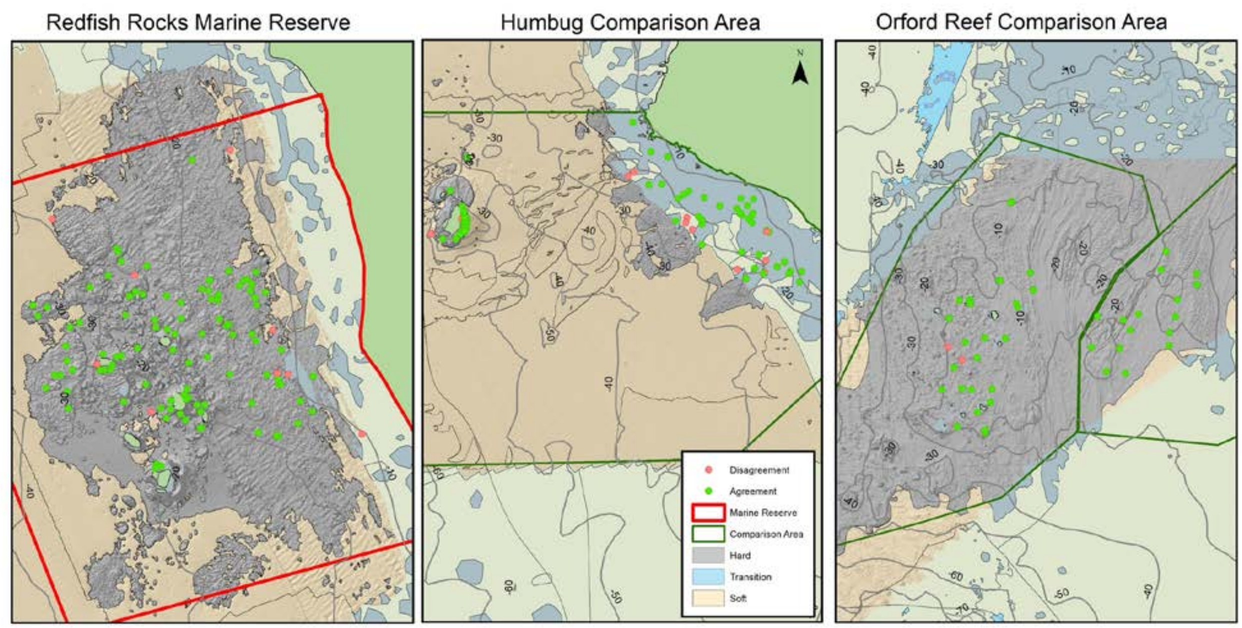


Figure 3: Comparison of the in situ habitat from lander observations compared to the general habitat (IND) category of SGH4 at the Redfish Rocks Marine Reserve and associated comparison areas. Green circles represent agreement and red circles represent disagreement between Lander observations and derived categories. Substrate is colored based on classification.

Hard vs Soft (Derived from SGH4)

Of the approximately 48 km^2 that make up the Redfish Rocks Region, 53% can be classified as soft substrates and 31% as hard substrates with the remaining 15% a mix of both hard and soft substrates. At the management area scale, soft substrates still dominate over hard substrates (Table 7). However, it is clear when looking at the site scale, substrate abundances are more variable. In the Orford Reef Comparison Area the substrate is dominated by hard substrates, while the opposite is true at the Humbug Comparison Area (Table 8).

Table 7: Percentage of the available area represented by each habitat classification for each one of the treatment categories (marine reserve (MR) and pooled comparison areas (CA)).

Region	Management Area	Substrate Type (SGH4, IND)		
		Hard	Mixed	Soft
Redfish Rocks	MR	33%	--	67%
	CA	31%	18%	51%

Table 8: Percentage of the available area represented by each habitat classification for Redfish Rocks Marine Reserve and associated comparison areas.

Region	Site	Substrate Type (SGH4, IND)		
		Hard	Mixed	Soft
Redfish Rocks	Humbug Comparison Area	12%	--	88%
	Orford Reef Comparison Area	54%	40%	5%
	Redfish Rocks Marine Reserve	33%	--	67%

Living Substrate

Table 9: Percentage of drops that contained the given biogenic categories by year for the Redfish Rocks Region, and the effort for each year represented by total drops. - indicate that no drops contained that category. The Redfish Rocks Region includes the Redfish Rocks Marine Reserve, Orford Reef Comparison Area and Humbug Comparison Area.

Region	Biogenic Category	Year				
		2010	2011	2012	2014	2015
Redfish Rocks	Canopy	7%	-	-	8%	4%
	Midstory	36%	4%	44%	47%	32%
	Understory	64%	43%	62%	88%	88%
	Turf/Crust	100%	100%	87%	97%	100%
	Seagrass	-	-	-	-	-
	Total Drops	28	23	45	75	57

Table 10: Percentage of drops that contained the given biogenic categories by year for the Redfish Rocks Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year				
Region	Site	Biogenic Category	2010	2011	2012	2014	2015
Redfish Rocks	Humbug CA	Canopy	8%	-	-	-	6%
		Midstory	31%	-	-	38%	34%
		Understory	69%	57%	-	75%	78%
		Turf/Crust	100%	100%	33%	96%	100%
		Seagrass	-	-	-	-	-
		Total Drops	13	7	6	24	32
	Orford Reef CA	Canopy	-	-	-	38%	-
		Midstory	-	-	71%	88%	-
		Understory	-	-	100%	88%	-
		Turf/Crust	-	-	100%	94%	-
		Seagrass	-	-	-	-	-
		Total Drops	-	-	17	16	-
	Redfish Rocks MR	Canopy	7%	-	-	-	-
		Midstory	40%	6%	36%	34%	28%
		Understory	60%	38%	50%	97%	100%
		Turf/Crust	100%	100%	91%	100%	100%
		Seagrass	-	-	-	-	-
		Total Drops	15	16	22	35	25

Biogenic Complexity by Category

Table 11: Percentage of drops that contained the given abundance index for the associated biogenic categories by year for the Redfish Rocks Region and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year				
Region	Biogenic Category	Abundance Index	2010	2011	2012	2014	2015
Redfish Rocks	Canopy	None	93%	100%	100%	92%	96%
		< 5% of cover	7%	-	-	8%	4%
		5 – 25 %	-	-	-	-	-
		26 – 50 %	-	-	-	-	-
		51 – 75 %	-	-	-	-	-
		76 – 100 %	-	-	-	-	-
	Mid-story	None	64%	96%	56%	53%	68%
		< 5% of cover	18%	-	18%	8%	11%
		5 – 25 %	7%	4%	7%	24%	11%
		26 – 50 %	7%	-	13%	11%	9%
		51 – 75 %	4%	-	4%	3%	2%
		76 – 100 %	-	-	2%	1%	-
	Understory	None	36%	57%	38%	12%	12%
		< 5% of cover	21%	26%	20%	19%	30%
		5 – 25 %	36%	17%	22%	63%	42%
		26 – 50 %	7%	-	7%	5%	9%
		51 – 75 %	-	-	13%	1%	7%
		76 – 100 %	-	-	-	-	-
	Turf/Crust	None	-	-	13%	3%	-
		< 5% of cover	-	-	9%	1%	2%
		5 – 25 %	7%	-	13%	9%	4%
		26 – 50 %	36%	9%	24%	15%	14%
		51 – 75 %	39%	39%	24%	36%	54%
		76 – 100 %	18%	52%	16%	36%	26%
	Seagrass	None	100%	100%	100%	100%	100%
		< 5% of cover	-	-	-	-	-
		5 – 25 %	-	-	-	-	-
		26 – 50 %	-	-	-	-	-
		51 – 75 %	-	-	-	-	-
		76 – 100 %	-	-	-	-	-
		Total Drops	28	23	45	75	57

Primary Habitat: Deep Rocky Reefs

ROV

Non-living substrate

In 2010 the ROV completed a total of 117 transects in the Redfish Rocks Region. A total of 42 completed transects were completed in the Redfish Rocks Marine Reserve; 35 transects in the Humbug Comparison Area and 40 transects completed at Orford Reef Comparison Area. Transect depths ranged from 19-49 meters for all transects in 2010 Table 12). Slightly more than half of the primary habitat observed in ROV transects consisted of hard substrate (Figure 4). Bedrock was the most commonly observed hard bottom substrate whereas sand was the most commonly observed soft bottom substrate.

Table 12 Depth range of ROV transects at all sites in the Redfish Rocks Region for 2010 and 2016.

Year	Location	Depth (m)		
		Min	Median	Max
Redfish Rocks Region				
2010	Redfish Rocks MR	19.1	28.0	36.7
2010	Orford Reef	20.0	25.1	49.3
2010	Humbug	18.0	26.4	45.2
2016	Redfish Rocks MR	19.0	26.4	37.3
2016	Orford Reef	19.9	32.5	42.9
2016	Humbug	21.1	27.4	44.9

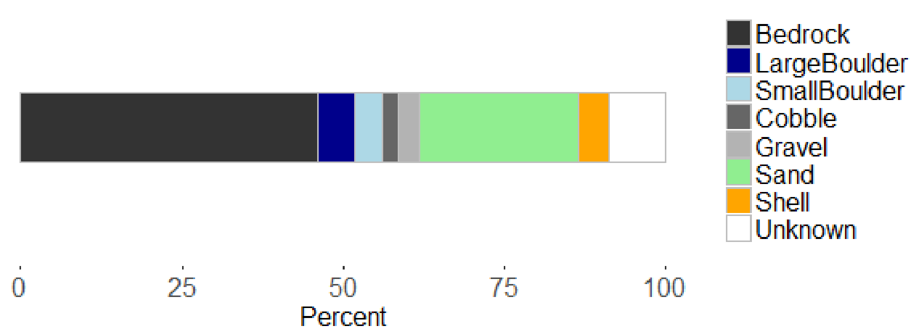


Figure 4: Relative frequency of each primary habitat observed in ROV transects at the Redfish Rocks Region, in 2010, shown as percent of total linear transect distance. The Redfish Rocks Marine Reserve region includes the Redfish Rocks Marine Reserve, Orford Reef Comparison Area and Humbug Comparison Area.

The ROV transects from 2010 observed the Redfish Rocks Marine Reserve and Humbug Comparison Areas to have similar amounts of hard substrate (~ 50%, 5). However, they differ in the types of unconsolidated substrate (Figure 5). More than 75% of the Orford Reef Comparison Area consisted of hard substrates (Figure 5).

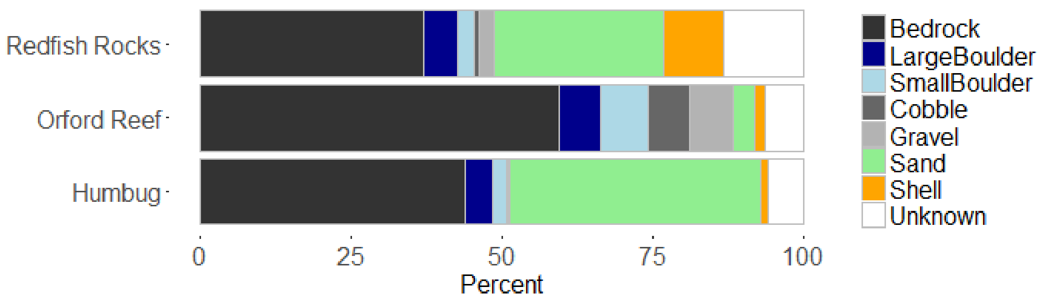


Figure 5: Primary Habitat relative frequency from the 2010 ROV substrate data in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data summarize the substrate covered by all transects in each location.

In 2016 the ROV completed a total of 71 transects in the Redfish Rocks Region. A total of 35 completed transects were completed in the Redfish Rocks Marine Reserve; 13 transects in the Humbug Comparison Area and 23 transects completed at Orford Reef Comparison Area. Transect depths ranged from 19-45 meters for all transects in 2016 (Table 5). Slightly more than half of the primary habitat observed in ROV transects consisted of hard substrate (Figure 6). Bedrock was the most commonly observed hard bottom substrate whereas sand was the most commonly observed soft bottom substrate.

The ROV transects from 2016 were similar to 2010 confirming Orford Reef had the most hard substrate observed (~ 85%, Figure 7). Similar to the 2010 data, the Humbug Comparison Area had the greatest percentage of sand whereas the Redfish Rocks Marine Reserve had the largest percentage of shell. Overall the ROV transects had similar relative frequencies of primary habitat observed in both 2010 and 2016 (Figure 7).

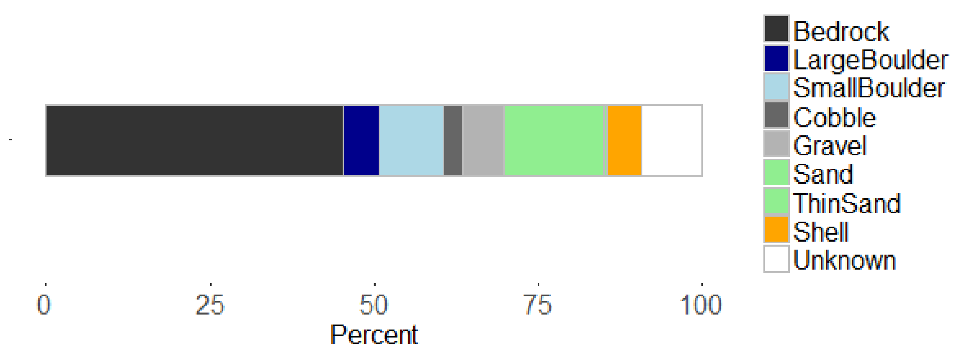


Figure 6: Relative frequency of each primary habitat observed in ROV transects at the Redfish Rocks Region, in 2016, shown as percent of total linear transect distance.

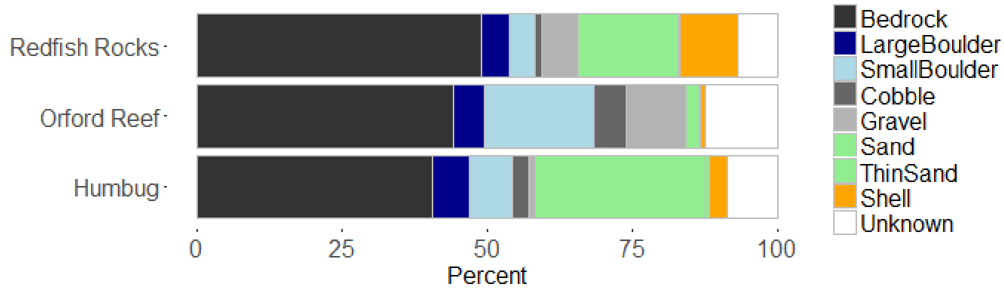


Figure 7: Primary Habitat relative frequency from the 2016 ROV substrate data in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data summarize the substrate covered by all transects in each site.

Otter Rock

Habitat data were collected using landers, scuba divers and ROV since monitoring began in 2010 (Table 13).

Table 13: Habitat variables collected at the Redfish Rocks Marine Reserve, and associated comparison areas by year. - indicate that no data were collected. D = scuba diver, L = Lander, R = ROV, I = intertidal

			Year							
Region	Site	Metric	2010	2011	2012	2013	2014	2015	2016	2017
Otter Rock	Otter Rock MR	Depth	D, L	D, L	-	-	-	D, L	-	D, L
		Relief	D, L	D, L	-	-	-	D, L, I	-	D, L
		Substrate Type	D, L	D, L	-	-	-	D, L, I	-	D, L
		Kelp	D, L	D, L	-	-	-	D, L, I	-	D, L
		Macroalgae	D, L	D, L	-	-	-	D, L, I	-	D, L
		Biogenic complexity	D, L	D, L	-	-	-	D, L	-	D, L
	Cape Foulweather CA	Depth	L	L	-	-	-	L	-	D, L
		Relief	L	L	-	-	-	L	-	D, L
		Substrate Type	L	L	-	-	-	L	-	D, L
		Kelp	L	L	-	-	-	L	-	D, L
		Macroalgae	L	L	-	-	-	L	-	D, L
		Biogenic complexity	L	L	-	-	-	L	-	L

Intertidal

Intertidal habitat data are not available for summarization at this time because of limited staff capacity.

Rocky Subtidal: Shallow

Scuba Diver Survey Effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 14.

Table 14: Scuba diver survey effort (number of transects) by year in the Otter Rock Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Algae= algal swath counts of specific macroalgaes

		Year							
		2010		2011		2015		2017	
Region	Site	UPC	Algae	UPC	Algae	UPC	Algae	UPC	Algae
Otter Rock	Otter Rock MR	4	4	14	14	7	-	16	16
	Cape Foulweather CA	-	-	-	-	-	-	11	11
	All Sites Combined	4	4	34	34	7	-	27	27

Lander

Given constraints of view, visibility and habitat type only a proportion of the lander drops are useable (Table 15). For five of the six years of data the yield was no more than 19 useable drops, even when we combine drops from Otter Rock Marine Reserve and Cape Foulweather (Table 15). In 2015, we had the most useable drops at both the Otter Rock Marine Reserve and Cape Foulweather. We did not begin tracking total drops compared to useable drops until 2015. Since then our percentage of useable drops have ranged from 46-66%. When we combine useable drops for all sites to look at sample size for the Otter Rocks Region, the largest sample size was in 2015 with 151 useable drops.

Table 15: Lander effort represented by total number of useable drops by year in the Otter Rock Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year					
Region	Site	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	4	3	7	84	-	6
	Cape Foulweather CA	10	16	8	67	17	10
	All Sites	14	19	15	151	17	16
	Total Drops Conducted	NA	NA	NA	228	34	35
	% Useable Drops	NA	NA	NA	66%	50%	46%

Non-living Substrate

Depth

A total of 232 drops were completed in the Otter Rock Region from 2010-2017 (Table 16). The depths of these drops ranged from 2.8m-18.7m, with a mean depth of 11.08 m (±0.27SE).

Of the 232 drops that were completed from 2010-2017, 104 were completed Otter Rock Marine Reserve (Table 16). The depths for which these drops were conducted ranged from 2.8m – 18m, with a mean depth of 8.49m (±0.31SE). The remaining 128 drops were conducted in Cape Foulweather Comparison Area (Table 16). When comparing the depths surveyed by the Lander for each of the comparison areas independently they ranged from 4.6m – 18.7m, with a mean depth of 13.18m (±0.31SE) (Table 16).

Table 16: Depth range and mean depth surveyed each year in the Otter Rock Marine Reserve and associated comparison areas by the lander with associated lander effort represented by total drops. – indicate where no data were collected.

			Year					
Region	Site	Metric	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	Depth Range	10.4 - 14.4m	10.6 - 12.8m	3.4 - 12m	2.8 - 18m	-	6 - 12.6m
		Mean Depth (±SE)	12.12 (±1.02)	11.57 (±0.65)	6.86 (±1.31)	8.21 (±0.33)	-	10.27 (0.98)
		Total Drops	4	3	7	84	-	6
	Cape Foulweather CA	Depth Range	12.8 - 17.5m	13.3 - 18.6m	9.5 - 18.2m	4.6 - 18.7m	6.4 - 18.6m	9.1 - 17.2m
		Mean Depth (±SE)	14.77 (±0.56)	15.81 (±0.38)	13.32 (±1.18)	11.84 (±0.47)	14.39 (±0.69)	14.16 (±0.85)
		Total Drops	10	16	8	67	17	10
	All Sites Combined	Depth Range	10.4 - 17.5m	10.6 - 18.6m	3.4 - 18.2m	2.8 - 18.7m	6.4 - 18.6m	6 - 17.2m
		Mean Depth (±SE)	14.01 (±0.58)	15.14 (±0.49)	10.31 (±1.21)	9.82 (±0.31)	14.39 (±.69)	12.7 (±.79)
		Total Drops	14	19	15	151	17	16

Given the depth of the reserve and comparison area, all of the 232 drops were conducted in shallow depths (<25m). Thus for future analyses lander drops will be used to only classify shallow rocky reef communities for the Otter Rock region.

Relief

Table 17: Percentage of drops that contained the given relief category by year for the Otter Rock Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year					
Region	Site	Relief Code	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	Low	100%	34%	43%	14%	-	17%
		Mod	-	33%	43%	37%	-	83%
		High	-	33%	14%	49%	-	-
		Total Drops	4	3	7	84	-	6
	Cape Foulweather CA	Low	60%	31%	13%	25%	29%	30%
		Mod	40%	44%	25%	31%	24%	40%
		High		25%	62%	44%	47%	30%
		Total Drops	10	16	8	67	17	10
	All Sites Combined	Low	71%	32%	27%	19%	29%	25%
		Mod	29%	42%	33%	34%	24%	56%
		High	-	26%	40%	47%	47%	19%
		Total Drops	14	19	15	151	17	16

Substrate Type

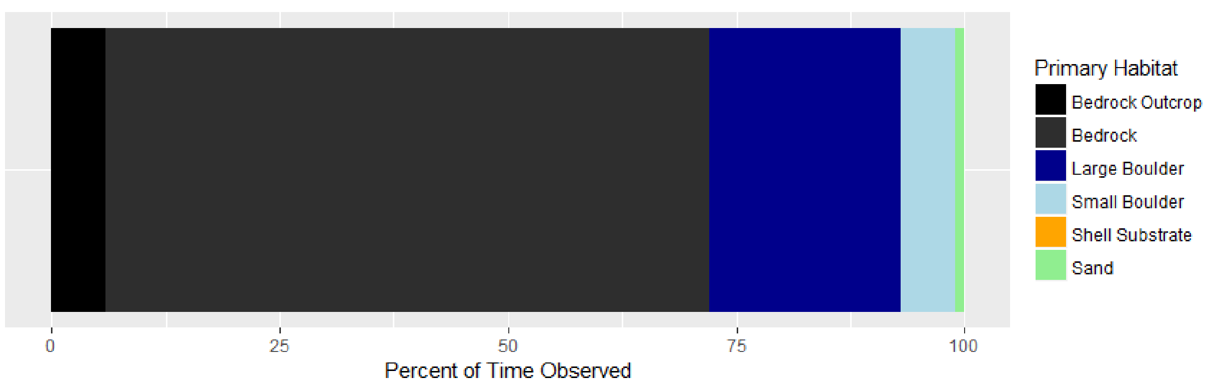


Figure 8: Relative frequency of each primary habitat observed lander drops at the Otter Rock Region. The Otter Rock Marine Reserve region includes the Otter Rock Marine Reserve and Cape Foulweather Comparison Area.

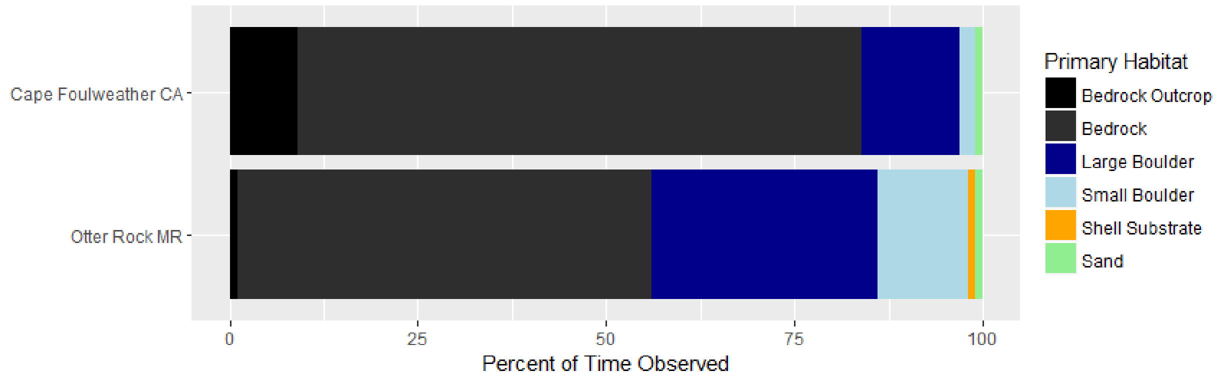


Figure 9: Relative frequency of each primary habitat observed during lander drops in the Otter Rock Marine Reserve and Cape Foulweather Comparison Area.

Ground Truthing Derived Habitat Classification

In the Otter Rock Region, pooling across all areas, a total of 322 drops were used for comparison. Seventy-seven percent of the drops showed agreement between the in situ and derived habitat classifications across all primary (SGH4) habitat categories (Figure 10).

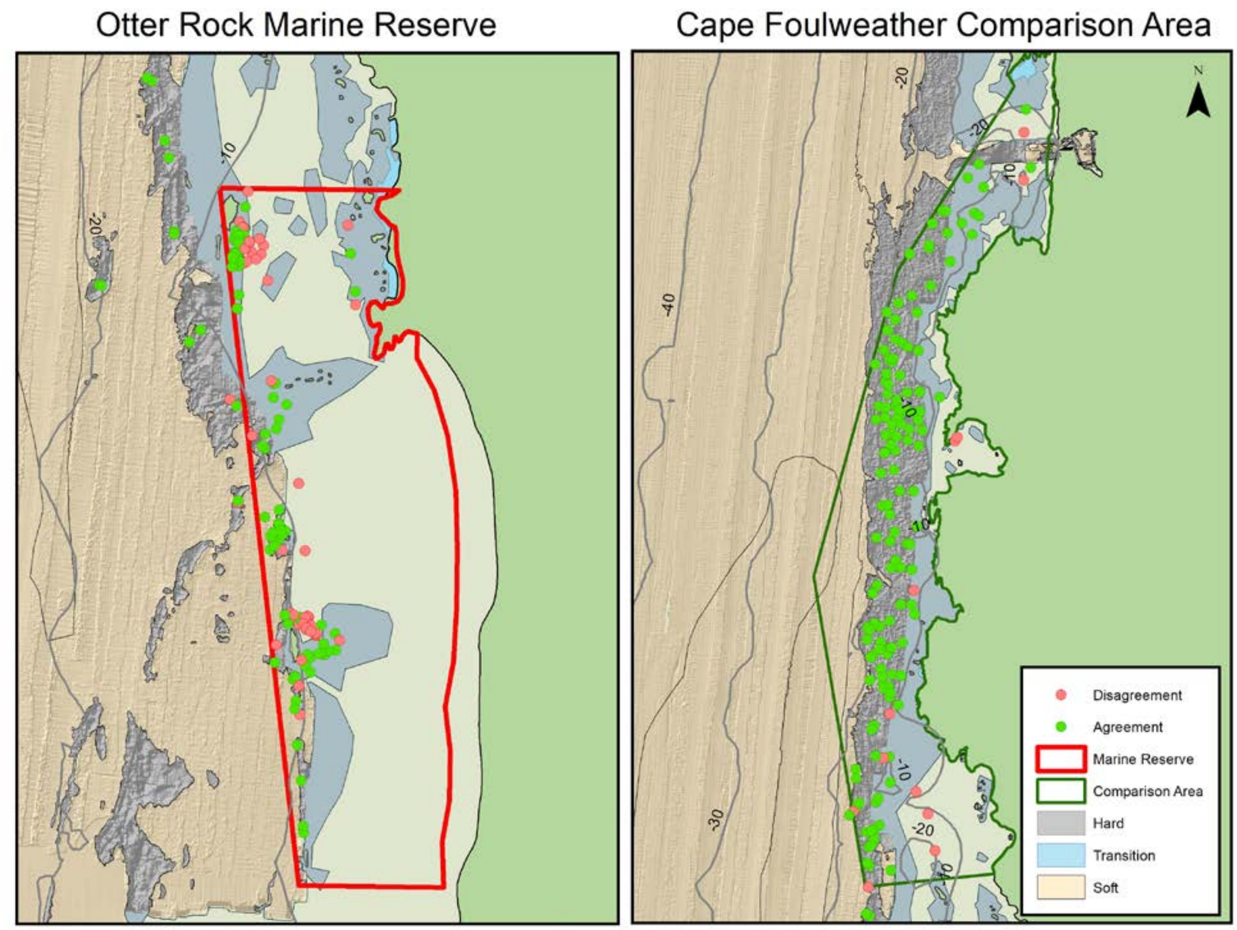


Figure 10: Comparison of the in situ habitat lander observation compared to the IND category of SGH4 at the Otter Rock Marine Reserve and associated comparison areas. Green circles represent agreement and red circles represent disagreement between lander observations and derived categories. Substrate is colored based on classification.

Hard vs Soft (Derived from SGH4)

Of the approximately 7.5 km^2 that make up the Otter Rock region, 53% can be classified as soft substrates and 47% as hard substrates. At the site level soft substrates dominate over hard substrates in the Cape Foulweather Comparison Area but the reverse is true for the Otter Rock Marine Reserve (Table 18).

Table 18: Percentage of the available area represented by each habitat classification for Otter Rock Marine Reserve and associated comparison areas.

Region	Site	Hard	Mixed	Soft
Otter Rock	Otter Rock MR	25%	0%	75%
	Cape Foulweather CA	61%	0%	39%

Living Substrate

Table 19: Percentage of drops that contained the given biogenic categories by year for the Otter Rock Region as well as the effort for each year represented by total drops. - indicate that no drops contained that category. The Otter Rock Marine Reserve region includes the Otter Rock Marine Reserve and Cape Foulweather Comparison Area.

		Year					
Region	Biogenic Category	2010	2011	2012	2015	2016	2017
Otter Rock	Canopy	-	-	-	7%	-	-
	Midstory	7%	5%	27%	48%	-	25%
	Understory	79%	68%	73%	85%	100%	100%
	Turf/Crust	100%	100%	67%	100%	100%	100%
	Seagrass	7%	5%	-	9%	-	-
	Total Useable Drops	14	19	15	151	17	16

Table 20: Percentage of drops that contained the given biogenic categories by year for the Otter Rock Marine Reserve and associated comparison areas as well as the effort for each year represented by total drops. - indicate that no drops contained that category

			Year					
Region	Site	Biogenic Category	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	Canopy	-	-	-	6%	-	-
		Midstory	25%	33%	57%	67%	-	50%
		Understory	75%	100%	86%	93%	-	100%
		Turf/Crust	100%	100%	57%	100%	-	100%
		Seagrass	25%	33%	-	15%	-	-
		Total Drops	4	3	7	84	-	6
	Cape Foulweather CA	Canopy	-	-	-	9%	-	0%
		Midstory	-	-	-	25%	-	10%
		Understory	80%	63%	63%	76%	100%	100%
		Turf/Crust	100%	100%	75%	100%	100%	100%
		Seagrass	-	-	-	-	-	-
		Total Drops	10	16	8	67	17	10

Biogenic Complexity by Category

Table 21: Percentage of drops that contained the given abundance index for the associated biogenic categories by year for the Otter Rock Region as well as the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year					
Region	Biogenic Category	Abundance Index	2010	2011	2012	2015	2016	2017
Otter Rock	Canopy	None	100%	100%	100%	93%	100%	100%
		< 5% of cover	-	-	-	6%	-	-
		5 – 25 %	-	-	-	1%	-	-
		26 – 50 %	-	-	-	-	-	-
		51 – 75 %	-	-	-	-	-	-
		76 – 100 %	-	-	-	-	-	-
	Midstory	None	93%	95%	73%	52%	100%	75%
		< 5% of cover	-	5%	13%	13%	-	13%
		5 – 25 %	-	-	7%	23%	-	13%
		26 – 50 %	7%	-	7%	13%	-	-
		51 – 75 %	-	-	-	-	-	-
		76 – 100 %	-	-	-	-	-	-
	Understory	None	21%	32%	27%	15%	-	-
		< 5% of cover	21%	16%	-	32%	71%	56%
		5 – 25 %	21%	21%	20%	39%	29%	25%
		26 – 50 %	14%	21%	20%	13%	-	19%
		51 – 75 %	7%	11%	7%	2%	-	-
		76 – 100 %	14%	-	27%	-	-	-
	Turf/Crust	None	-	-	33%	-	-	-
		< 5% of cover	-	-	13%	1%	-	6%
		5 – 25 %	29%	5%	27%	5%	-	-
		26 – 50 %	21%	42%	7%	22%	-	19%
		51 – 75 %	21%	21%	13%	34%	29%	25%
		76 – 100 %	29%	32%	7%	38%	71%	50%
	Seagrass	None	93%	95%	100%	91%	100%	100%
		< 5% of cover	7%	5%	-	3%	-	-
		5 – 25 %	-	-	-	2%	-	-
		26 – 50 %	-	-	-	1%	-	-
		51 – 75 %	-	-	-	2%	-	-
		76 – 100 %	-	-	-	-	-	-

Total Drops	14	19	15	151	17	16

Cascade Head

Habitat data were collected using landers, scuba divers, and ROV since monitoring began in 2012 (Table 22).

Table 22: Habitat variables collected at the Cascade Head Marine Reserve, and associated comparison areas by year. - indicate that no data were collected. D = scuba diver, L = lander, R = ROV, I = intertidal

			Year					
Region	Site	Metric	2012	2013	2014	2015	2016	2017
Cascade Head	Cascade Head MR	Depth	L, R	D, R	D, L	R	L, R	D, L, R
		Relief	L	D	D, L	I	L	D, L
		Substrate Type	L, R	D, R	D, L	R, I	L, R	D, L, R
		Kelp	L	D	D, L	I	L	D, L
		Macroalgae	L	D	D, L	I	L	D, L
		Biogenic complexity	L	-	L	-	L	L
	Schooner Creek CA	Depth	L	L,R	D	R	L,R	D,L, R
		Relief	L	L	D	-	L	D, L
		Substrate Type	L	L,R	D	R	L,R	D, L, R
		Kelp	L	L	D	-	L	D, L
		Macroalgae	L	L	D	-	L	D, L
		Biogenic complexity	L	L	-	-	L	L
	Cavalier CA	Depth	L, R	D, L	-	-	L, R	D, R
		Relief	L	D, L	-	-	L	D
		Substrate Type	L, R	D, L	-	-	L, R	D, R
		Kelp	L	D, L	-	-	L	D
		Macroalgae	L	D, L	-	-	L	D
		Biogenic complexity	L	L	-	-	L	-

Intertidal

Intertidal habitat data are not available for summarization at this time because of limited staff capacity.

Rocky Subtidal: Shallow

Scuba Diver Survey Effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 23.

Table 23: Scuba diver survey effort (number of transects) by year in the Cascade Head Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Algae= algal swath counts of specific macroalgaes

		Year					
		2013		2014		2017	
Region	Site	UPC	Algae	UPC	Algae	UPC	Algae
Cascade Head	Cascade Head MR	13	10	10	2	12	12
	Schooner Creek CA	-	-	17	4	8	8
	Cavalier CA	14	8	-	-	4	4
	All Sites Combined	27	18	27	6	24	24

Lander

Only a proportion of the lander drops are useable for data collection, given constraints of view, visibility and habitat type (Table 24). Tracking total drops compared to useable drops was not calculated until 2015. Since then the percentage of useable drops has never been higher than 54%.

Table 24: Lander effort represented by total number of useable drops by year in the Cascade Head Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year				
Region	Site	2012	2013	2014	2016	2017
Cascade Head	Cascade Head MR	55		6	-	12
	Cavalier CA	43	9	-	21	-
	Schooner Creek CA	55	56	-	28	9
	All Sites Combined	153	65	6	49	21

Total Drops Conducted	NA	NA	NA	111	39
% Useable Drops	NA	NA	NA	44%	54%

Non-living Substrate

Depth

A total of 294 drops were completed in the Cascade Head Region from 2012-2017 (Table 25). The depths for which these drops were conducted ranged from 6.4m – 47.5m, with a mean depth of 25.86m (±0.56SE). Of the 294 drops that were completed in the Cascade Head region, 73 were completed in Cascade Head Marine Reserve (Table 25). The depths of these drops ranged from 9.3m – 40m, with a mean depth of 22.46m (±0.89SE). The remaining 221 drops were conducted in Cascade Head comparison areas (Table 25). At the site level, the depths for which the 73 lander drops were conducted in the Cavalier Comparison Area ranged from 8.5m – 47.5m, with a mean depth of 27.2m (±1.27SE) (Table 25). While the 148 drops conducted at the Schooner Creek Comparison Area ranged from 6.4m – 45m, with a mean depth of 26.87m (±0.78SE) (Table 25).

Table 25: Depth range and mean depth surveyed each year in the Cascade Head Marine Reserve and associated comparison areas by the lander with associated effort represented by total drops. – indicate where no data were collected.

Region	Site	Metric	Year 2012	2013	2014	2016	2017
Cascade Head	Cascade Head MR	Depth Range	9.3 - 40m	-	14 - 21m	-	10.8 - 21.5m
		Mean Depth (±SE)	24.46 (±1.03)	-	17.5 (±1.09)	-	15.75 (±0.92)
		Total Drops	55	-	6	-	12
	Cavalier CA	Depth Range	11.8 - 47.5m	16 - 41m	-	8.5 - 27.1m	-
		Mean Depth (±SE)	29.84 (±1.71)	33.22(±2.69)	-	19.22(±1.27)	-
		Total Drops	43	9	-	21	-
	Schooner Creek CA	Depth Range	6.4 - 43.8m	16 - 45m	-	9.6 - 28.7m	11.7 - 17.2m
		Mean Depth (±SE)	27.17(±1.36)	32.5(±0.86)	-	18.84(±0.91)	14.92(±0.61)
		Total Drops	55	56	-	28	9
	All Sites Combined	Depth Range	6.4 - 47.5m	16 - 45m	14 - 21m	8.5 - 28.7m	10.8 - 21.5m
		Mean Depth (±SE)	26.95 (±0.79)	32.6 (±0.82)	17.5 (±1.09)	19 (±0.74)	15.4 (±0.58)
		Total Drops	153	65	6	49	21

Overall, 144 of these drops were conducted in shallow depths (<25m) while the remaining 150 were conducted in deep (>25m) depths. Thus, for future analysis Lander drops will be used to classify both shallow and deep rocky reef communities for the Cascade Head Region.

Relief

Table 26: Percentage of drops that contained the given relief category by year for the Cascade Head Marine Reserve and associated Comparison Areas as well as the effort for each year represented by total drops. - indicate that no drops contained that category.

Region	Site	Relief Code	Year 2012	2013	2014	2016	2017
Cascade Head	Cascade Head MR	Low	16%	-	17%	-	25%
		Mod	35%	-	33%	-	58%
		High	49%	-	50%	-	17%
		Total Drops	55	-	6	-	12
	Cavalier CA	Low	16%	33%	-	24%	-
		Mod	40%	-	-	43%	-
		High	44%	67%	-	33%	-
		Total Drops	43	9	-	21	-
	Schooner Creek CA	Low	15%	41%	-	32%	33%
		Mod	42%	-	-	21%	33%
		High	43%	59%	-	47%	34%
		Total Drops	55	56	-	28	9
	All Sites Combined	Low	16%	40%	17%	29%	28%
		Mod	38%	-	33%	31%	48%
		High	46%	60%	50%	40%	24%
		Total Drops	153	65	6	49	21

Substrate Type

Figure 11: Relative frequency of each primary habitat observed during lander drops at the Cascade Head Marine Reserve Region. The Cascade Head Region includes the Cascade Head Marine Reserve, Cavalier Comparison Area, and Schooner Creek Comparison Area.

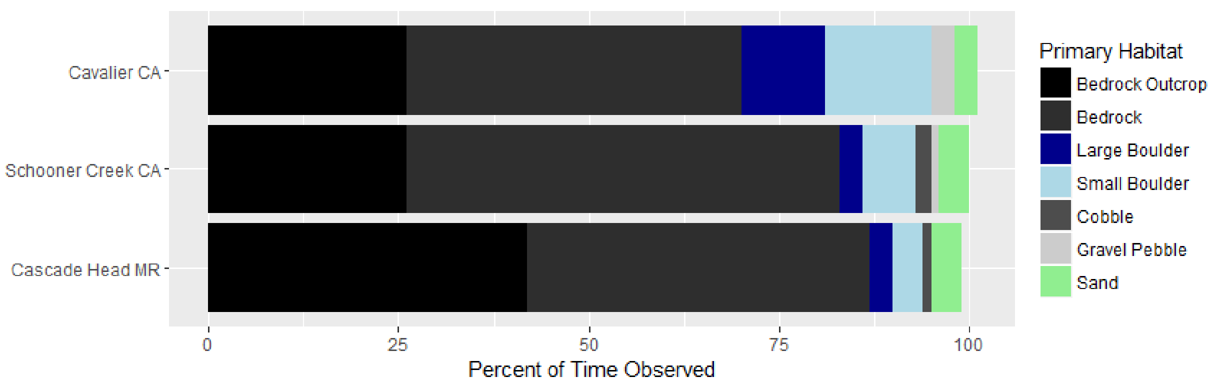


Figure 12: Relative frequency of each primary habitat observed during lander drops at the Cascade Head Marine Reserve, Cavalier Comparison Area, and Schooner Creek Comparison Area.

Ground Truthing Derived Habitat Classification

In the Cascade Head Region, pooling across all sites, a total of 334 drops were used for comparisons. Eighty-nine percent of the drops showed agreement between the in situ and the derived habitat classifications (Figure 13).

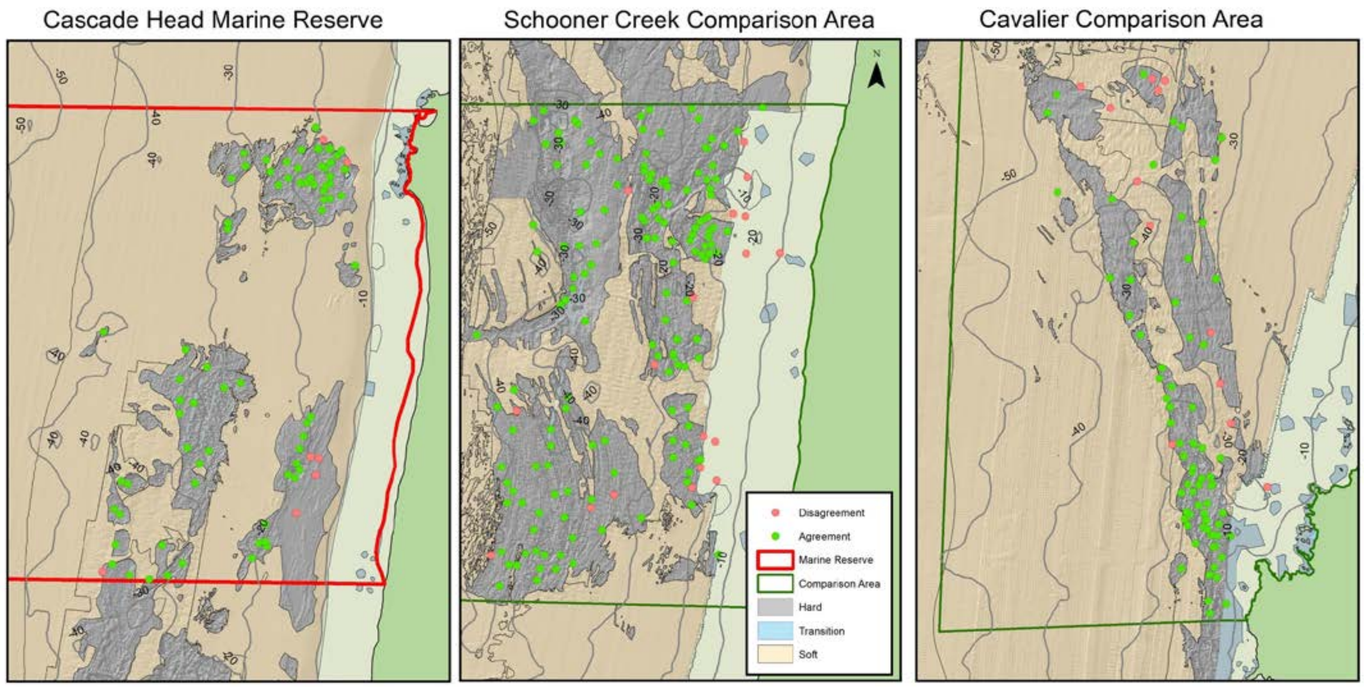


Figure 5: Comparison of the in situ habitat lander observation compared to the IND category of SGH4 at the Cascade Head Marine Reserve and associated comparison areas. Green circles represent agreement and red circles represent disagreement between lander observations and derived categories. Substrate is colored based on classification.

Hard vs Soft (Derived from SGH4)

Of the approximately 83 km^2 that make up the Cascade Head Region, 77% can be classified as soft substrates and 23% as hard substrates. At the management area scale, soft substrates still dominate over hard substrates (Table 27). However, it is clear when looking at the site level substrate abundances are more variable. In the Schooner Creek Comparison Area the substrate is more evenly split between hard and soft substrates (Table 28).

Table 27: Percentage of the available area represented by each habitat classification by management area (marine reserve (MR) and pooled comparison areas (CA)).

		Substrate Type (SGH4, IND)		
Region	Management Area	Hard	Mixed	Soft
Cascade Head	MR	15%	-	85%
	CA	27%	-	73%

Table 28: Percentage of the available area represented by each habitat classification for Redfish Rocks Marine Reserve and associated comparison areas.

Region	Site	Substrate Type (SGH4, IND)		
		Hard	Mixed	Soft
Cascade Head	Cascade Head MR	15%	-	85%
	Cavalier CA	14%	-	86%
	Schooner Creek CA	41%	-	59%

Living Substrate

Table 29: Percentage of drops that contained the given biogenic categories by year for the Cascade Head Region and the effort for each year represented by total drops. - indicate that no drops contained that category. The Cascade Head Region includes the Cascade Head Marine Reserve, Schooner Creek Comparison Area, and Cavalier Comparison Area.

Region	Biogenic Category	Year				
		2012	2013	2014	2016	2017
Cascade Head	Canopy	-	-	-	-	10%
	Midstory	3%	-	17%	6%	24%
	Understory	67%	82%	83%	84%	86%
	Turf/Crust	84%	100%	100%	98%	100%
	Seagrass	1%	-	-	-	-
	Total Drops	153	65	6	49	21

Table 30: Percentage of drops that contained the given biogenic categories by year for the Cascade Head Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year				
Region	Site	Biogenic Category	2012	2013	2014	2016	2017
Cascade Head	Cascade Head MR	Canopy	-	-	-	-	-
		Midstory	-	-	17%	-	25%
		Understory	78%	-	83%	-	75%
		Turf/Crust	87%	-	100%	-	100%
		Seagrass	-	-	-	-	-
		Total Drops	55	-	6	-	12
	Cavalier Ca	Canopy	-	-	-	-	-
		Midstory	-	-	-	-	-
		Understory	65%	89%	-	81%	-
		Turf/Crust	95%	100%	-	100%	-
		Seagrass	2%	-	-	-	-
		Total Drops	43	9	-	21	-
	Schooner Creek	Canopy	-	-	-	-	22%
		Midstory	7%	-	-	11%	22%
		Understory	58%	80%	-	86%	100%
		Turf/Crust	71%	100%	-	96%	100%
		Seagrass	-	-	-	-	-
		Total Drops	55	56	-	28	9

Biogenic Complexity by Category

Table 31: Percentage of drops that contained the given abundance index for the associated biogenic categories by year for the Cascade Head Region and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year				
Region	Biogenic Category	Abundance Index	2012	2013	2014	2016	2017
Cascade Head	Canopy	None	100%	100%	100%	100%	90%
		< 5% of cover	-	-	-	-	10%
		5 – 25 %	-	-	-	-	-
		26 – 50 %	-	-	-	-	-
		51 – 75 %	-	-	-	-	-
		76 – 100 %	-	-	-	-	-
	Midstory	None	97%	100%	83%	94%	76%
		< 5% of cover	1%	-	-	6%	10%
		5 – 25 %	1%	0%	17%	-	10%
		26 – 50 %	-	-	-	-	5%
		51 – 75 %	-	-	-	-	0%
		76 – 100 %	1%	-	-	-	-
	Understory	None	33%	18%	17%	16%	14%
		< 5% of cover	30%	52%	50%	65%	43%
		5 – 25 %	20%	25%	33%	18%	14%
		26 – 50 %	9%	3%	-	-	29%
		51 – 75 %	5%	2%	-	-	-
		76 – 100 %	3%	-	-	-	-
	Turf/Crust	None	16%	-	-	2%	-
		< 5% of cover	3%	5%	-	2%	-
		5 – 25 %	12%	6%	-	2%	5%
		26 – 50 %	14%	9%	-	4%	14%
		51 – 75 %	20%	51%	17%	20%	19%
		76 – 100 %	35%	29%	83%	69%	62%
	Seagrass	None	99%	100%	100%	100%	100%
		< 5% of cover	1%	-	-	-	-
		5 – 25 %	-	-	-	-	-
		26 – 50 %	-	-	-	-	-
		51 – 75 %	-	-	-	-	-
		76 – 100 %	-	-	-	-	-
		Total Drops	153	65	6	49	21

Primary Habitat: Deep Rocky Reefs

ROV

Non-living substrate

Table 32 Number of transects conducted by the ROV by year for the Cascade Head Marine Reserve and associated comparison areas.

Site	2012	2013	2014	2015	2016	2017
Cascade Head	16	10	----	4	3	11
Schooner Creek	0	10	----	4	4	15
Cavalier	16	0	----	0	4	14
All sites	32	20	----	8	11	40

Table 33 Depth range of ROV transects at all sites for all years in the Cascade Head Region.

Year	Location	Depth (m)		
		Min	Median	Max
2012	Cascade Head MR	21.3	28.1	41.0
2012	Cavalier	21.6	31.9	39.6
2013	Cascade Head MR	26.8	30.5	37.7
2013	Schooner Creek	20.7	30.9	40.3
2017	Cascade Head MR	22.5	29.1	36.2
2017	Cavalier	25.2	34.2	38.1
2017	Schooner Creek	25.2	35.8	41.4

The 2012 ROV transects found that Cascade Head Marine Reserve and Cavalier Comparison Areas have similar amounts of bedrock and small boulder (Figure 5.14). Cavalier had more gravel substrate in its transects than the Cascade Head Marine Reserve (Figure 5.14). Cascade Head had the greatest percentage of overall unconsolidated substrates (Figure 5.14).

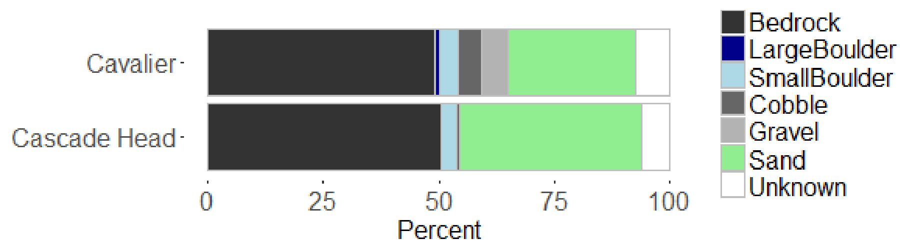


Fig 14: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve and Cavalier Comparison Area in 2012, shown as percent of total linear transect distance.

Bedrock was the dominate substrate found during ROV surveys in the Cascade Head Region during 2012. Hard bottom substrates (Bedrock, large and small boulder, cobble, and gravel) accounted for the majority of substrates surveyed. Sand was the most frequently observed soft bottom substrate in 2012 for all sites (Fig 15).

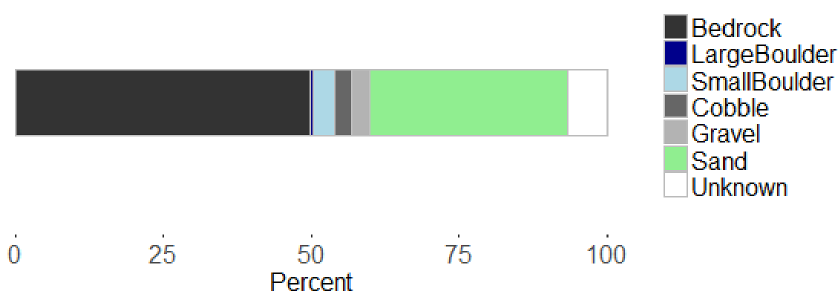


Fig 15: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve site, in 2012, shown as percent of total linear transect distance. The Cascade Head Marine Reserve site in 2012 included the Cascade Head Marine Reserve, and Cavalier Comparison Area.

The 2013 ROV transects found that Schooner Creek Comparison Areas had more hard substrate than Cascade Head Marine Reserve (Figure 16). Schooner Creek had more bedrock, small boulder and cobble substrates in its transects than the Cascade Head Marine Reserve (Fig 16). Cascade Head had the greatest percentage of overall unconsolidated substrates (Fig 16).

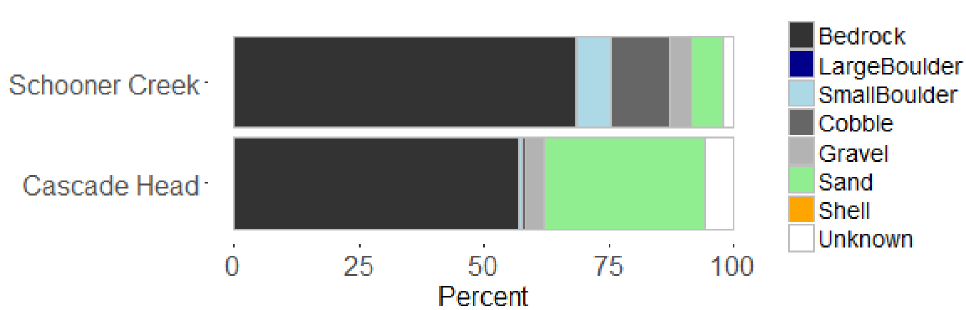


Fig 5.16: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve and Schooner Creek Comparison Area in 2013, shown as percent of total transect duration.

Bedrock was the dominate substrate found during ROV surveys in the Cascade Head Region during 2013. Hard bottom substrates (Bedrock, large and small boulder and cobble) accounted for the majority of substrates surveyed. Sand was the most frequently observed soft bottom substrate in 2013 for all sites (Figure 5.17).

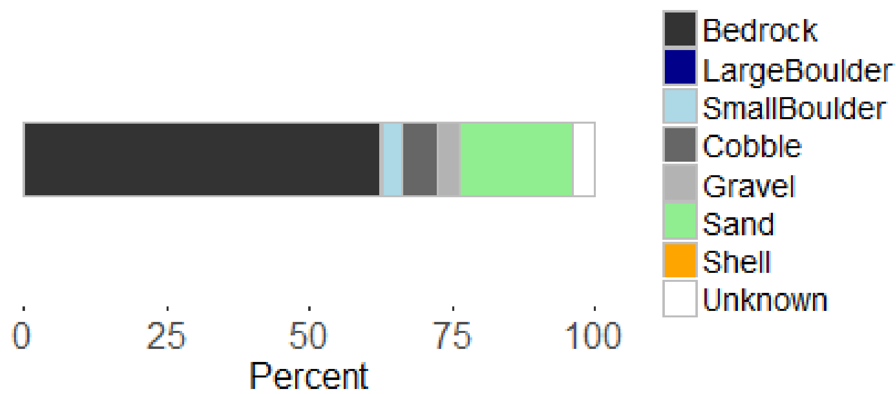


Fig 17: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve site, in 2013, shown as percent of total transect duration. The Cascade Head Marine Reserve site in 2013 included the Cascade Head Marine Reserve, and Schooner Creek Comparison Area.

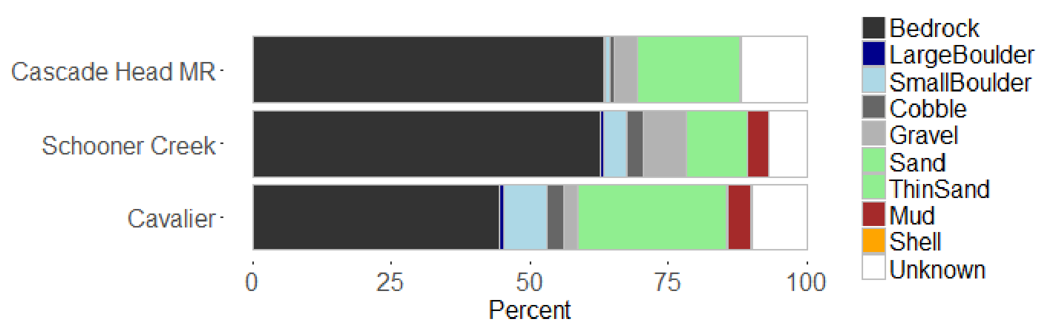


Figure 18: Primary Habitat relative frequency from the 2017 ROV substrate data from the Cascade Head Marine Reserve, Schooner Creek and Cavalier Comparison Areas. Data summarize the substrate covered by all transects in each location.

The 2017 ROV transects found that Cascade Head Marine Reserve and Schooner Creek Comparison Areas have similar amounts of bedrock (Figure 18). Schooner Creek and Cavalier Comparison Areas had more small boulder and mud observed in transects than the Cascade Head Marine Reserve (Figure 18). Cavalier had the greatest percentage of overall unconsolidated substrates and also the largest percentage of sand of all areas surveyed (Figure 18).

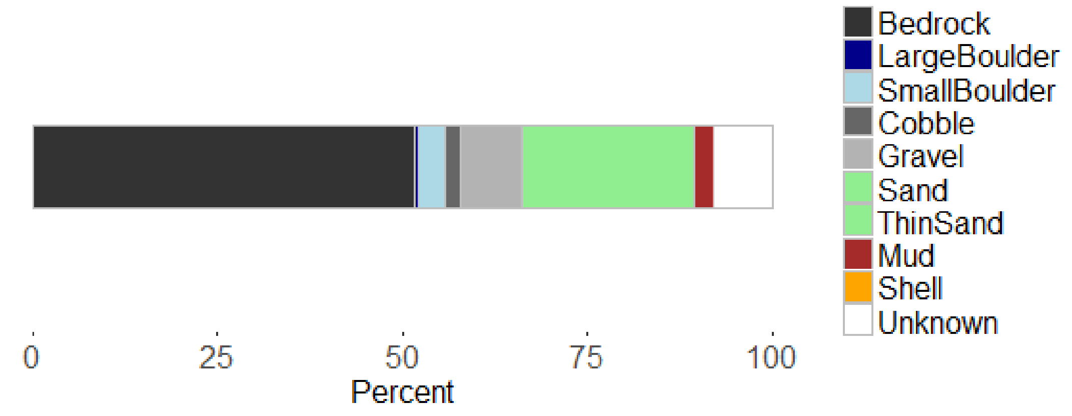


Fig 19: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Region, in 2017, shown as percent of total linear transect distance. The Cascade Head Region includes the Cascade Head Marine Reserve, Schooner Creek Comparison Area and Cavalier Comparison Area.

Bedrock was the dominate substrate found during ROV surveys in the Cascade Head Region during 2017. Hard bottom substrates (Bedrock, large and small boulder, cobble, and gravel) accounted for the majority of substrates surveyed. Sand was the most frequently observed soft bottom substrate in 2017 for all sites (Figure 19).

Cape Perpetua

The majority of habitat data from the Cape Perpetua Marine Reserve was collected with ROV since monitoring began in 2012 (Table 34).

Table 34: Habitat variables collected at the Cape Perpetua Marine Reserve, and associated comparison areas by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, I = intertidal

			Year					
Region	Site	Meteric	2012	2013	2014	2015	2016	2017
Cape Perpetua	Cape Perpetua MR	Depth	L, R	-	-	R	-	R
		Relief	L	-	-	-	-	-
		Substrate Type	L, R	-	-	R	-	R
		Kelp	L	-	-	-	-	-
		Macroalgae	L	-	-	-	-	-
		Biogenic complexity	L	-	-	-	-	-
	Postage Stamp CA	Depth	L	-	L	-	-	-
		Relief	L	-	L	-	-	-
		Substrate Type	L	-	L	-	-	-
		Kelp	L	-	L	-	-	-
		Macroalgae	L	-	L	-	-	-
		Biogenic complexity	L	-	L	-	-	-

Deep Rocky Subtidal

Lander

Only two years of data were collected in the Cape Perpetua Marine Reserve Region (Table 35). Total lander drops were not recorded until 2015.

Table 35: Lander effort represented by total number of useable drops by year in the Cape Perpetua Marine Reserve and associated comparison area for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. - indicate that no data were collected

		Year	
Region	Site	2012	2014
Cape Perpetua	Cape Perpetua MR	4	-
	Postage Stamp CA	1	4
	All Sites Combined	5	4

Total Drops Conducted	NA	NA
% Useable Drops	NA	NA

Non-living Substrate

Depth

A total of 9 drops were completed in Cape Perpetua Region from 2012-2017 (Table 36). The depths of these drops ranged from 10.9m – 51.3m, with a mean depth of 34.43m (±4.77SE). Of the 9 useable drops that were completed only 4 were completed in the Cape Perpetua Marine Reserve (Table 36).

The depths of these drops ranged from 20.2m – 51.3m, with a mean depth of 41.62m (±7.34SE). The remaining five drops were conducted in Postage Stamp Comparison Area (Table 36) with depths ranging from 10.9m – 38.6m, with a mean depth of 28.68m (±5.57SE) (Table 36)

Table 36: Depth range and mean depth surveyed each year in the Cape Perpetua Marine Reserve and associated comparison areas by the lander with effort represented by total drops. – indicate where no data were collected.

			Year	
Region	Site	Metric	2012	2014
Cape Perpetua	Cape Perpetua MR	Depth Range	20.2 - 51.3m	-
		Mean Depth (±SE)	41.62 (± 7.34)	-
		Total Drops	4	-
	Postage Stamp CA	Depth Range	10.9	20.3 - 38.6m
		Mean Depth (±SE)	10.9	33.12 (±4.33)
		Total Drops	1	4
	All Sites Combined	Depth Range	10.9 - 51.3m	20.3 - 38.6m
		Mean Depth (±SE)	35.48 (±8.37)	33.12 (±4.33)
		Total Drops	5	4

Relief

Table 37: Percentage of drops that contained the given relief category by year for the Cape Perpetua Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category

		Year		
Region	Site	Relief Code	2012	2014
Cape Perpetua	Cape Perpetua MR	Low	25%	-
		Mod	50%	-
		High	25%	-
		Total Drops	4	-
	Postage Stamp CA	Low	-	-
		Mod	-	-
		High	100%	100%
		Total Drops	1	4
	All Sites Combined	Low	20%	-
		Mod	40%	-
		High	40%	100%
		Total Drops	5	4

Substrate Type

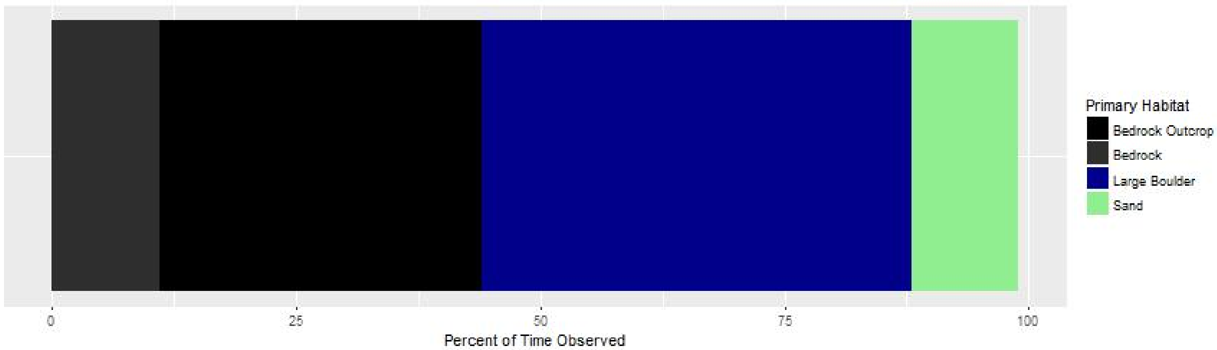


Figure 20: Relative frequency of each primary habitat observed during lander drops at the Cape Perpetua Region. The Cape Perpetua Region includes the Cape Perpetua Marine Reserve and Postage Stamp Comparison Area.

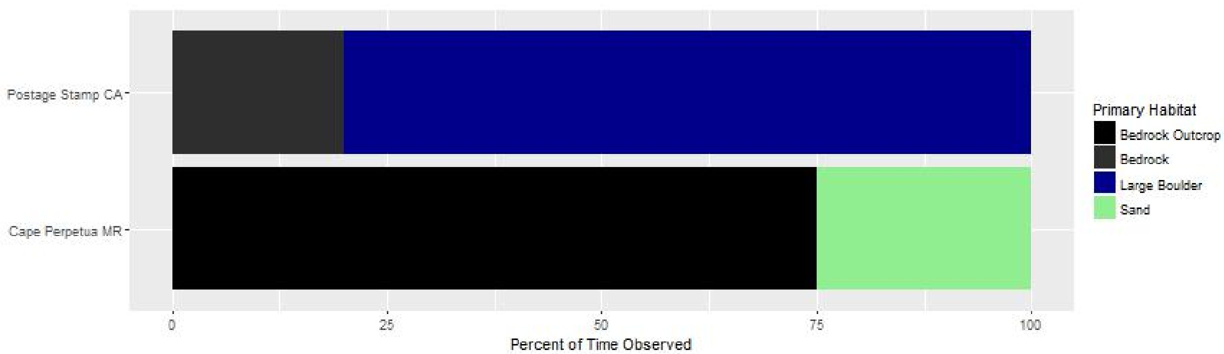


Figure 21: Relative frequency of each primary habitat observed during lander drops in the Cape Perpetua Marine Reserve and Postage Stamp Comparison Areas.

Ground Truthing Derived Habitat Classification

In the Cape Perpetua Region, pooling across all sites, a total of 9 drops were used for comparison. Thirty-three percent of the drops showed agreement between the in situ and the derived habitat classifications (Figure 22).

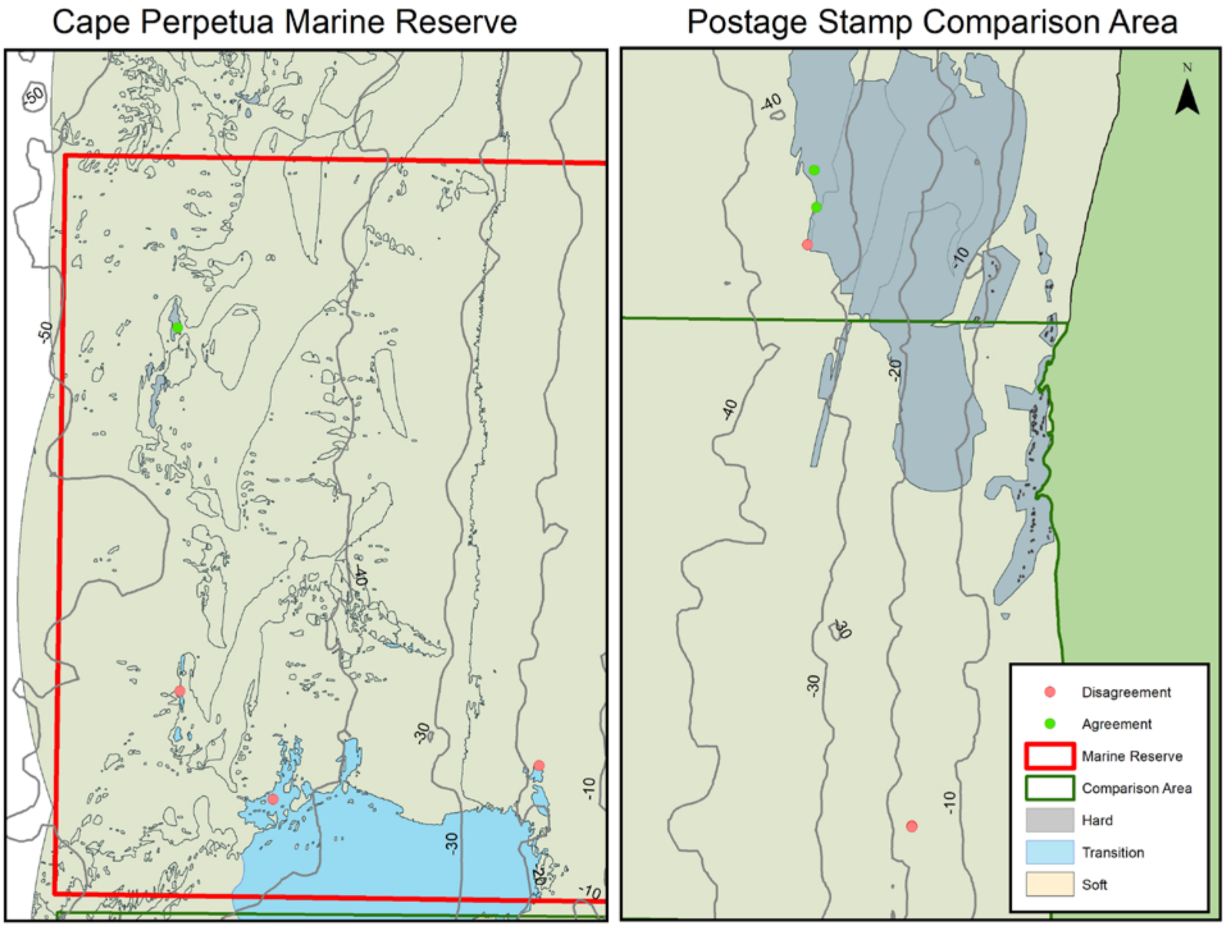


Figure 6: Comparison of the in situ habitat lander observations compared to the IND category of SGH4 at the Cape Perpetua Marine Reserve and associated comparison areas. Green circles represent agreement and red circles represent disagreement between lander observations and derived categories. Substrate is colored based on classification.

Hard vs Soft (Derived from SGH4)

Of the approximately 74 km^2 that is the Cape Perpetua Region, 96% can be classified as soft substrates and 2% as hard substrates, and the remaining 2% as mixed substrates. At the site level soft substrates are the dominate substrate compared to the occurrence of hard substrates (Table 38).

Table 38: Percentage of the available area represented by each habitat classification for Cape Perpetua Marine Reserve and associated comparison areas. - indicate that no drops contained that category.

		Substrate Type (SGH4, IND		
Region	Site	Hard	Mixed	Soft
Cape Perpetua	Cape Falcon Marine Reserve	1%	-	99%
	Cape Mears Comparison Area	2%	4%	94%

Living Substrate

Table 39: Percentage of drops that contained the given biogenic categories by year for the Cape Perpetua Region and the effort for each year represented by total drops. - indicate that no drops contained that category. The Cape Perpetua Region includes the Cape Perpetua Marine Reserve and Postage Stamp Comparison Area. - indicate that no drops contained that category.

		Year	
Region	Biogenic Category	2012	2014
Cape Perpetua	Canopy	-	-
	Midstory	-	-
	Understory	40%	100%
	Turf/Crust	100%	100%
	Seagrass	-	-
	Total Drops	5	4

Table 40: Percentage of drops that contained the given biogenic categories by year for the Cape Perpetua Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year	
Region	Site	Biogenic Category	2012	2014
Cape Perpetua	Cape Perpetua MR	Canopy	-	-
		Midstory	-	-
		Understory	25%	-
		Turf/Crust	100%	-
		Seagrass	-	-
		Total Drops	4	-
	Postage Stamp CA	Canopy	-	-
		Midstory	-	-
		Understory	100%	100%
		Turf/Crust	100%	100%
		Seagrass	-	-
		Total Drops	1	4

Biogenic Complexity by Category

Table 41: Percentage of drops that contained the given abundance index for the associated biogenic categories by year for the Cape Perpetua Region as well as the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year	
Region	Biogenic Category	Abundance Index	2012	2014
Cape Perpetua	Canopy	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-
	Midstory	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-
	Understory	None	60%	-
		< 5% of cover	-	50%
		5 – 25 %	20%	50%
		26 – 50 %	-	-
		51 – 75 %	20%	-
		76 – 100 %	-	-
	Turf/Crust	None	-	-
		< 5% of cover	20%	-
		5 – 25 %	20%	-
		26 – 50 %	20%	25%
		51 – 75 %	20%	75%
		76 – 100 %	20%	-
	Seagrass	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-

Total Drops	5	4

Primary Habitat: Deep Rocky Reefs

ROV

Non-living substrate

ROV transects for 2017 occurred at deep depths, around 50 meters Table 42

Table 42 Depth range of ROV transects in the Cape Perpetua Marine Reserve.

Year	Location	Depth (m)		
		Min	Median	Max
Cape Perpetua Region				
2017	Cape Perpetua MR	49.1	49.9	50.7

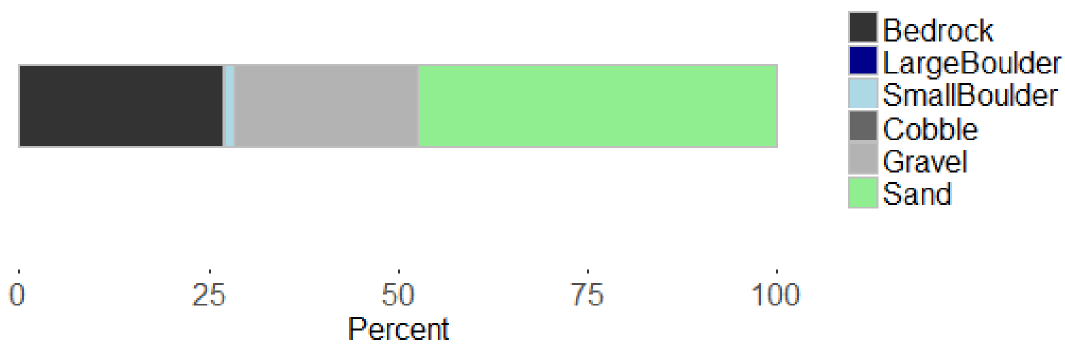


Figure 23: Relative frequency of each primary habitat observed in ROV transects at Cape Perpetua Marine Reserve in 2017, shown as percent of total linear transect distance.

Bedrock and gravel are the two dominant hard bottom substrates observed in the surveys from 2017 of the Cape Perpetua Marine Reserve. However close to 50% of the habitat observations consisted of unconsolidated substrate, dominated by sand (Fig. 23).

Cape Falcon

The habitat data from the Cape Falcon Marine Reserve was collected with scuba divers and landers since monitoring began in 2016 (Table 43).

Table 43: Habitat variables collected at the Cape Falcon Marine Reserve, and associated comparison areas by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, I = intertidal

			Year	
Region	Site	Metric	2016	2017
Cape Falcon	Cape Falcon MR	Depth	D, L	D, L
		Relief	D, L	D, L
		Substrate Type	D, L	D, L
		Kelp	D, L	D, L
		Macroalgae	D, L	D, L
		Biogenic complexity	L	L
	Cape Meares CA	Depth	-	D, L
		Relief	-	D, L
		Substrate Type	-	D,L
		Kelp	-	D,L
		Macroalgae	-	D,L
		Biogenic complexity	-	L
	Comparison Areas with varied fishing pressure	Depth	L	D, L
		Relief	L	D, L
		Substrate Type	L	D, L
		Kelp	L	D, L
		Macroalgae	L	D, L
		Biogenic complexity	L	L

Rocky Subtidal: Shallow

Scuba diver survey effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 44.

Table 44: Scuba diver survey effort (number of transects) by year in the Cape Falcon Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Algae= algal swath counts of specific macroalgaes

		Year			
		2016		2017	
Region	Site	UPC	Algae	UPC	Algae
Cape Falcon	Cape Falcon MR	8	-	12	-
	Cape Meares CA	-	-	10	-
	Comparison Areas with Varied Fishing Pressure	-	-	8	-
	All Sites Combined	8	-	30	-

Lander

Given the constraints of view, visibility and habitat type, only a proportion of the lander drops are useable (Table 45). Two years of lander surveys yielded limited useable drops (Table 45). The majority of useable drops were from the Cape Falcon Marine Reserve in 2016 and from the comparison areas with varied fishing pressure in 2017. The percentage of useable drops has never been higher than 45%.

Table 45: Lander effort represented by total number of useable drops by year in the Cape Falcon Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicated where no data were collected

		Year	
Region	Site	2016	2017
Cape Falcon	Cape Falcon MR	11	4
	Cape Meares CA	-	1
	Comparison Areas with Varied Fishing Pressure	2	7
	All Sites Combined	13	12

Total Drops Conducted	29	54
% Useable Drops	45%	22%

Non-living Substrate

Depth

25 drops were completed in the Cape Falcon Region from 2016-2017 (Table 46). The depths of these drops ranged from 8.7m - 23.5m, with a mean depth of 14.51m (±0.73SE). Of the 25 drops, 15 were completed from Cape Falcon Marine Reserve (Table 46). The depths of these drops ranged from 8.7m – 20.5m, with a mean depth of 14.13m (±0.86SE). The remaining ten drops were conducted in Cape Falcon's associated comparison areas (Table 46). At the site level, the depth of the single lander drop in

the Cape Meares Comparison Area was 14.5m (Table 46). While the nine drops conducted at the Comparison Areas with varied fishing pressure ranged from 11m – 23.5m, with a mean depth of 15.16m (±1.5SE) (Table 46).

Table 46: Depth range and mean depth surveyed each year in the Cape Falcon Marine Reserve and associated comparison areas by the lander with effort represented by total drops. – indicate where no data were collected.

			Year	
Region	Site	Metric	2016	2017
Cape Falcon	Cape Falcon MR	Depth Range	8.7 - 19.6m	12.3 - 20.5m
		Mean Depth (±SE)	13.55 (±0.92)	15.72 (±1.97)
		Total Drops	11	4
	Cape Meares CA	Depth Range	-	14.5m
		Mean Depth (±SE)	-	14.5
		Total Drops	-	1
	Comparison Areas with Varied Fishing Pressure	Depth Range	22.2 - 23.5m	11 -14.9m
		Mean Depth (±SE)	22.85 (±0.65)	12.96(±0.48)
		Total Drops	2	7
	All Sites Combined	Depth Range	8.7 - 23.5m	11 - 20.5m
		Mean Depth (±SE)	14.98 (±1.24)	14.01 (±0.76)
		Total Drops	13	12

Overall, all 25 drops completed were conducted in the shallow (<25m) depths. Thus, for future analysis lander drops will be used to classify both shallow and deep rocky reef communities for the Cape Falcon Region.

Relief

Table 47: Percentage of drops that contained the given relief category by year for the Cape Falcon Marine Reserve and associated comparison areas and the effort for each year is represented by total drops. - indicate that no drops contained that category

			Year	
Region	Site	Relief Code	2016	2017
Cape Falcon	Cape Falcon MR	Low	18%	50%
		Mod	55%	25%
		High	27%	25%
		Total Drops	11	4
	Cape Meares CA	Low	-	-
		Mod	-	1
		High	-	
		Total Drops	-	1
	Comparison Areas with Varied Fishing Pressure	Low	-	43%
		Mod	50%	57%
		High	50%	-
		Total Drops	2	7
	All Sites Combined	Low	-	-
		Mod	-	-
		High	-	-
		Total Drops	13	12

Substrate Type

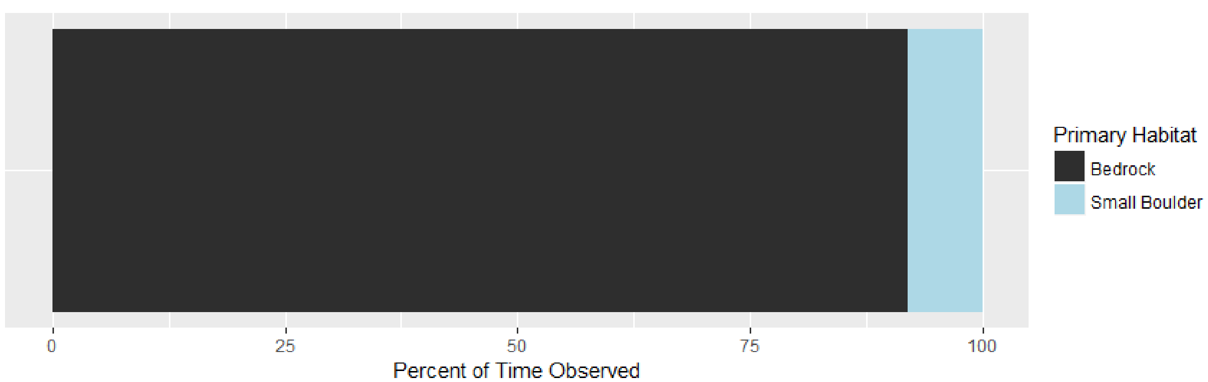


Figure 7: Relative frequency of each primary habitat observed from lander drops at the Cape Falcon Region. The Cape Falcon Region includes the Cape Falcon Marine Reserve, Cape Meares Comparison Area, and Comparison Areas with varied fishing pressure.

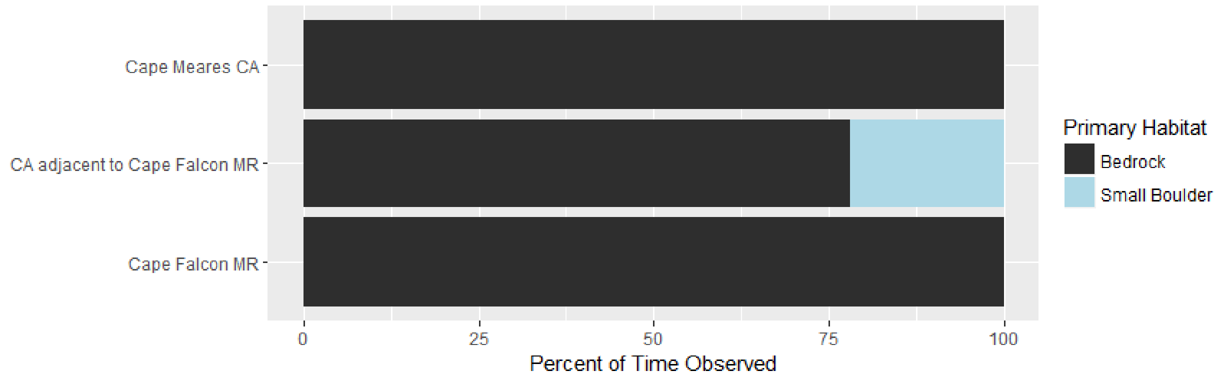


Figure 8 Relative frequency of each primary habitat observed lander drops in the Cape Falcon Marine Reserve, Cape Meares Comparison Area, and Comparison Areas adjacent to Cape Falcon MR are also known as comparison areas with varied fishing pressure.

Ground Truthing Derived Habitat Classification

In the Cape Falcon Region, a total of 78 drops were used for comparisons. Seventy-seven percent of the drops showed agreement between the in situ and the derived habitat classifications (Figure 26). This percentage was consistent across all three SGH 4 categories.

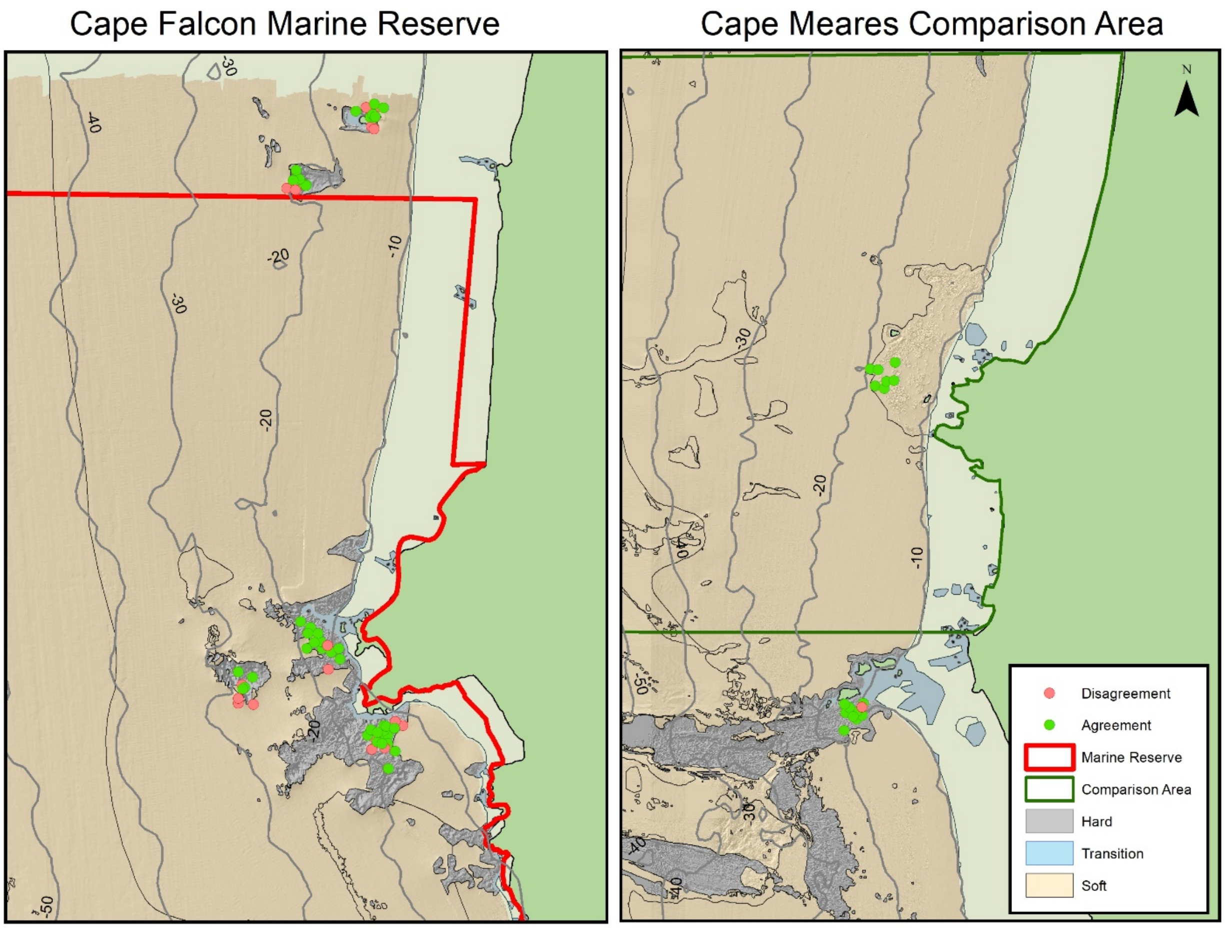


Figure 9: Lander drop locations showing the agreement (Green dot) and disagreement (red dot) between in situ observations of habitat and derived metrics from the Cape Falcon Marine Reserve and the Cape Meares Comparison Area.

Hard vs Soft (Derived from SGH4)

Of the approximately 65 km^2 that make up the Cape Falcon Region, 96% were classified as soft substrates and 4% as hard substrates. This pattern is consistent across both the management area and site scales (Table 48).

Table 48: Percentage of the available area represented by each habitat classification for each one of the treatment categories (marine reserve (MR) and pooled comparison areas (CA)). Note the Comparison Areas with varied fishing pressure are not included in these summaries. – indicate where a category was not observed.

		Substrate Type (SGH4, IND)		
Region	Management Area	Hard	Mixed	Soft
Cape Falcon	MR	4%	-	96%
	CA	4%	-	96%

Living Substrate

Table 49: Percentage of drops that contained the given biogenic categories by year for the Cape Falcon Region and the effort for each year represented by total drops. - indicate that no drops contained that category. The Cape Falcon Region includes the Cape Falcon Marine Reserve, Cape Meares Comparison Area and Comparison Areas with varied fishing pressure.

		Year	
Region	Biogenic Category	2016	2017
Cape Falcon	Canopy	-	-
	Midstory	-	-
	Understory	46%	100%
	Turf/Crust	100%	100%
	Seagrass	-	-
	Total Useable Drops	13	12

Table 50: Percentage of drops that contained the given biogenic categories by year for the Cape Falcon Marine Reserve and associated comparison areas and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year	
Region	Site	Biogenic Category	2016	2017
Cape Falcon	Cape Falcon MR	Canopy	-	-
		Midstory	-	-
		Understory	55%	100%
		Turf/Crust	100%	100%
		Seagrass	-	-
		Total Drops	11	4
	Cape Meares CA	Canopy	-	-
		Midstory	-	-
		Understory	-	100%
		Turf/Crust	-	100%
		Seagrass	-	-
		Total Drops	-	1
	Comparison Areas with Varied Fishing Pressure	Canopy	-	-
		Midstory	-	-
		Understory	-	100%
		Turf/Crust	100%	100%
		Seagrass	-	-
		Total Drops	2	7

Biogenic Complexity by Category

Table 51: Percentage of drops that contained the given abundance index for the associated biogenic categories by year for the Cape Falcon Region and the effort for each year represented by total drops. - indicate that no drops contained that category.

			Year	
Region	Biogenic Category	Abundance Index	2016	2017
Cape Falcon	Canopy	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-
	Midstory	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-
	Understory	None	54%	-
		< 5% of cover	23%	83%
		5 – 25 %	8%	17%
		26 – 50 %	15%	-
		51 – 75 %	-	-
		76 – 100 %	-	-
	Turf/Crust	None	-	-
		< 5% of cover	-	-
		5 – 25 %	8%	-
		26 – 50 %	15%	8%
		51 – 75 %	15%	50%
		76 – 100 %	62%	42%
	Seagrass	None	100%	100%
		< 5% of cover	-	-
		5 – 25 %	-	-
		26 – 50 %	-	-
		51 – 75 %	-	-
		76 – 100 %	-	-

Total Useable Drops	13	12

Invertebrates

ODFW's ecological monitoring program is tasked with identifying the invertebrate species and communities which exist within each site and how they change over time. Oregon's Marine Reserves have four main habitat types, but not all reserves have each habitat type (Table 3.1). Because our survey efforts have focused on rocky hard bottom areas we do not report on any subtidal soft bottom invertebrate communities. There are five main datasets that provide invertebrate information within Oregon's Marine Reserves (Table 3.2Table 3.3) We report on the invertebrate communities by habitat type (rocky subtidal shallow, rocky subtidal deep) for each reserve, and then by tool. We are working on data management for our scuba diver and intertidal surveys, therefore only effort summaries are reported by site by year.

Table 3.1: Habitat type by marine reserve.

Marine Reserve	Intertidal	Shallow Rocky Subtidal	Deep Rocky Subtidal
Redfish Rocks		X	X
Otter Rock	X	X	
Cascade Head	X	X	X
Cape Perpetua	X		X
Cape Falcon	X	X	

Table 3.2: Marine reserve monitoring tools and partner datasets that provide information on invertebrate species found in Oregon's marine reserves

	Intertidal	Shallow Rocky Subtidal	Deep Rocky Subtidal
SCUBA Diver		X	
Lander		X	
ROV			X
PISCO-OSU	X		
PISCO- UC Santa Cruz	X		

Table 3.3: Habitats surveyed for invertebrates at each marine reserve region by year. - indicates that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU, O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

		Year							
Region	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Intertidal	-	-	-	-	-	-	-	-
	Shallow Rocky Subtidal	D, L	D, L	L	-	D, L	D, L	-	-
	Deep Rocky Subtidal	R	-	-	-	-	-	R	-
Otter Rock	Intertidal	-	-	-	-	-	O, U	O	O
	Shallow Rocky Subtidal	D	D, L	L	-	-	D, L	-	D,L
	Deep Rocky Subtidal	-	-	-	-	-	-	-	-
Cascade Head	Intertidal	-	-	-	-	-	O, U	O	O
	Shallow Rocky Subtidal			L	D, L	D,L		L	D, L
	Deep Rocky Subtidal			R	R		R		R
Cape Perpetua	Intertidal								
	Shallow Rocky Subtidal								
	Deep Rocky Subtidal			R			R		R
Cape Falcon	Intertidal								
	Shallow Rocky Subtidal							D, L	D,L
	Deep Rocky Subtidal								

Redfish Rocks

Only scuba diver, lander, and ROV data are available to provide information on the invertebrate species observed in rocky subtidal habitats in the Redfish Rocks Marine Reserve (RRMR) and surrounding comparison areas (

Table 3.4). Each tool is restricted based on depth at which it can be conducted due to safety and gear limitations. Therefore, shallow subtidal rocky reefs are surveyed by both scuba diver (restricted to depths < 20m) and lander (restricted to depths < 30m) surveys. Deep rocky subtidal areas are surveyed solely by the ROV which is restricted to depths > 20m.

Table 3.4: Invertebrate data collected by habitat type by year in the Redfish Rocks Marine Reserve and its two comparison areas by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU , O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

			Year							
Region	Site	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Redfish Rocks MR	Shallow Rocky Subtidal	D, L	D, L	L	-	D, L	D, L	-	-
		Deep Rocky Subtidal	R	-	-	-	-	-	R	-
	Orford Reef CA	Shallow Rocky Subtidal	-	-	-	L	L	-	-	-
		Deep Rocky Subtidal	R	-	-	-	-	-	R	-
	Humbug Mountain CA	Shallow Rocky Subtidal	D, L	D, L	L	-	D, L	D, L	-	-
		Deep Rocky Subtidal	R	-	-	-	-	-	R	-

Rocky Subtidal: Shallow

Scuba Diver Survey Efforts

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 3.5.

Table 3.5: Scuba diver effort (number of transects) by year in the Redfish Rocks Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Invert = invertebrate swath counts of specific mobile invertebrates.

		Year							
		2010		2011		2014		2015	
Region	Site	UPC	Invert	UPC	Invert	UPC	Invert	UPC	Invert
Redfish Rocks	Redfish Rocks MR	15	15	16	16	1	1	30	30
	Orford Reef CA	-	-	-	-	-	-	-	-
	Humbug Mountain CA	5	5	8	8	6	4	18	16
	All Sites Combined	20	20	24	24	7	5	48	46

Lander

The utility of the video lander for collecting benthic invertebrate data was limited due to constraints of view, visibility and habitat type (Table 3.6). For any given year the yield was never more than 35 useable drops per site (Table 3.6). Even combined, the sample size of useable drops are never greater than 75 for the Redfish Rocks Region for any year. In 2015, the first year we recorded total drops compared to useable drops, only 62% of the total lander drops were useable for invertebrate data collection (Table 3.6).

Table 3.6: Lander effort represented by total number of useable drops by year in the Redfish Rocks Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – represent no data were recorded.

		Year					
Region	Site	2010	2011	2012	2014	2015	Total Useable Drops
Redfish Rocks	Redfish Rocks MR	15	16	22	35	25	113
	Orford Reef CA	-	-	17	16	-	33
	Humbug Mountain CA	13	7	6	24	32	82
	All Sites Combined	28	23	45	75	57	228
	Total Drops Conducted	NA	NA	NA	NA	93	
	% Useable Drops	NA	NA	NA	NA	62%	

Lander drops yielded low observations of invertebrate species (Table 3.7). For four of the five years of lander drops, the vast majority of videos yielded no observations of invertebrates (Table 3.7). It was rare to see more than two different species on any given drop in any given year.

Table 3.7: The percentage of useable lander drops yielding observations of invertebrate species for the Redfish Rocks region.

		Year				
Region	Species Richness Value	2010	2011	2012	2014	2015
Redfish Rocks	0	79%	57%	73%	66%	31%
	1	21%	43%	16%	28%	21%
	2	-	-	11%	5%	25%
	3	-	-	-	1%	16%
	4	-	-	-	-	5%
	5	-	-	-	-	-
	6	-	-	-	-	2%
	Total Drops	28	23	45	75	57

Considering all useable drops, in all sites and years, invertebrates were identified to species in 40% of all useable lander drops. Overall, eighteen species of invertebrates were observed (Table 3.8). The Giant White Plumed Anemone, Purple Urchin, Red Urchin, Blood Star, and Embedded Sea Cucumber were the most frequently observed, while the remaining 13 species were observed less than 2% of all occurrences (Table 3.8). Given their low frequency of occurrence, all species were classified as rare. Even the Giant

White Plumed Anemones having the highest frequency of 18% was rarely observed (Table 3.8). When present, 10 (of 18) species exhibited mean MaxN values greater than one (Table 3.8).

Table 3.8: Of the drops that met condition of habitat, visibility, and view in the Redfish Rocks Region (n =228), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and the total number of individuals that were observed across all drops are provided. Data were collected over five years.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Redfish Rocks Region	Basket Star	1	0%	Rare	4.0	4
	Blood Star	17	7%	Rare	1.2	20
	Dungeness Crab	1	0%	Rare	1.0	1
	Embedded Sea Cucumber	13	6%	Rare	10.3	134
	Giant California Sea Cucumber	2	1%	Rare	1.0	2
	Leather Star	5	2%	Rare	1.2	6
	Morning Sun Star	1	0%	Rare	1.0	1
	Ochre Star	1	0%	Rare	1.0	1
	Pink Star	4	2%	Rare	1.5	6
	Purple Urchin	25	11%	Rare	9.3	233
	Rainbow Star	2	1%	Rare	1.0	2
	Red Urchin	22	10%	Rare	3.3	72
	Sunflower Star	4	2%	Rare	1.5	6
	Fish-eating Anemone	4	2%	Rare	1.0	4
	Giant Green Anemone	2	1%	Rare	1.0	2
	Giant White Plumed Anemone	42	18%	Rare	9.1	381
	Rock Scallop	2	1%	Rare	1.0	2
	Tennis-ball Sponge	2	1%	Rare	4.0	8

When comparing across individual sites by year, species richness is consistently less than 10 (Table 3.9). Even when combining species richness for all sites, the maximum value of species richness is 12. The Redfish Rocks Marine Reserve species richness across all years is similar to the Humbug Comparison Area. Species richness in Orford Reef was low (3) with few total individuals observed compared to all other sites. Many more total individuals were observed in both the Redfish Rocks Marine Reserve and Humbug Comparison Area in 2015.

Table 3.9: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Redfish Rocks Marine Reserve & associated comparison areas. - represent where no data were collected.

			Year				
	Site		2010	2011	2012	2014	2015
Redfish Rocks Region	Redfish Rocks MR	Total species richness	1	4	5	9	6
		Total # individuals observed	7	24	13	76	174
	Orford Reef CA	Total species richness	-	-	3	3	-
		Total # individuals observed	-	-	3	7	-
	Humbug CA	Total species richness	3	1	5	3	10
		Total # individuals observed	4	6	22	5	544
	All Sites Combined	Total species richness	4	4	9	12	10
		Total # individuals observed	11	30	38	88	718

Focal species: Sea Stars

Abundance was low for all sea stars species for all years in the Redfish Rocks Region (Figure 3.1). Basket, Leather, Morning Sun and Ochre Stars, were only observed in one of the five sampling years. Blood, Pink, Rainbow and Sunflower Stars were observed in two or more years. Only Blood and Leather Stars were observed in 2015. The years 2012 and 2014 were the most specious years with 4 and 5 species of sea stars identified respectively.

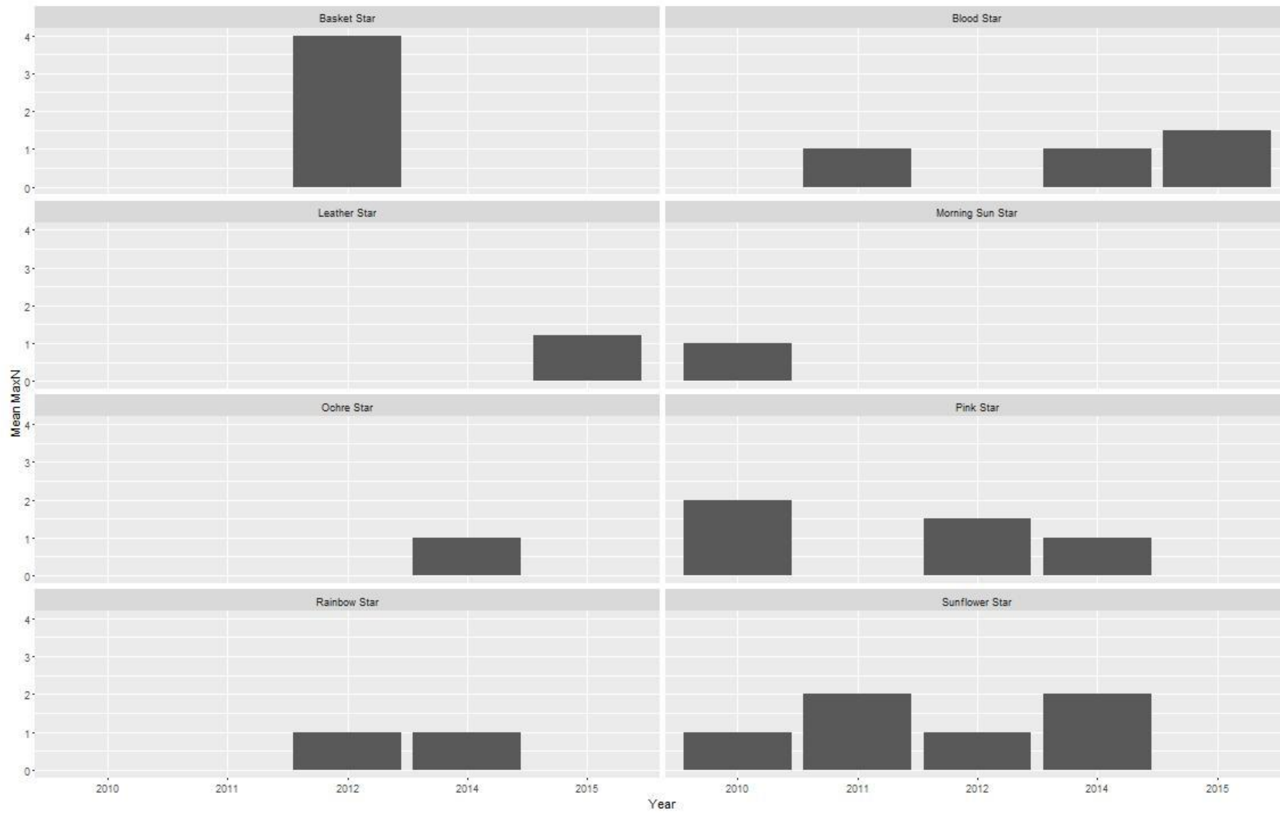


Figure 3.1: Mean MaxN for eight sea star species observed on lander drops in the Redfish Rocks Region during surveys from 2010-2015.

Deep Rocky Subtidal

ROV

The ROV successfully completed 117 transects in 2010 and 71 transects in 2016 surveying the Redfish Rocks Region (Table 3.10). Invertebrate abundance is presented here as total count per transect to allow preliminary assessment of overall abundance patterns for common species and taxonomic groups. Eventually, these data will be analyzed in a more detailed approach that takes into consideration the ROV view area appropriate to consistent detection of each group. Multivariate analyses of invertebrate community structure relative to reef substrate attributes may be more informative than the single-species approach used for analyzing fish. Initially, some striking observations from the 2010 invertebrate data (Figure 3.2a: Mean invertebrate abundance for crabs and nudibranch groups from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data are mean total counts per transect, weighted by viewable area. Note log scale.) include species that were substantially more abundant at Orford Reef than the other sites (e.g. basket stars, vermillion stars, several of the sponges, and tunicates). Generally, many species tended to be less abundant at Redfish Rocks Marine Reserve than the other sites; this result should be assessed against total visible transect distance, since Orford Reef tends to be a site with better visibility than the other two sites. Many invertebrate species had rather consistent abundance across the sites (e.g. Dorid nudibranchs, several sea stars, giant plumose anemones, rock scallops), perhaps indicating species that may provide useful reference points for future change in invertebrate community composition.

Table 3.10: Number of transects conducted by the ROV by year for the Redfish Rocks Marine Reserve and associated comparison areas

Site	2010	2016
Redfish Rocks Marine Reserve	42	35
Orford Reef	40	23
Humbug Comparison Area	35	13
All Sites Combined	117	71

Table 3.11: Species richness, total # individuals observed and top two dominant species identified in the ROV invertebrate datasets from 2010 and 2016 at the Redfish Rocks Marine Reserve and comparison areas. Note some dominant species are missing % observations because a data management issue was identified while finalizing the draft report.

		2010	2016
Redfish Rocks Marine Reserve	Species Richness	46	45
	Total # individuals observed	23,413	43,104
	Top 2 dominant species (% observations)	Giant Plumose Anemone (66%)	Burrowing sea cucumber (47.2%)
		Blood Star	Giant Plumose Anemone
Orford Reef Comparison Area	Species Richness	41	47
	Total # individuals observed	21,925	41,712
	Top 2 dominant species (% observations)	Giant Plumose Anemone (22%)	Burrowing sea cucumber (38.9%)
		Pink Pisaster Star	Red Urchin
Humbug Comparison Area	Species Richness	42	48
	Total # individuals observed	21,632	26,297
	Top 2 dominant species (% observations)	Giant Plumose Anemone (49%)	Burrowing sea cucumber (53.9%)
		Pink Pisaster Star	Giant Plumose Anemone
All Sites Combined	Species Richness	49	53
	Total # individuals observed	66,969	111,113
	Top 2 dominant species (% observations)	Giant Plumose Anemone (50.3%)	Burrowing sea cucumber (45.5%)
		Pink Pisaster Star	Giant Plumose Anemone (20%)

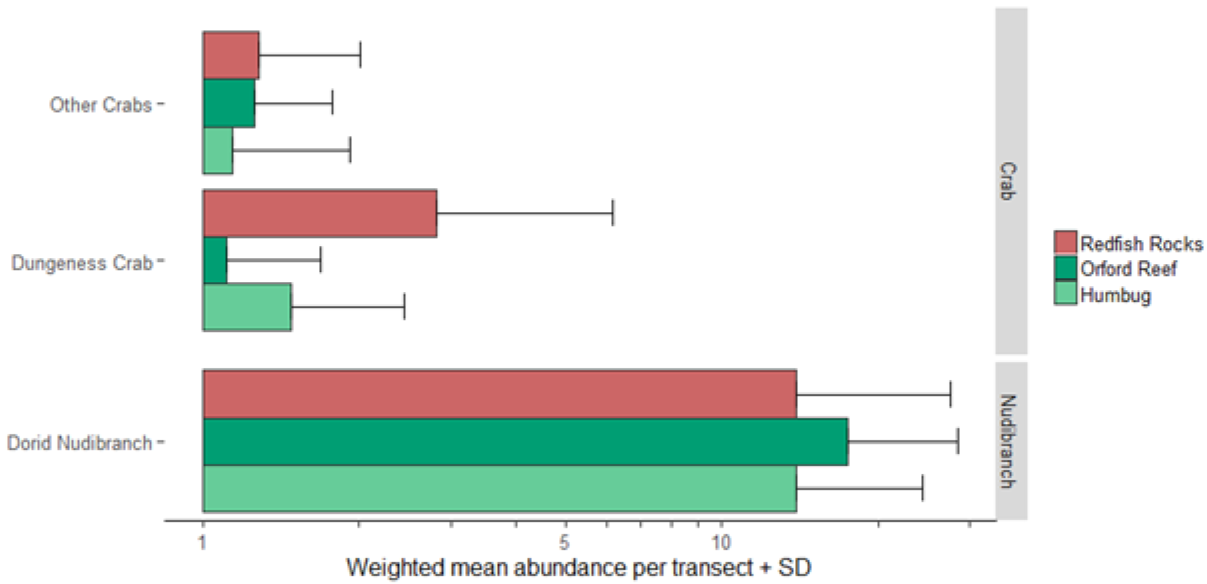


Figure 3.2a: Mean invertebrate abundance for crabs and nudibranch groups from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data are mean total counts per transect, weighted by viewable area. Note log scale.

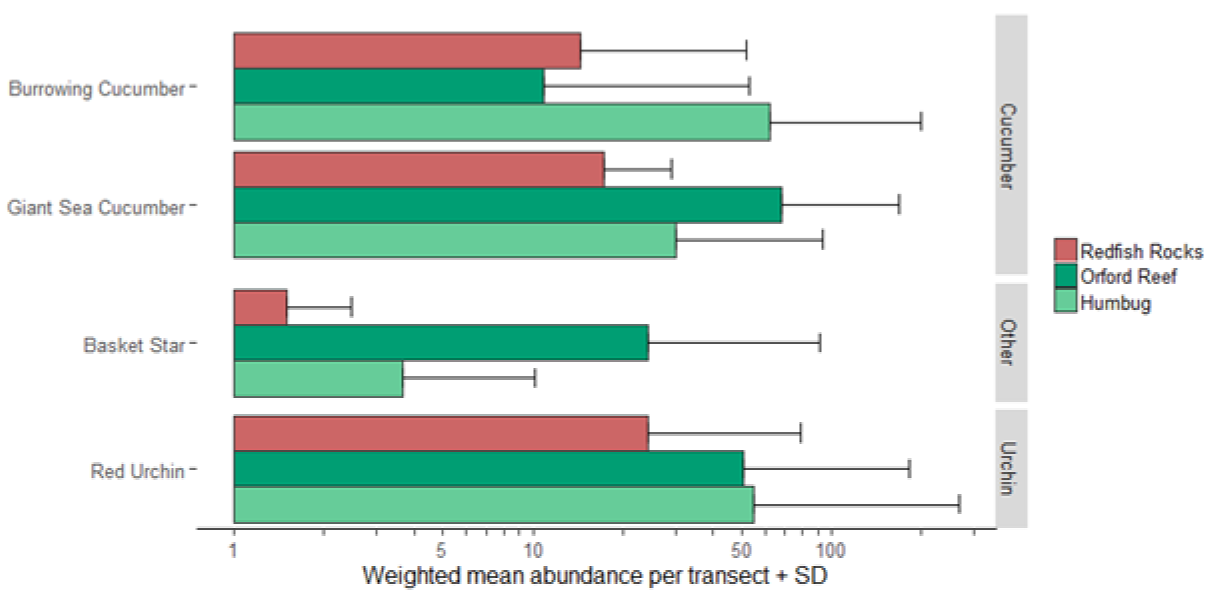


Figure 3.2b: Mean invertebrate abundance for sea cucumbers, basket stars and red urchins from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

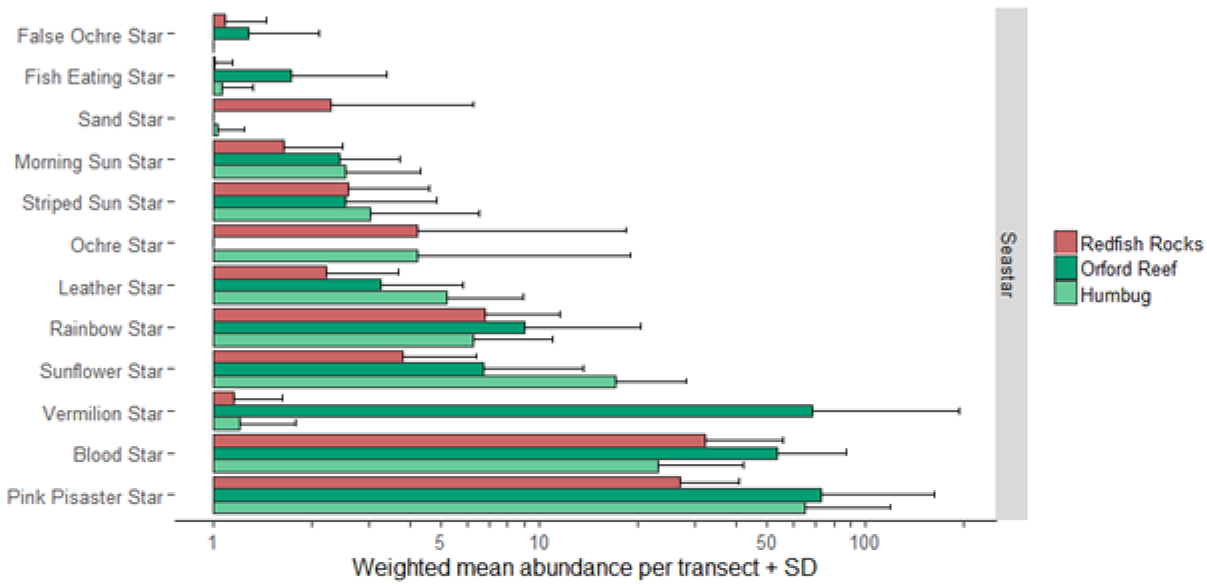


Figure 3.2c: Mean invertebrate abundance for sea stars from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

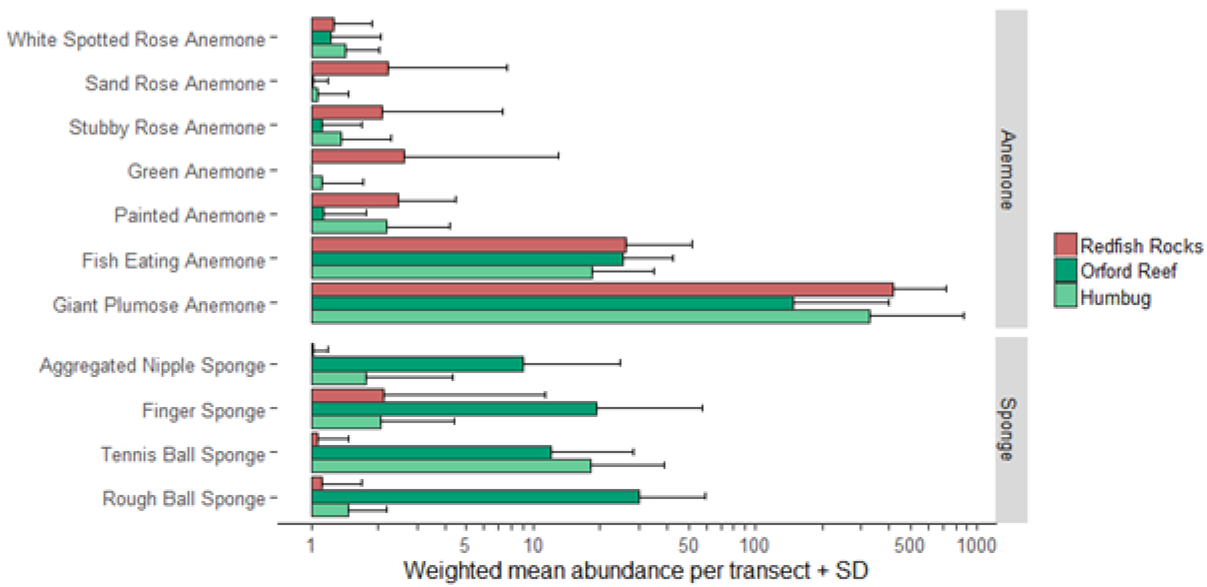


Figure 3.2d: Mean invertebrate abundance for anemones and sponges from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

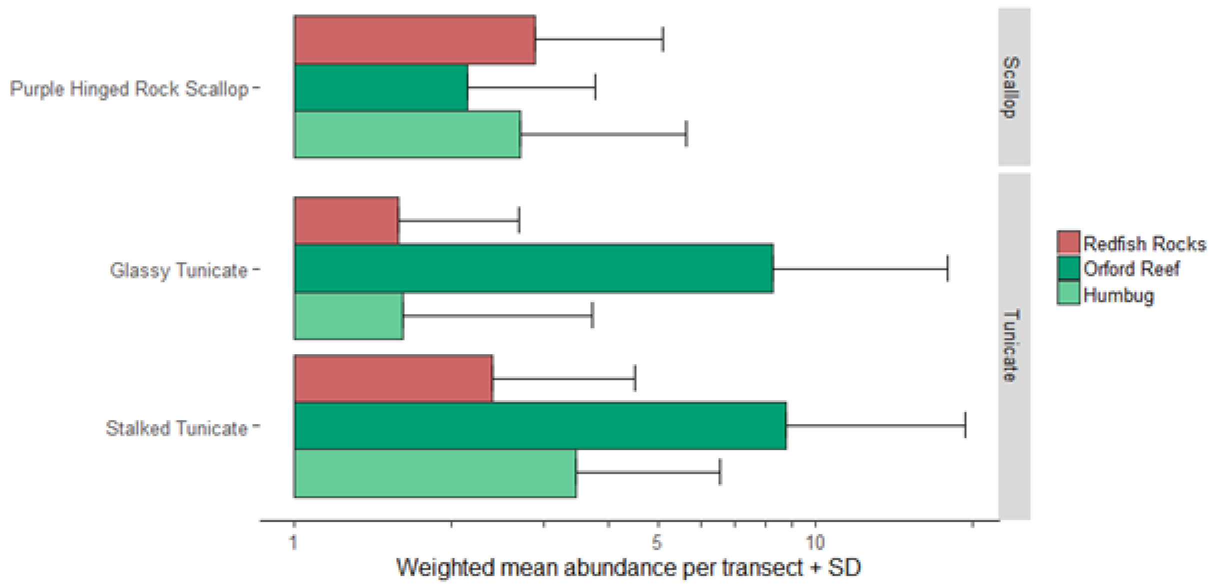


Figure 3.2e: Mean invertebrate abundance for purple hinged rock scallops and tunicates from the 2010 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

In 2016, the ROV data in the Redfish Rocks region documented a dramatic recruitment event of small Dungeness crabs that were seen in large swarms at the Redfish Rocks Marine Reserve site. The data also clearly show the impact of the Seastar Wasting Syndrome that ravaged Oregon's rocky habitats starting in 2013, with a dramatic loss of two previously dominant seastars, the pink pisaster start and the sunflower star. There was also a dramatic increase in Red Urchins between 2010 and 2016. Most notable is the appearance of Purple Urchins in 2016, which were previously rarely observed at the ROV surveys depths. A dramatic increase in burrowing cucumber abundance was another prominent change from 2010.

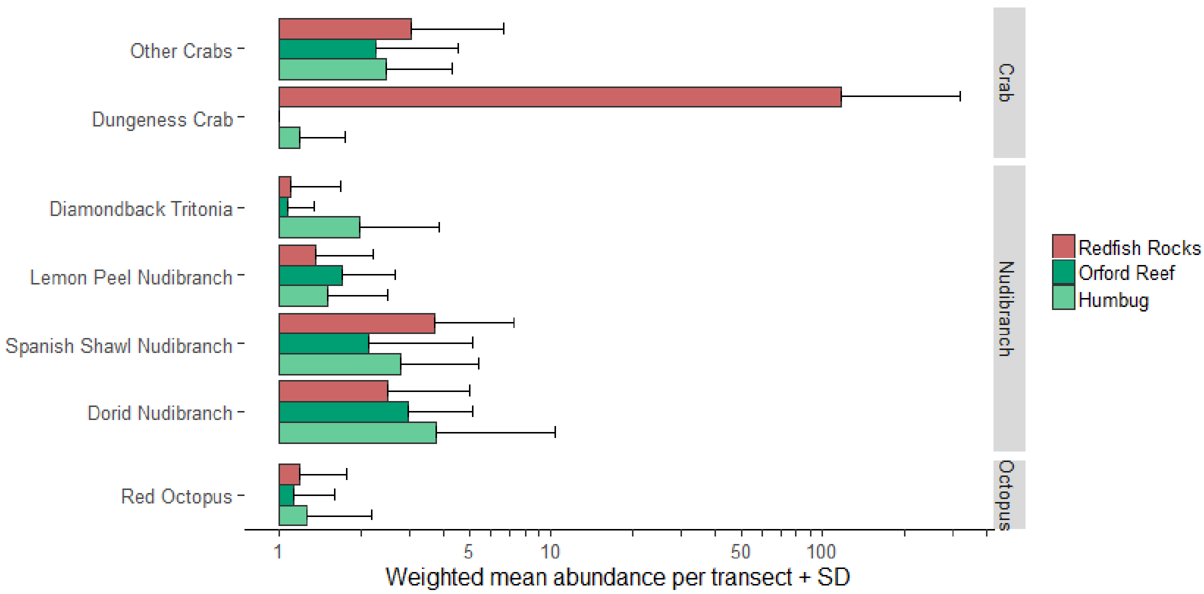


Figure 3.3a: Mean invertebrate abundance for crabs, nudibranchs and red octopus from the 2016 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data are mean total counts per transect, weighted by viewable area. Note log scale.

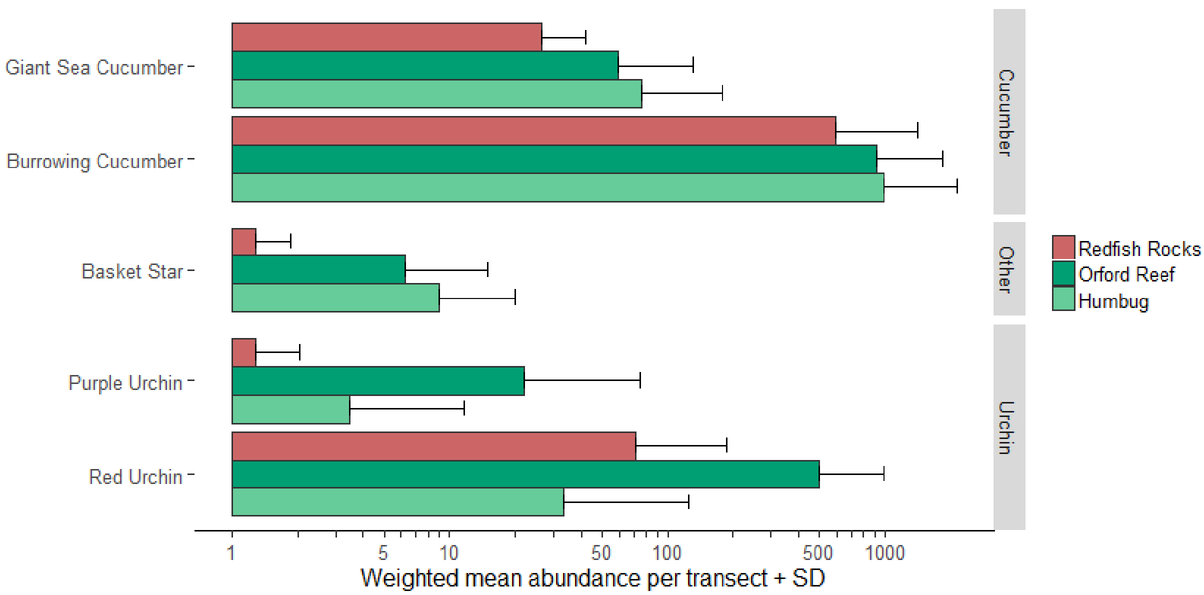


Figure 3.3b: Mean invertebrate abundance for sea cucumbers, basket stars and urchins from the 2016 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

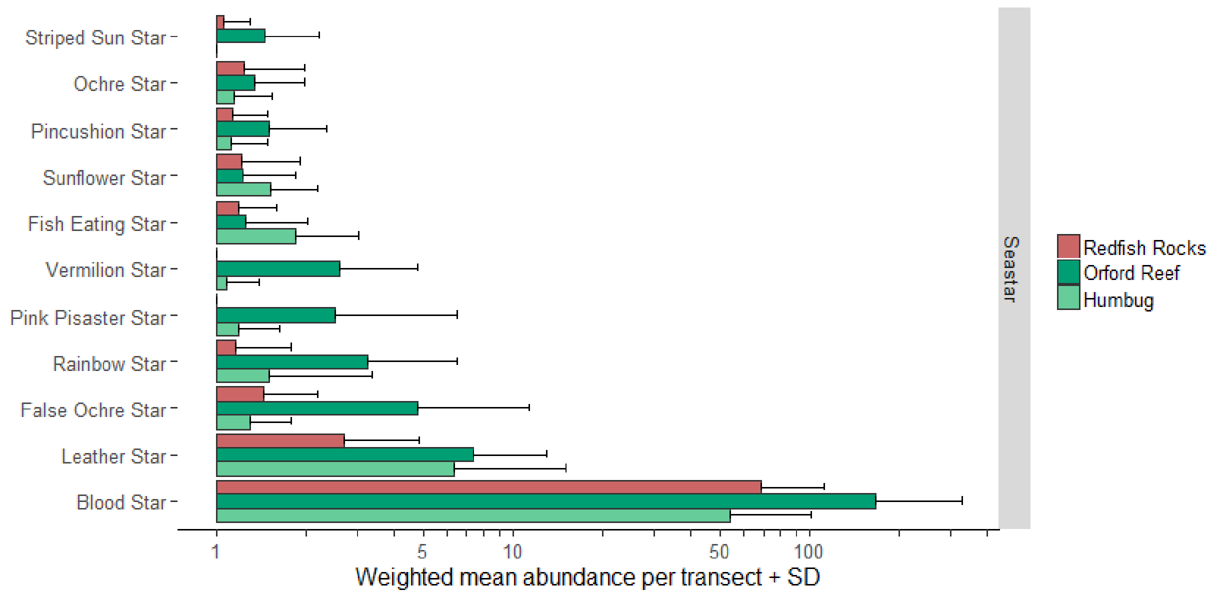


Figure 3.3c: Mean invertebrate abundance for sea stars from the 2016 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

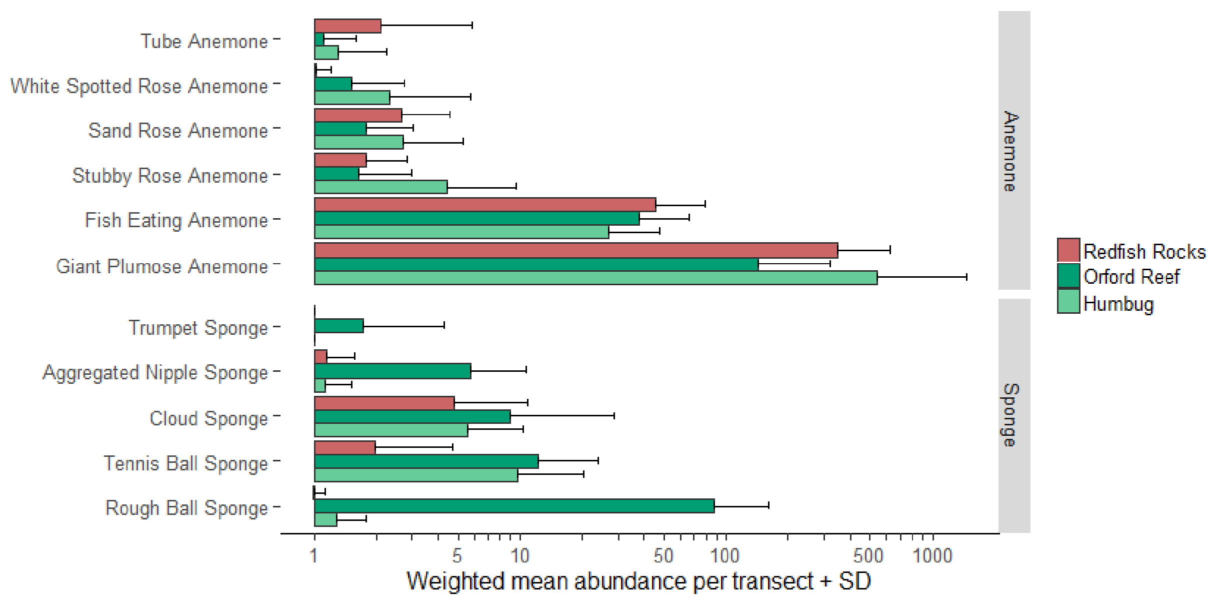


Figure 3.3d: Mean invertebrate abundance for anemones and sponges from the 2016 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

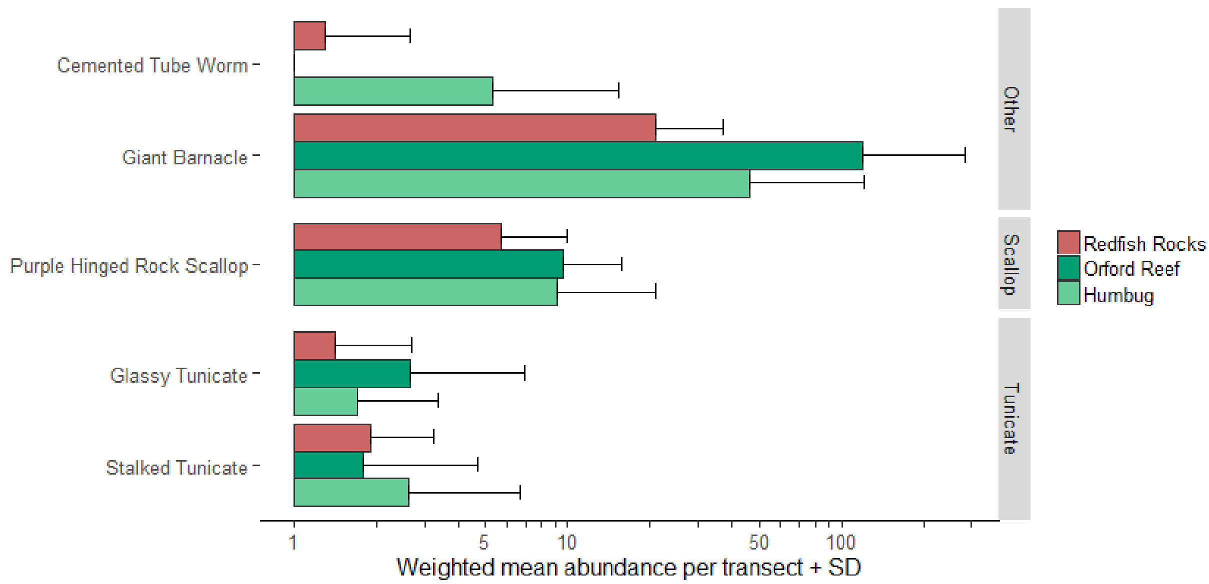


Figure 3.3e: Mean invertebrate abundance for tubeworms, barnacles, scallops, and tunicates from the 2016 ROV surveys in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Note log scale.

Focal Species: Sea Stars

The ROV observed twelve species of sea stars in the Redfish Rocks Region (Figure 3.4) during 2 years of surveys. Eight sea star species exhibited higher observations per transect in 2010 than 2016. The near-loss of *P. brevispinus* (Pink Pisaster Star) and *P. helianthoides* (Sunflower Star) show the dramatic effects of the Seastar Wasting Syndrome, along with a number of less prominent species. There are four species that had opposite trends; *Henricia* (Blood Star), *Dermasterias imbricate* (Leather Star), *Stylaster forreri* (Velcro Star) and *Evasterias troschellii* (False Ochre Star), exhibited higher observations per transect in 2016 than in 2010. An overall trend in the data is that there are more sea stars observed in the comparison areas than in the Redfish Rocks Marine Reserve during both years (Figure 3.4).

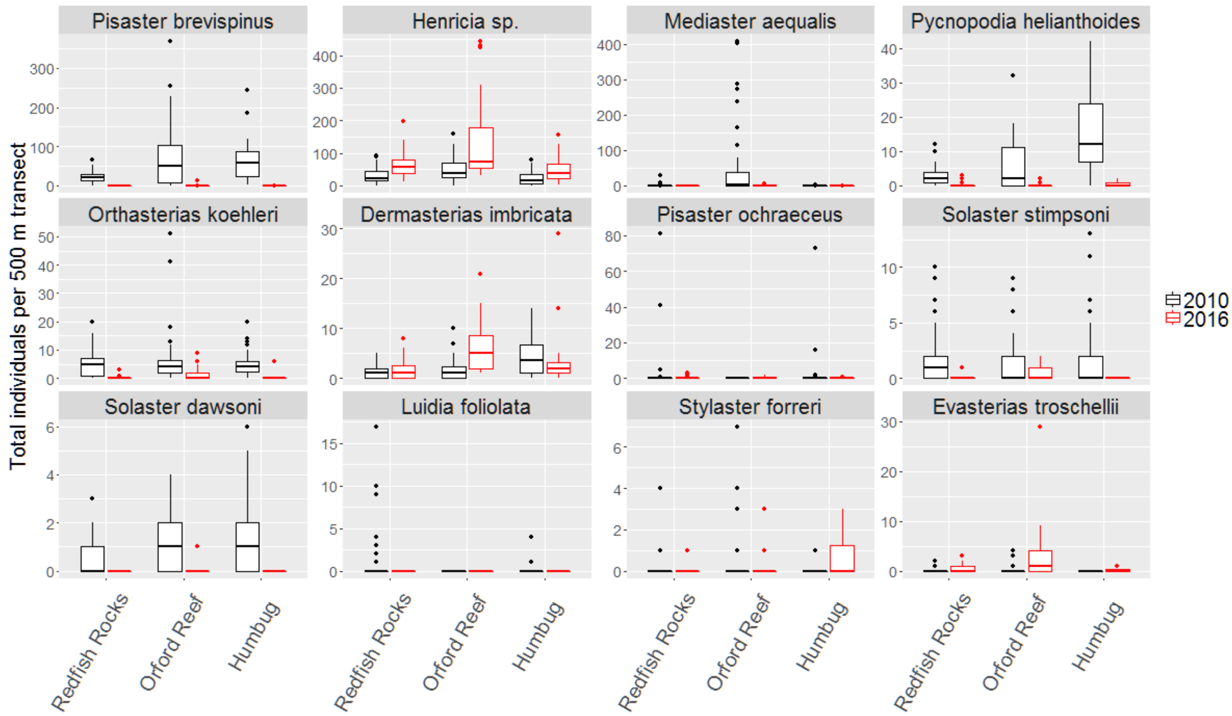


Figure 3.4: Summary comparison of total sea star counts from the 2010 and 2016 Redfish Rocks Region ROV surveys.

Otter Rock

Due to the shallow depths in the Otter Rock Marine Reserve and the Cape Foulweather Comparison Area, invertebrate data are restricted to intertidal, scuba diver and lander surveys (Table 3.12).

Table 3.12: Invertebrate data collected by habitat type by year in the Otter Rock Marine Reserve and its comparison area by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU, O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

			Year							
Region	Site	Habitat	2010	2011	2012	2013	2014	2015	2016	2017
Otter Rock	Otter Rock MR	Intertidal	-	-	-	-	-	O, U	O	O
		Shallow Rocky Subtidal	D, L	D, L	L	-	-	D, L	-	D, L
	Cape Foulweather CA	Intertidal	-	-	-	-	-	-	-	
		Shallow Rocky Subtidal	L	L	L	-	-	L	-	D, L

Intertidal

Intertidal invertebrate data collected by ODFW and UC Santa Cruz are available only in the Otter Rock Marine Reserve from 2015 onwards (Table 3.12). Data are not available for summarization at this time.

Shallow Rocky Subtidal

Scuba Diver Survey Effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site are in Table 3.13.

Table 3.13: Scuba diver effort (number of transects) by year in the Otter Rock Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Invert = invertebrate swath counts of specific mobile invertebrates.

		Year							
		2010		2011		2015		2017	
Region	Site	UPC	Invert	UPC	Invert	UPC	Invert	UPC	Invert
Otter Rock	Otter Rock MR	4	4	14	14	7	9	16	16
	Cape Foulweather CA	-	-	-	-	-	-	11	11
	All Sites Combined	4	4	34	34	7	9	27	27

Lander

The utility of the video lander for collecting benthic invertebrate data was limited due to constraints of view, visibility and habitat type (Table 3.14). For any given year the yield was never more than 19 useable drops per site (Table 3.14). But in 2015, the number of usable drops increased by a factor of 8 from both the Otter Rock Marine Reserve and Cape Foulweather Comparison Area. In 2015, the first year we recorded total drops compared to useable drops, only 66% of the total lander drops were useable for invertebrate data collection (Table 3.14). Since then the percentage of useable drops have ranged from 46-66%.

Table 3.14: Lander effort represented by total number of useable drops by year in the Otter Rock Marine Reserve and Associated Comparison Areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year						
Region	Site	2010	2011	2012	2015	2016	2017	Total Useable Drops
Otter Rock	Otter Rock MR	4	3	7	84	-	6	104
	Cape Foulweather CA	10	16	8	67	17	10	128
	All Sites	14	19	15	151	17	16	232
	Total Drops Conducted	NA	NA	NA	228	34	35	
	% Useable Drops	NA	NA	NA	66%	50%	46%	

Lander drops yielded low observations of invertebrate species (Table 3.15). For five of the six years of lander drops, the vast majority of videos yielded no observations of invertebrates (Table 3.15). It was rare to see more than two different species on any given drop in any given year.

Table 3.15: The percentage of useable lander drops yielding observations of invertebrate species for the Otter Rock Region.

		Year					
	Species Richness Value	2010	2011	2012	2015	2016	2017
Otter Rock Region	0	86%	89%	100%	58%	59%	25%
	1	14%	11%	-	32%	23%	69%
	2	-	-	-	5%	18%	6%
	3	-	-	-	4%	-	-
	4	-	-	-	1%	-	-
	5	-	-	-	-	-	-
	6	-	-	-	-	-	-
	Total Drops	14	19	15	151	17	16

Considering all useable drops, from all locations and years, invertebrates were identified to species in 38% (n =87) of lander drops . Overall, sixteen species of invertebrates were identified (Table 3.16). The Purple Urchin, Ochre Star, Red Urchin, Blood Star, and Leather Star were the most frequently observed, while the remaining 11 species were observed less than 3% of all occurrences (Table 3.16). All species occurrences were classified as rare with Purple Urchin having the highest frequency of 9% (Table 3.16). When present, 10 (of 16) species exhibited mean MaxN values greater than one (Table 3.16). Purple urchins had the highest mean MaxN (6.4) and total number of individuals observed (134).

Table 3.16: Of the drops that met condition of habitat, visibility, and view (n =232), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and the total number of individuals that were observed across all drops are provided.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Otter Rock Region	Blood Star	15	6%	Rare	1.3	20
	Dungeness Crab	3	1%	Rare	1.0	3
	Embedded Sea Cucumber	6	3%	Rare	1.5	9
	False Ochre Star	1	0%	Rare	1.0	1
	Gumboot Chiton	4	2%	Rare	1.0	4
	Leather Star	13	6%	Rare	1.1	14
	Ochre Star	19	8%	Rare	1.8	35
	Pink Star	2	1%	Rare	1.0	2
	Purple Urchin	21	9%	Rare	6.4	134
	Red Urchin	15	6%	Rare	1.7	26
	Six-armed Star	3	1%	Rare	1.0	3
	Fish-eating Anemone	1	0%	Rare	1.0	1
	Giant Acorn Barnacle	2	1%	Rare	2.0	4
	Giant Green Anemone	5	2%	Rare	5.8	29
	Giant White Plumed Anemone	3	1%	Rare	4.7	14
	Rock Scallop	1	0%	Rare	2.0	2

When comparing across individual sites by year, species richness is highest in 2015 and lowest in 2012 (Table 3.17). The maximum species richness is 15 for all sites combined. The Otter Rock Marine Reserve has similar species richness across all years compared to Cape Foulweather Comparison Area. From the useable lander drops, a total of 301 individual invertebrates were observed over the six years of data collection (Table 3.17). 2015 is a unique year where species richness increased 2-3 times greater and more total individuals (10s to 100s) were observed in both the Otter Rock Marine Reserve and Cape Foulweather Comparison Area than for any other year when observations were made.

Table 3.17: Total species richness, total # of individuals observed in the Lander invertebrate datasets by year at the Otter Rock Marine Reserve & associated comparison area. - represent where no data were collected.

			Year					
Region	Site	Metric	2010	2011	2012	2015	2016	2017
Otter Rock	Otter Rock MR	Total species richness	1	-	0	10	-	5
		Total # individuals observed	1	-	0	87	-	5
	Cape Foulweather CA	Total species richness	1	2	0	12	5	3
		Total # individuals observed	1	3	0	162	28	14
	All Sites Combined	Total species richness	2	2	0	15	5	5
		Total # individuals observed	2	3	0	249	28	19

Focal Species: Sea Stars

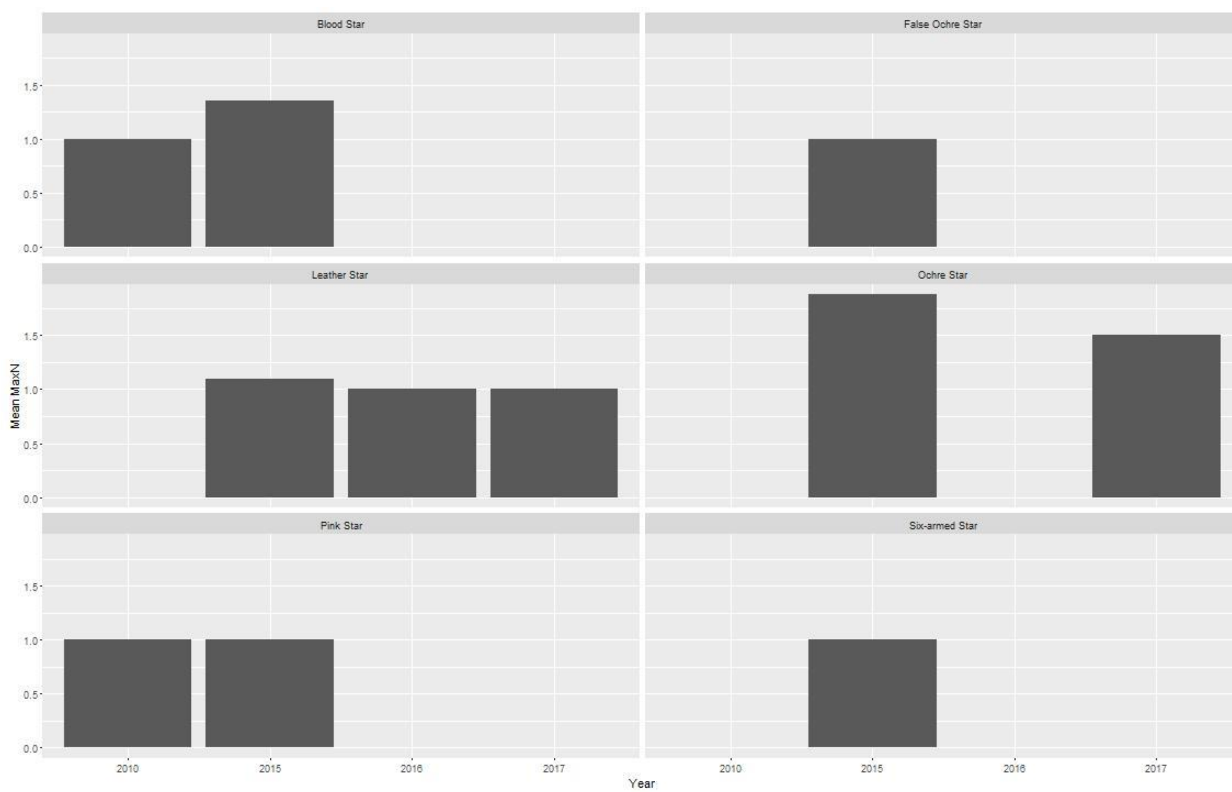


Figure 3.5: Mean MaxN for six sea star species observed on Lander drops in the Otter Rock Region during surveys from 2010-2017.

Abundance of six sea stars species was low for all years (Figure 3.5). Observations of False Ochre Stars and six-armed stars only occurred during one of five sampling years (2015). Leather Stars were the most frequently observed sea star, being identified three of six years, whereas Ochre Stars had the highest abundance of all sea stars (Figure 3.5).

Cascade Head

Three data sets, scuba diver, lander and ROV, are available to provide information on the invertebrate species observed in rocky subtidal habitats in the Cascade Head Region (

). Each tool has depth restrictions due to safety and gear limitations. Therefore, shallow subtidal rocky reefs were surveyed by Scuba diver surveys restricted to depths < 20m and Landers surveys restricted to depths < 30m. Deep rocky subtidal areas are surveyed solely by the ROV which is restricted to depths > 20m. Intertidal data were collected in the Cascade Head Marine Reserve only.

Table 3.18: Invertebrate data collected by habitat type by year in the Cascade Head Marine Reserve and its three comparison areas by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU, O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

			Year					
Region	Site	Habitat	2012	2013	2014	2015	2016	2017
Cascade Head	Cascade Head MR	Intertidal				O, U	O	O
		Shallow Rocky Subtidal	L	D, L	D, L	-	-	D, L
		Deep Rocky Subtidal	R	R	-	R	-	R
	Cavalier CA	Intertidal	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	-	D	-	-	D
		Deep Rocky Subtidal	-	R	-	R	R	R
	Schooner Creek CA	Intertidal	-	-	-	-	-	-
		Shallow Rocky Subtidal	-	D	-	-	-	D
		Deep Rocky Subtidal	R	-	-	-	R	R
	Cape Foulweather CA	Intertidal	-	-	-	-	-	-
		Shallow Rocky Subtidal	L	-	-	L	-	D, L
		Deep Rocky Subtidal	-	-	-	-	-	-

Intertidal

Intertidal invertebrate data collected by ODFW and UC Santa Cruz are available only for the Cascade Head Marine Reserve and only from 2015 onwards (

). However data are not available for summarization at this time.

Shallow Rocky Subtidal

Scuba Diver Survey Efforts

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 3.19.

Table 3.19: Scuba diver effort (number of transects) by year in the Cascade Head Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Invert = invertebrate swath counts of specific mobile invertebrates.

		Year					
		2013		2014		2017	
Region	Site	UPC	Invert	UPC	Invert	UPC	Invert
Cascade Head	Cascade Head MR	13	13	10	13	12	12
	Cavalier CA	-	-	17	18	8	8
	Schooner Creek CA	14	12	-	-	4	4
	Cape Foulweather CA	-	-	-	-	11	11
	All Sites Combined	27	25	27	31	35	35

Lander

The utility of the video lander for collecting benthic invertebrate data was limited due to constraints of view, visibility and habitat type (Table 3.20). Five years (2012, 2013, and 2016) of Lander drops provided 294 videos for invertebrate data collection (Table 3.20). The only year data were collected from both the Cascade Head Marine Reserve and in the 2 comparison areas was in 2012, the year with the most useable drops. In 2016, the first year we recorded total drops compared to useable drops, only 44% of the total lander drops were useable for invertebrate data collection (Table 3.20). The percentage of useable drops in 2017 was 54%.

Table 3.20: Lander effort represented by total number of useable drops by year in the Cascade Head Marine Reserve and associated comparison areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicate that no data were collected.

		Year					
Region	Site	2012	2013	2014	2016	2017	Total Useable Drops
Cascade Head	Cascade Head MR	55		6	-	12	73
	Cavalier CA	43	9	-	21	-	73
	Schooner Creek CA	55	56	-	28	9	148
	All Sites	153	65	6	49	21	294

Total Drops Conducted	NA	NA	NA	111	39	
% Useable Drops	NA	NA	NA	44%	54%	

Lander drops yielded low observations of invertebrate species (Table 3.21). For all five years of Lander drops, the vast majority of videos yielded no observations of invertebrates (Table 3.21). It was rare to see more than two different species on any given drop in any given year.

Table 3.21: The percentage of useable lander drops yielding observations of invertebrate species for the Cascade Head Region.

		Year				
	Species Richness Value	2012	2013	2014	2016	2017
Cascade Head Region	0	66%	47%	66%	55%	52%
	1	27%	29%	17%	39%	33%
	2	6%	15%	17%	4%	10%
	3	1%	9%	-	2%	-
	4	-	-	-	-	5%
	5	-	-	-	-	-
	6	-	-	-	-	-
	Total Drops	161	65	6	49	21

Considering only useable drops, in all locations and years, invertebrates were identified to species in 40% (n =122) of Lander drops. Overall, nineteen species of invertebrates were observed. The Giant White Plumed Anemone, Blood Star, Giant California Sea Cucumber, Embedded Sea cucumber and Red Urchin were the most frequently observed, while the remaining 14 species were observed less than 3% of all occurrences (Table 3.22). All species occurrences were classified as rare with the Giant White Plumed Anemone having the highest frequency of 13% (Table 3.8). When present, 11 (of 19) species exhibited mean MaxN values greater than one (Table 3.22). Giant White Plumed Anemone had the highest mean MaxN (5.8) and total number of individuals observed (221).

Table 3.22: Of the drops that met condition of habitat, visibility, and view (n =294), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and the total number of individuals that were observed across all drops are provided.

Region	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Cascade Head	Basket Star	6	2%	Rare	1.2	7
	Bat Star	1	0%	Rare	1.0	1
	Blood Star	30	10%	Rare	1.5	45
	Dungeness Crab	1	0%	Rare	1.0	1
	Embedded Sea Cucumber	16	5%	Rare	4.3	69
	Giant California Sea Cucumber	17	6%	Rare	1.3	22
	Giant Pacific Octopus	1	0%	Rare	1.0	1
	Leather Star	6	2%	Rare	1.0	6
	Ochre Star	2	1%	Rare	1.5	3

	Pink Star	8	3%	Rare	1.4	11
	Purple Urchin	5	2%	Rare	4.4	22
	Rainbow Star	1	0%	Rare	1.0	1
	Red Urchin	15	5%	Rare	2.5	38
	Stimpson's Sun Star	1	0%	Rare	1.0	1
	Sunflower Star	4	1%	Rare	1.0	4
	Fish-eating Anemone	8	3%	Rare	1.1	9
	Giant Acorn Barnacle	6	2%	Rare	4.3	26
	Giant White Plumed Anemone	38	13%	Rare	5.8	221
	Rock Scallop	1	0%	Rare	1.0	1

For all sites, the maximum species richness is 15 within Cascade Head Region (Table 3.23). The Cascade Head Marine Reserve has similar species richness in 2012 and 2017 to its comparison areas, with the exception of Cape Foulweather. From the useable Lander drops, a total of 489 individual invertebrates were observed over the five years of data collection. 2012 stands out as a year where more total individuals were observed in both the Cascade Head Marine Reserve and its comparison areas, although this is also the year with the most useable lander drops.

Table 3.23: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Cascade Head Marine Reserve & associated comparison areas. - represent where no data were collected.

			Year				
Region	Sites	Metric	2012	2013	2014	2016	2017
Cascade Head	Cascade Head	Total species richness	8	-	3	-	4
		Total # individuals observed	74	-	9	-	43
	Cavalier CA	Total species richness	8	5	-	5	-
		Total # individuals observed	105	14	-	31	-
	Schooner Creek CA	Total species richness	8	14	-	8	4
		Total # individuals observed	56	105	-	32	20
	All Sites Combined	Total species richness	12	15	3	8	6
		Total # individuals observed	235	119	9	63	63

Focal Species: Sea Stars

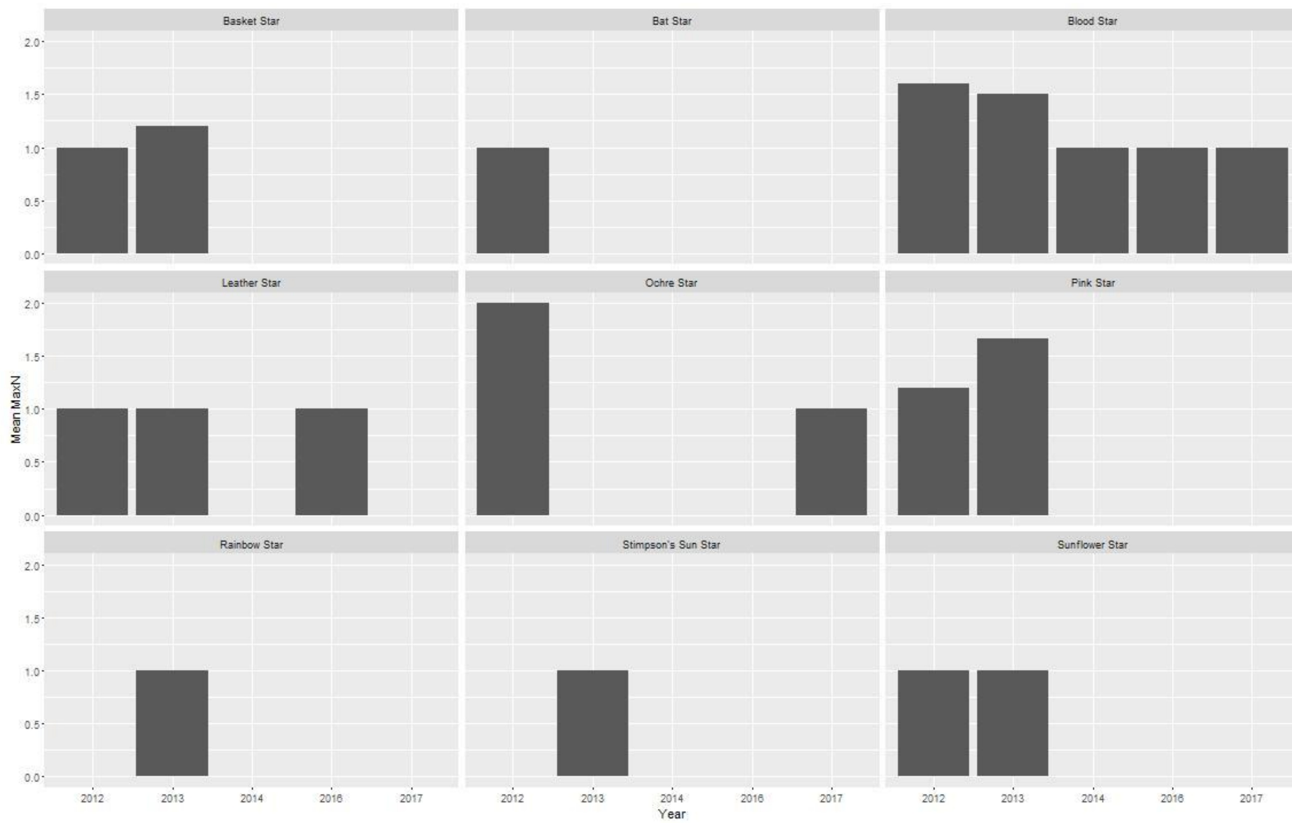


Figure 3.6: Mean MaxN for nine sea star species observed on Lander drops in the Cascade Head Region during surveys from 2012-2017.

Abundance was low for all nine sea stars species for all years (Figure 3.6). Bat, Rainbow and Stimpson's Sun sea stars, were only observed during one of five years of sampling. Blood stars were observed during all years of surveys. In 2012, Ochre stars had the highest abundance of all sea stars; this abundance was the highest observed for all years surveyed, and for all sea stars (Figure 3.6).

Deep Rocky Subtidal

ROV

Invertebrate data are summarized below for the 2017 ROV survey only. Data for earlier years (2012 and 2013) will be available after corrections are applied to the ROV position data.

Table 3.24: Number of transect conducted by the ROV by year for the Cascade Head Region.

Site	2012	2013	2014	2015	2016	2017
Cascade Head MR	16	10	----	4	3	11
Schooner Creek CA	0	10	----	4	4	15
Cavalier CA	16	0	----	0	4	14
All sites	32	20	----	8	11	40

Table 3.25: Species richness, total # individuals observed and top two dominant species in the ROV invertebrate datasets by year at the Cascade Head Marine Reserve & associated comparison areas.

Sites	Metric	2012	2013	2015	2016	2017
Cascade Head Marine Reserve	Species richness					41
	Total # individuals observed					9,426
	Top 2 dominant species (% observations)					Giant Sea Cucumber (32.7%)
						Burrowing Sea Cucumber
Schooner Creek CA	Species richness					44
	Total # individuals observed					17,350
	Top 2 dominant species (% observations)					Burrowing Sea Cucumber (40%)
						Giant Sea Cucumber
Cavalier CA	Species richness					40
	Total # individuals observed					8,703
	Top 2 dominant species (% observations)					Burrowing Sea Cucumber (22.6%)
						Metridium Anemone
All Sites	Species richness					49
	Total # individuals observed					39,340
	Top 2 dominant species (% observations)					Burrowing Sea Cucumber (33.6%)
						Giant Sea Cucumber

ROV observations in 2017 suggested substantial variability in abundance among sites for many species, but very few species upon first glance were obviously more abundant in Cascade Head Marine Reserve than in the comparison areas (Figure 3.7-3.11). A large swarm of Dungeness crabs was observed in the Cavalier Comparison Area. The 2017 data showed the potential for recovery of Pink Pisaster stars after the Seastar Wasting Syndrome. This species had not been seen in great abundance elsewhere since the outbreak in 2013.

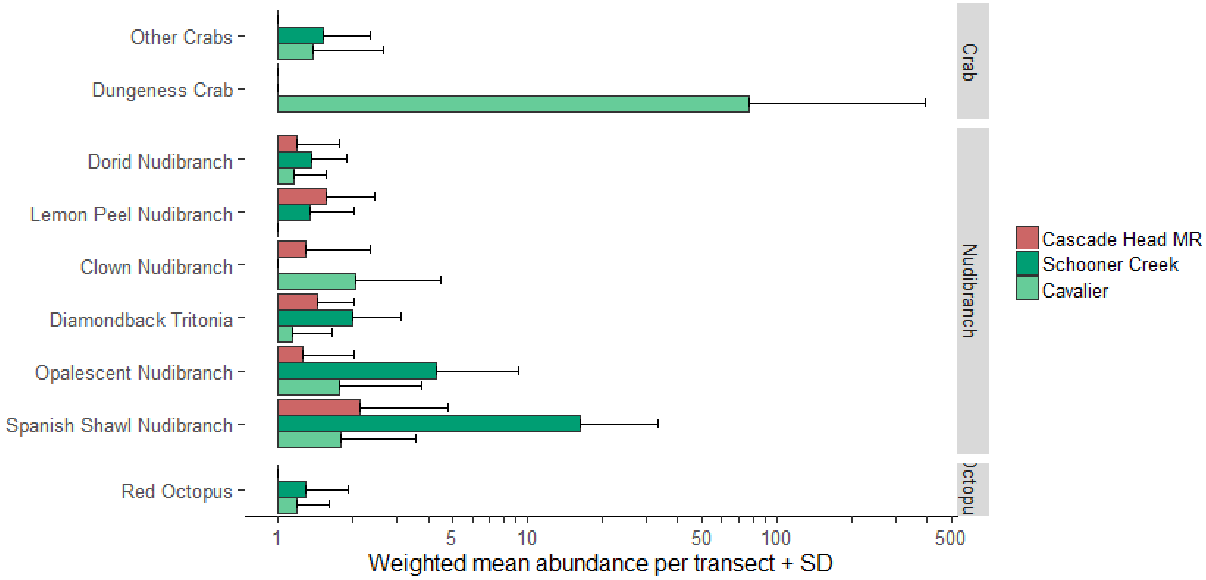


Figure 3.7: Mean invertebrate abundance for crabs, nudibranchs, and red octopus from the 2017 ROV survey in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas. Data are mean total counts per transect, weighted by viewable area. Note log scale.

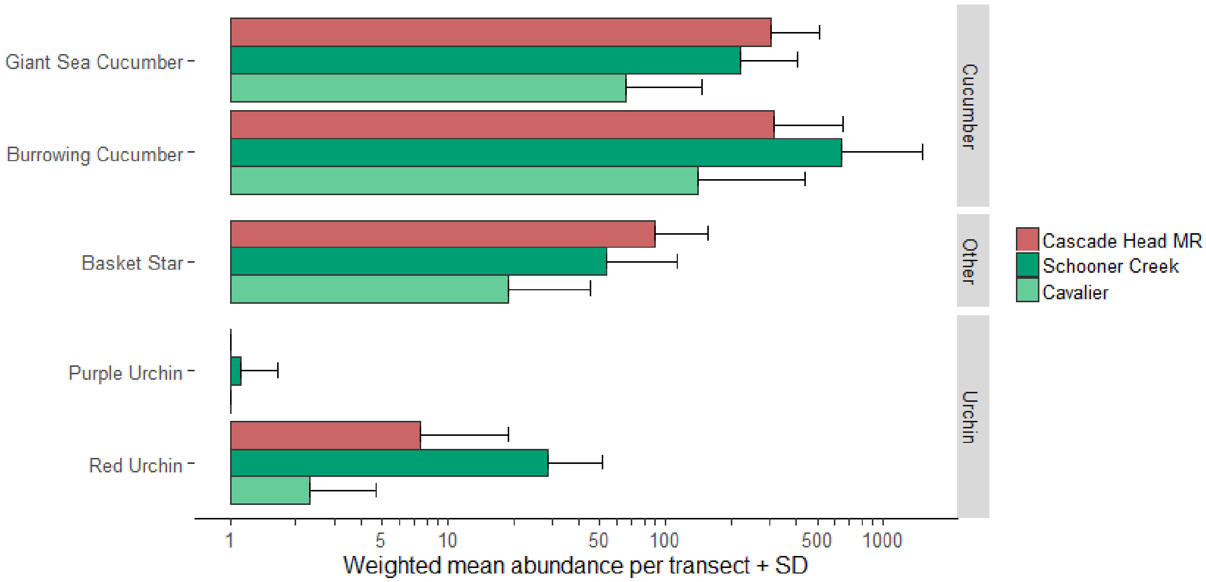


Figure 3.8: Mean invertebrate abundance for sea cucumbers, basket stars and urchins from the 2017 ROV survey in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas.

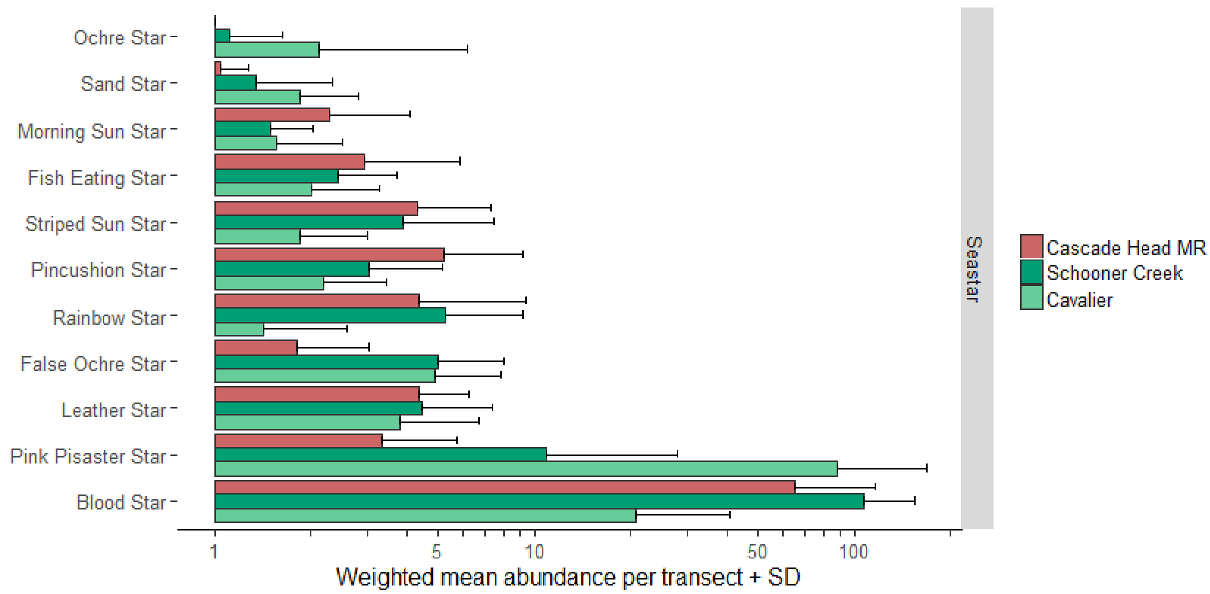


Figure 3.9: Mean invertebrate abundance for sea stars from the 2017 ROV survey in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas. Note log scale.

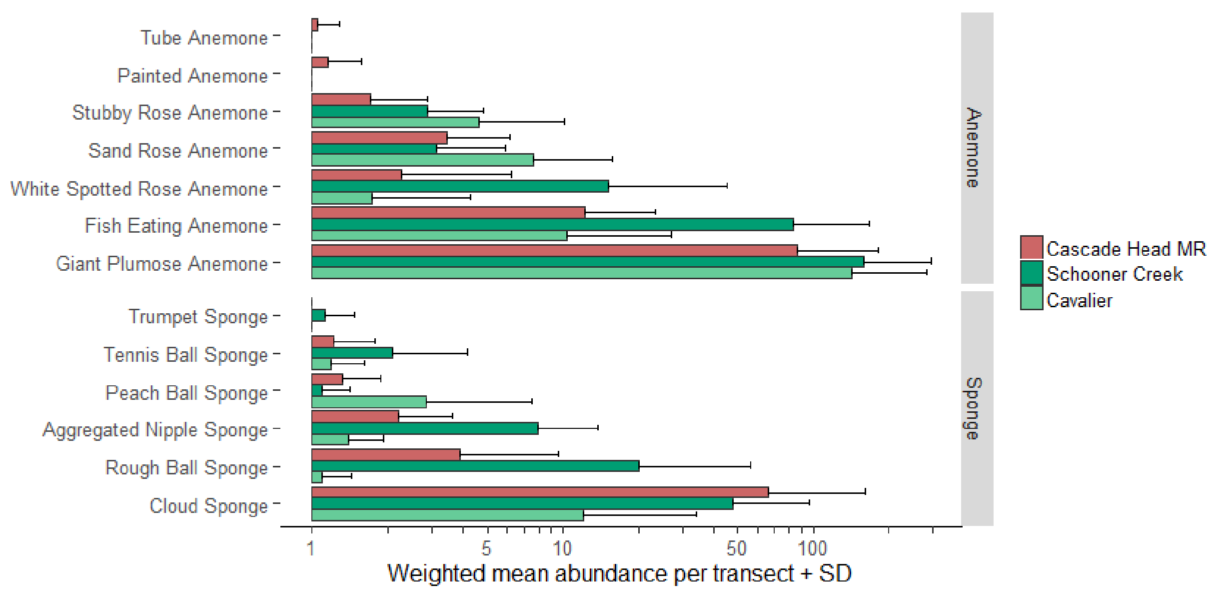


Figure 3.10: Mean invertebrate abundance for anemones and sponges from the 2017 ROV survey in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas. Note log scale.

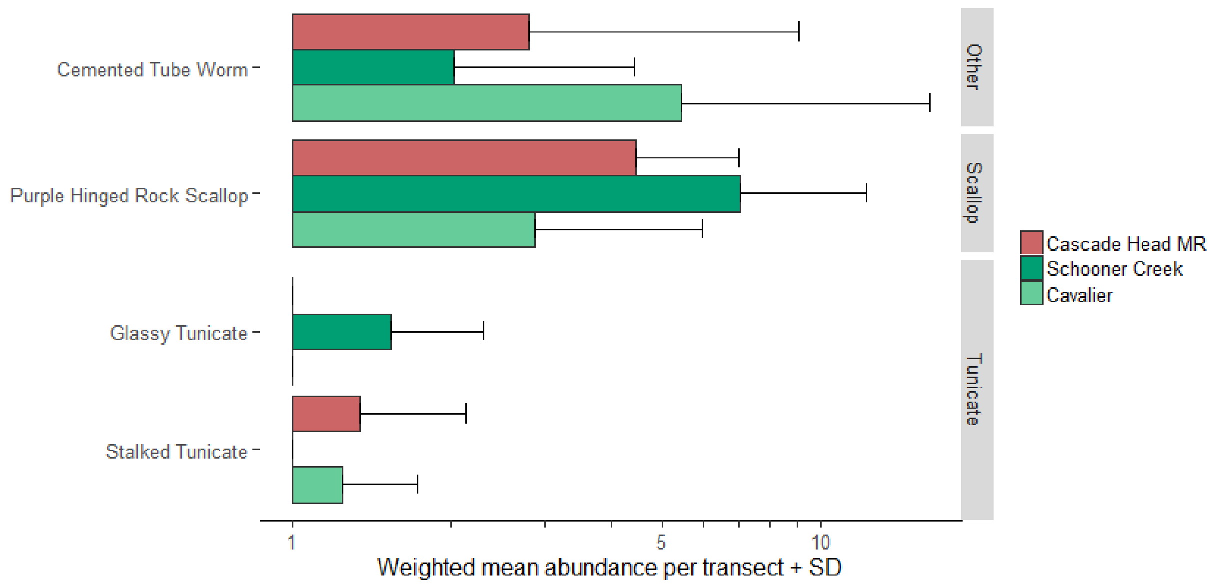


Figure 3.11: Mean invertebrate abundance for tube worms, scallops, and tunicates from the 2017 ROV survey in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas.

Cape Perpetua

Due to the deep depths in the Cape Perpetua Marine Reserve and surrounding comparison areas data on the invertebrates species observed is restricted to Lander and ROV surveys (Table 3.26).

Table 3.26: Invertebrate data collected by habitat type by year in the Cape Perpetua Marine Reserve and its comparison area by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU, O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

			Year					
Region	Site	Habitat	2012	2013	2014	2015	2016	2017
Cape Perpetua	Cape Perpetua MR	Intertidal	-	-	-	-	-	-
		Deep Rocky Subtidal	R, L	R	-	R	-	R
	Postage Stamp CA	Intertidal	-	-	-	-	-	-
		Deep Rocky Subtidal	L	-	L	-	-	-

Intertidal

Intertidal invertebrate data have been collected by PISCO in the Cape Perpetua Region. However, we are still working with PISCO to understand where and when these surveys occurred in relation to the Cape Perpetua Marine Reserve.

Deep Rocky Subtidal

Lander

Only two years of data were collected in the Cape Perpetua Marine Reserve (Table 3.6). This is because sampling with the lander resulted in very low numbers of useable drops. The reef at Cape Perpetua is so small and deep it was challenging to have successful drops over rocky habitats. Therefore this tool was discontinued after 2014.

Table 3.26: Lander effort represented by total number of useable drops by year in the Cape Perpetua Marine Reserve and associated comparison area for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. - indicate that no data were collected

		Year		
Region	Site	2012	2014	Total Useable Drops
Cape Perpetua	Cape Perpetua MR	4	-	4
	Postage Stamp CA	1	4	5
	All Sites	5	4	9

Total Drops Conducted	NA	NA	
% Useable Drops	NA	NA	

Lander drops yielded low observations of invertebrate species (Table 3.28). The first year of surveys yielded no drops where invertebrates were observed, whereas the second year resulted in all drops with invertebrate observations (Table 3.28). No more than two different species were observed in any one drop during 2014.

Table 3.28: The percentage of useable lander drops yielding observations of invertebrate species for the Cape Perpetua Marine Reserve.

		Year	
	Species Richness Value	2012	2014
Cape Perpetua Region	0	100%	-
	1	-	75%
	2	-	25%
	3	-	-
	4	-	-
	5	-	-
	6	-	-
	Total Drops	5	4

Considering all useable drops and all years, invertebrates were identified to species in 44% (n =4) of lander drops from 2014 only and these drops are from the Postage Stamp Comparison Area (Table 3.27). The end result is that no invertebrate species were observed in the Cape Perpetua Marine Reserve with the Lander (Table 3.30). Overall, four species of invertebrates were observed, representing 21 individuals (Table 3.29). The Giant White Plumed Anemone was the most frequently observed (22% of all useable drops), and can be classified as common. The three remaining species all had a frequency of occurrence of 11%, and are considered rare (Table 3.29). When present, three (of four) species exhibited mean MaxN values greater than one (Table 3.8). Giant White Plumed Anemone had the highest mean MaxN (8) and total number of individuals observed (16).

Table 3.27: Of the drops that met condition of habitat, visibility, and view (n =9) for the Cape Perpetua Region, sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species present, and the total number of individuals that were observed across all drops are provided.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals Observed
Cape Perpetua Region	Blood Star	1	11%	Rare	1	1
	Rainbow Star	1	11%	Rare	2	2
	Six-armed Star	1	11%	Rare	2	2
	Giant White Plumed Anemone	2	22%	Common	8	16

Table 3.30: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Cape Perpetua Marine Reserve & associated comparison area. - represent where no data were collected.

Region	Site	Metric	Year 2012	Year 2014
Cape Perpetua	Cape Perpetua CA	Total species richness	0	-
		Total # individuals observed	0	-
	Postage Stamp CA	Total species richness	0	4
		Total # individuals observed	0	21
	All Sites Combined	Total species richness	0	4
		Total # individuals observed	0	21

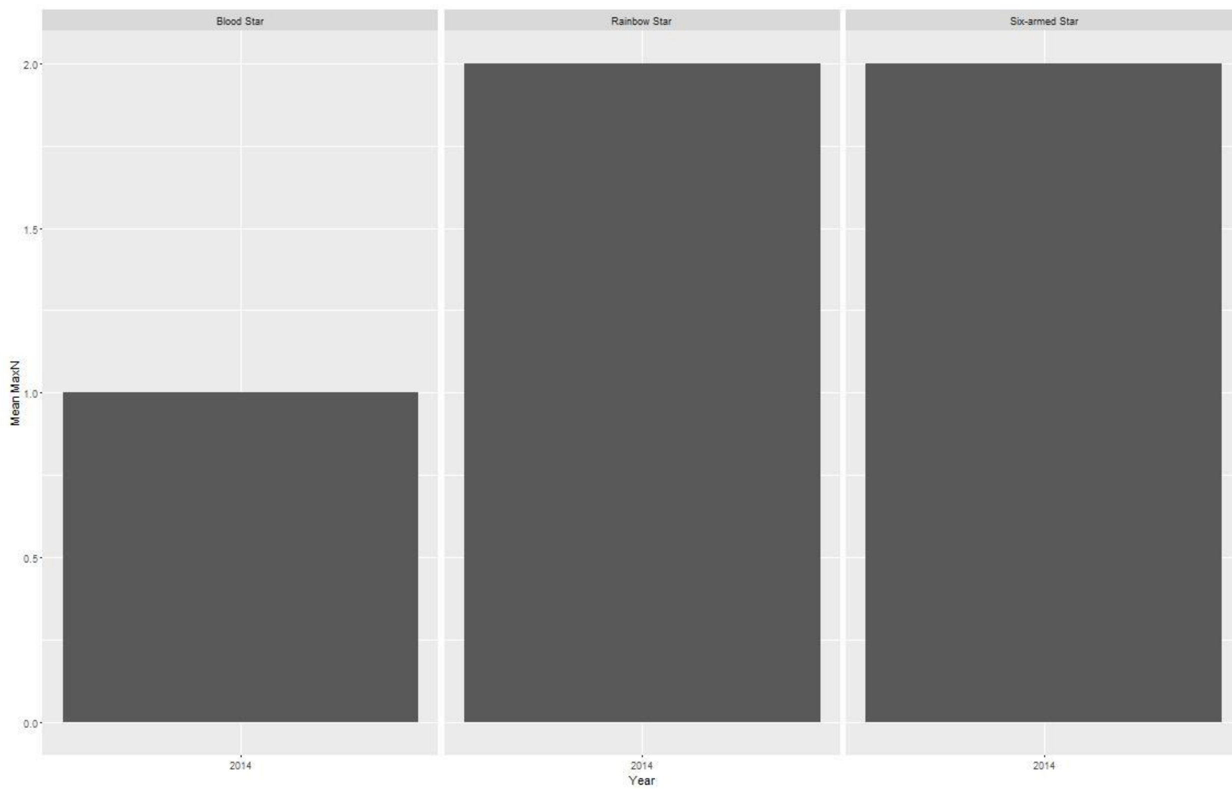


Figure 3.12: Mean MaxN for three sea star species observed on lander drops in the Cape Perpetua Region during surveys in 2014.

Abundance was low for all three sea stars species (Figure 3.12). Rainbow and six-armed stars had the highest abundance in 2014 (MaxN = 2). Blood Stars had the lowest abundance (MaxN = 1).

ROV

ROV invertebrate data has been collected over several years at the Cape Perpetua Marine Reserve by the ODFW Habitat team (Table 3.). However data are not available for summarization at this point in time.

Cape Falcon

Due to the shallow depths in the Cape Falcon Marine Reserve and comparison areas, observational data on invertebrates species is restricted to scuba diver and lander surveys only (Table). Because of the implementation date of the Cape Falcon Marine Reserve (2016) only two years of effort have been performed.

Table 3.31: Invertebrate data collected by habitat type by year in the Cape Falcon Marine Reserve and its associated comparison areas by year. - indicate that no data were collected. D = Scuba diver, L = Lander, R = ROV, P=PISCO OSU, O = ODFW following PISCO protocol, U = PISCO UC Santa Cruz

			Year	
Region	Site	Habitat	2016	2017
Cape Falcon	Cape Falcon MR	Intertidal	-	-
		Shallow Rocky Subtidal	D, L	D, L
	Cape Meares CA	Intertidal	-	-
		Shallow Rocky Subtidal	-	D, L
	Comparison Areas with varied fishing pressure	Intertidal	-	-
		Shallow Rocky Subtidal	L	D, L

Intertidal

Intertidal invertebrate data have been collected by PISCO in the Cape Falcon Region. However, we are still working with PISCO to understand where and when these surveys occurred in relation to the Cape Falcon Marine Reserve.

Shallow Rocky Subtidal

Scuba Diver Survey Effort

Scuba diver data are unavailable for analysis at this time, but effort by year by site can be found in Table 3.32.

Table 3.32: Scuba diver effort (number of transects) by year in the Cape Falcon Marine Reserve and associated comparison areas for invertebrate surveys. UPC = uniform point count of sessile invertebrates, Invert = invertebrate swath counts of specific mobile invertebrates.

		Year			
		2016		2017	
Region	Site	UPC	Invert	UPC	Invert
Cape Falcon	Cape Falcon MR	8	13	12	12
	Cape Meares CA	-	-	10	10
	Comparison Areas with varied fishing pressure	-	-	8	8
	All Sites Combined	8	13	30	30

Lander

The utility of the video lander for collecting benthic invertebrate data was limited due to constraints of view, visibility and habitat type (Table). For any given year the yield was never more than 13 useable drops per site (Table 3.33). he majority of useable drops were for the Cape Falcon Marine Reserve in 2016 and from the comparison areas with varied fishing pressure in 2017. The percentage of useable drops has never been higher than 45%.

Table 3.33: Lander effort represented by total number of useable drops by year in the Cape Falcon Marine Reserve and associated Comparison Areas for invertebrate surveys. NA indicate years in which total drops conducted was not recorded. – indicated where no data were collected.

Region	Site	Year 2016	Year 2017	Total Useable Drops
Cape Falcon	Cape Falcon MR	11	4	15
	Cape Meares CA	-	1	1
	Comparison Areas with varied fishing pressure	2	7	9
	All Sites Combined	13	12	25

	2016	2017	
Total Drops Conducted	29	54	
% Useable Drops	45%	22%	

Lander drops yielded low observations of invertebrate species (Table 3.34). The majority of lander drops in 2017 yielded no observation of invertebrate species (58%) whereas the majority of lander drops in 2016 did observe invertebrates (54%). No more than two different species were observed on any given drop, or year.

Table 3.34: The percentage of useable lander drops yielding observations of invertebrate species for the Cape Falcon Marine Reserve region.

	Species Richness Value	Year 2016	Year 2017
Cape Falcon Region	0	46%	58%
	1	31%	25%
	2	23%	17%
	3	-	-
	4	-	-
	5	-	-
	6	-	-
	Total Useable Drops	13	12

Considering all useable drops, in all locations and years, species level identifications of invertebrates were made for 48% (n =12) of Lander drops (Table 3.35). Overall, seven species of invertebrates were observed (Table 3.35). The Ochre Star and Giant White Plumed Anemone were the most frequently observed, while the remaining five species were observed less than 8% of all occurrences (Table 3.85). All species occurrences were classified as rare with the Ochre Star having the highest frequency of 20% (Table 3.835). All species exhibited mean MaxN values of one or greater (Table 3.835). The Giant White Plumed Anemone had the highest mean MaxN (26.3) and total number of individuals observed (79).

Table 3.35: Of the drops from Cape Falcon Region that met condition of habitat, visibility, and view (n =25), sample size containing that species (N), frequency of observation, categorical occurrence grouping, and the mean MaxN when the species is present, and the total number of individuals that were observed across all drops are provided.

	Species	N	Frequency	Occurrence	Mean MaxN (when present)	Total Individuals
Cape Falcon Region	Dungeness Crab	2	8%	Rare	2.0	4
	Embedded Sea Cucumber	2	8%	Rare	10.5	21
	Leather Star	2	8%	Rare	1.0	2
	Ochre Star	5	20%	Rare	1.2	6
	Red Urchin	2	8%	Rare	1.5	3
	Giant White Plumed Anemone	3	12%	Rare	26.3	79
	Tennis-ball Sponge	1	4%	Rare	2.0	2

The Cape Falcon Marine Reserve had similar species richness to its comparison areas in 2017 (Table 3.36). From the 12 usable lander drops, a total of 117 individual invertebrates were observed over the two years of data collection. 2016 had the most total individuals observed in both the Cape Falcon Marine Reserve and its comparison areas.

Table 3.36: Total species richness, total # individuals observed in the Lander invertebrate datasets by year at the Cape Falcon Marine Reserve & associated comparison areas. Blanks represent where no data was collected.

			Year	
Region	Site	Metric	2016	2017
Cape Falcon	Cape Falcon MR	Total species richness	5	3
		Total # individuals observed	81	9
	Cape Meares CA	Total species richness	-	-
		Total # individuals observed	-	-
	Comparison Areas with varied fishing pressure	Total species richness	2	3
		Total # individuals observed	21	6
	All Sites Combined	Total species richness	6	6
		Total # individuals observed	102	15

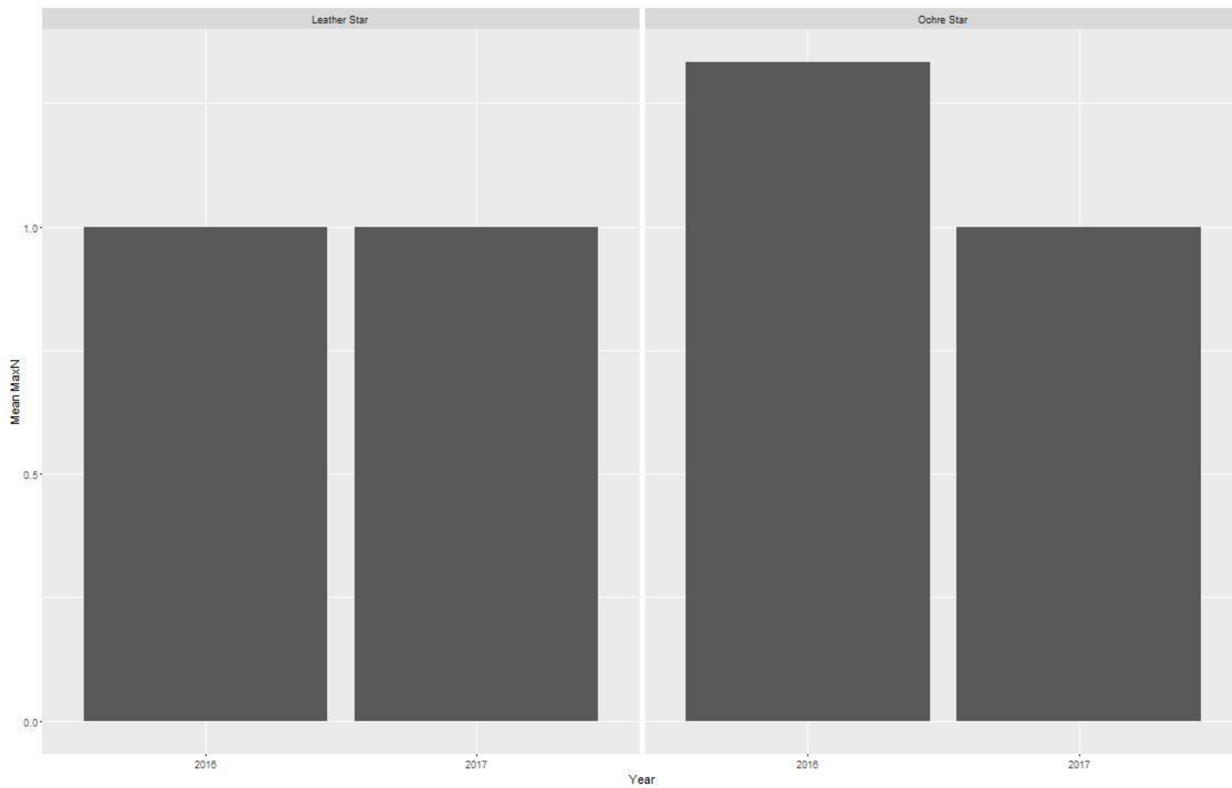


Figure 3.13: Mean MaxN for two sea star species observed on lander drops in the Cape Falcon Region during surveys from 2016-2017.

Abundance was low for both sea stars species for all years (Figure 3.13). Both the Leather and Ochre Stars, were observed in 2016 and 2017. Leather Stars had the same mean MaxN in 2016 and 2017, whereas Ochre Stars had slightly higher mean Max N in 2016 than 2017.

Section 5: Oceanography

The ODFW's ecological monitoring program is tasked with understanding the oceanographic conditions of each marine reserve and how they change over time. Oregon's five marine reserves and nearshore waters are a unique part of the Northern California Current Ecosystem (NCCE). The NCCE ranges from Cape Mendocino, in northern California to Vancouver Island, British Columbia. The onshore North Pacific Current crosses the Pacific from Japan to Canada and splits into northward and southward flowing currents. The southward flowing current which dominates the NCCE is called the California Current. Strongest in the summer over the continental shelf, this current weakens and is displaced by the northward flowing Davidson current associated with winter storms. Cape Blanco, just to the north of the Redfish Rocks Marine Reserve, is considered to be a dividing point between a distinct northern region from Cape Blanco to the Columbia River at the Oregon-Washington border and a southern region that extends from Cape Blanco to Cape Mendocino in California.

Redfish Rocks

Sensor Deployment Over Time (Effort)

Mooring and BoP deployments occurred in 2010-13 at the Redfish Rocks Marine Reserve (RRMR) and the Humbug CA (RRH) (Table 5.1). Temperature and salinity sensors were deployed on SMURF moorings in 2014-2017. Additionally, one HOBO temperature mooring was deployed at the Orford Reef CA in 2011.

Table 5.1: Oceanographic variables and data collection by year for the Redfish Rocks Marine Reserve and the Humbug and Orford Reef Comparison Areas. O = ODFW; P = PISCO; * = intertidal data

Site		Temperature	Salinity	DO	pH	Chlorophyll
Redfish Rocks Marine Reserve	2010	O	O	O		O
	2011	O	O	O		O
	2012	O		O		O
	2013	O		O		O
	2014	O	O			
	2015	O	O			
	2016	O	O			
	2017	O	O		P*	
Humbug Comparison Area	2010	O				
	2011	O				
	2012	O	O	O		O
	2013	O	O	O		O
	2014	O	O			
	2015	O	O			
	2016	O	O			
	2017	O	O			
Orford Reef Comparison Area	2010					
	2011	O				
	2012					
	2013					
	2014					
	2015					
	2016					
	2017					

CT Sensor Results

CT data are available over a span of four years (2010-2013) at RRMR and two years (2012-2013) the RRH Comparison Area. The CT was deployed in RR from August-September 2010 (Figure 5.1) and May-August 2011 (Figure 5.2). All data from the 12 month deployment from March 2012-March 2013 are shown in figure 5.3 and includes both RRMR and RRH data.

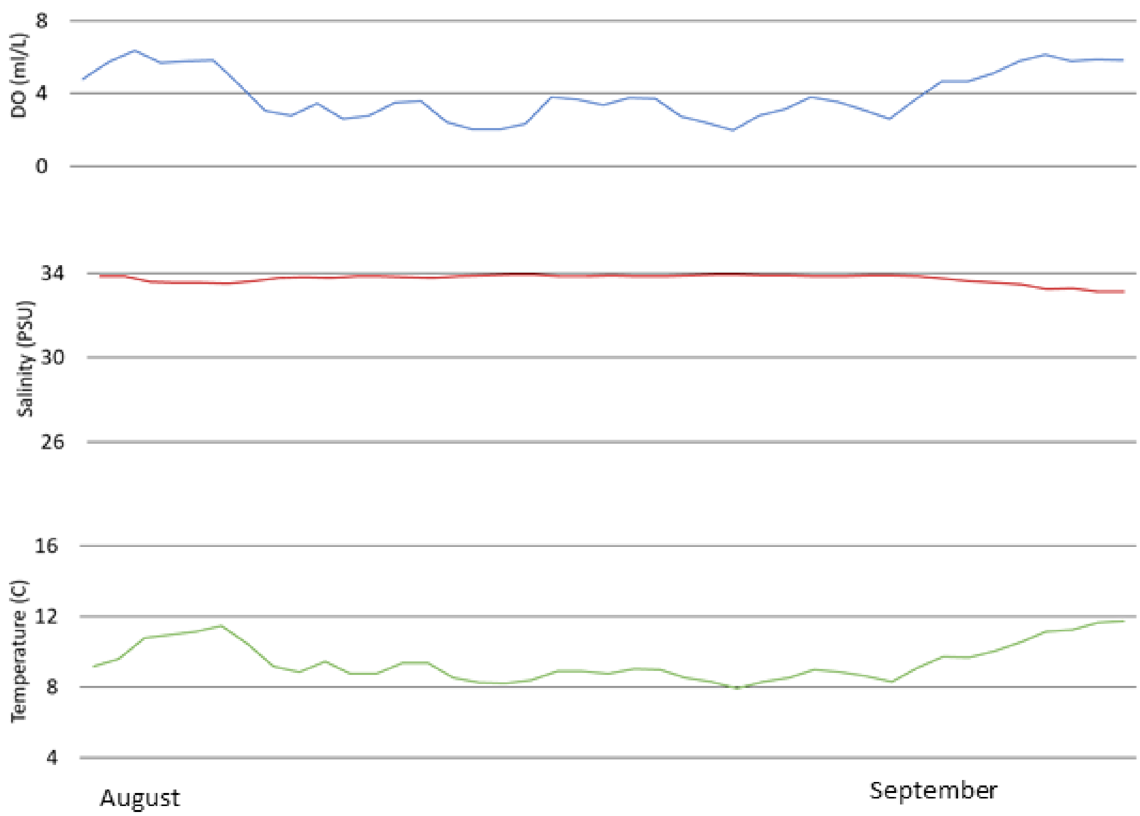


Figure 5.1. CT data collected in 2010 at RRMR. The CT was moored at a depth of 20m inside the reserve.

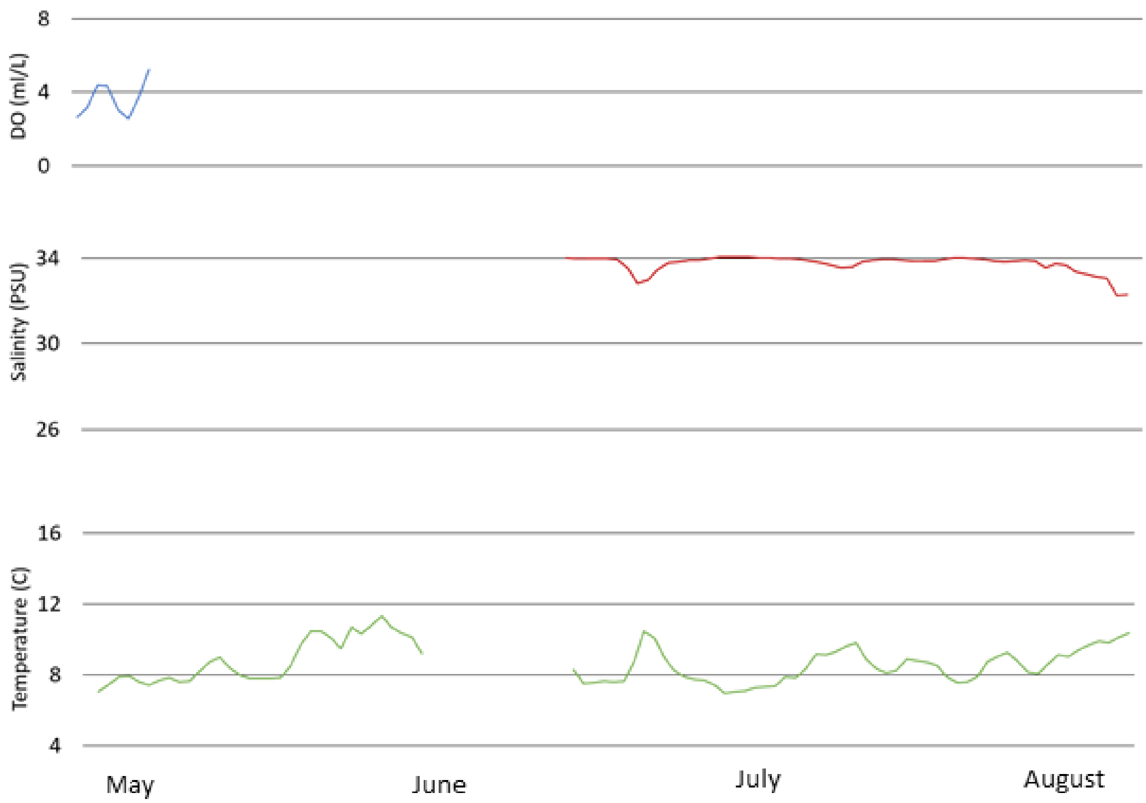


Figure 5.2. CT data collected in 2011 at RRMR. The CT was on a BOP at a depth of 20m inside the reserve. Some technical issues prevented getting full data streams for all variables from this time period.

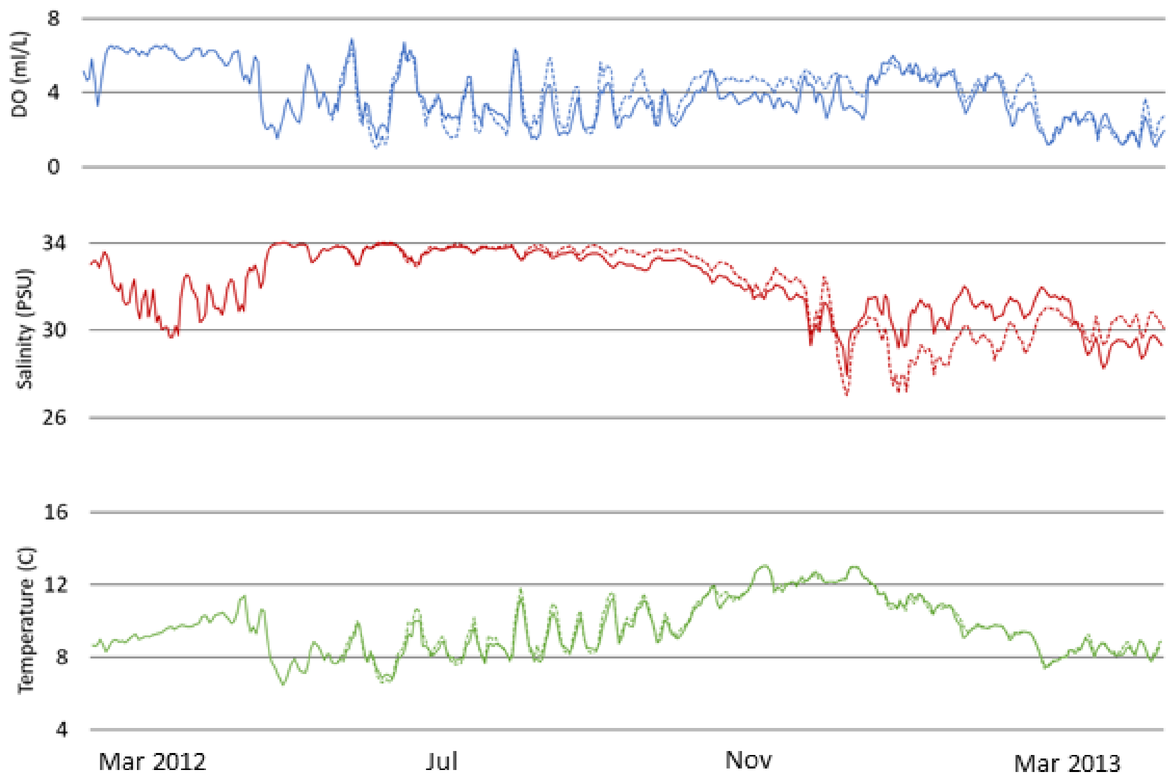


Figure 5.3. CT data collected in 2012-2013 at RRMR and Humbug CA. Both CTs were on BOPs at a depth of 20m inside the reserve. Solid lines indicate data from the marine reserve; dotted lines indicate data from the comparison areas

Oceanographic data indicate that water temperature, dissolved oxygen, and salinity were comparable over time between the marine reserve and the Humbug Comparison Area (data collected in 2012-13) (Figure 5.3). Temperature in particular varied within half a degree Celsius (0.5°C) between the reserve and Humbug Comparison Area. Although our oceanographic baseline comparisons are spatially limited, the high agreement between the oceanographic variables measured in the Redfish Rocks Marine Reserve and Humbug suggests that Humbug is an appropriate comparison area to the reserve with respect to oceanographic conditions

Reserve vs. Comparison Area: Temperature

The Marine Reserves Program has continued to collect temperature data within the Redfish Rocks Marine Reserve and Humbug Comparison areas after the initial baseline. There has been similar temperatures found in both locations over the eight years of data collection (Figure 5.4). HOBO sensor data from 1-3m depth were used. For the plots in Figure 5.4, data from a sensor inside and outside the reserve are plotted together. Data used are available from 2010-11 from oceanographic moorings and 2014-17 from SMURF moorings.

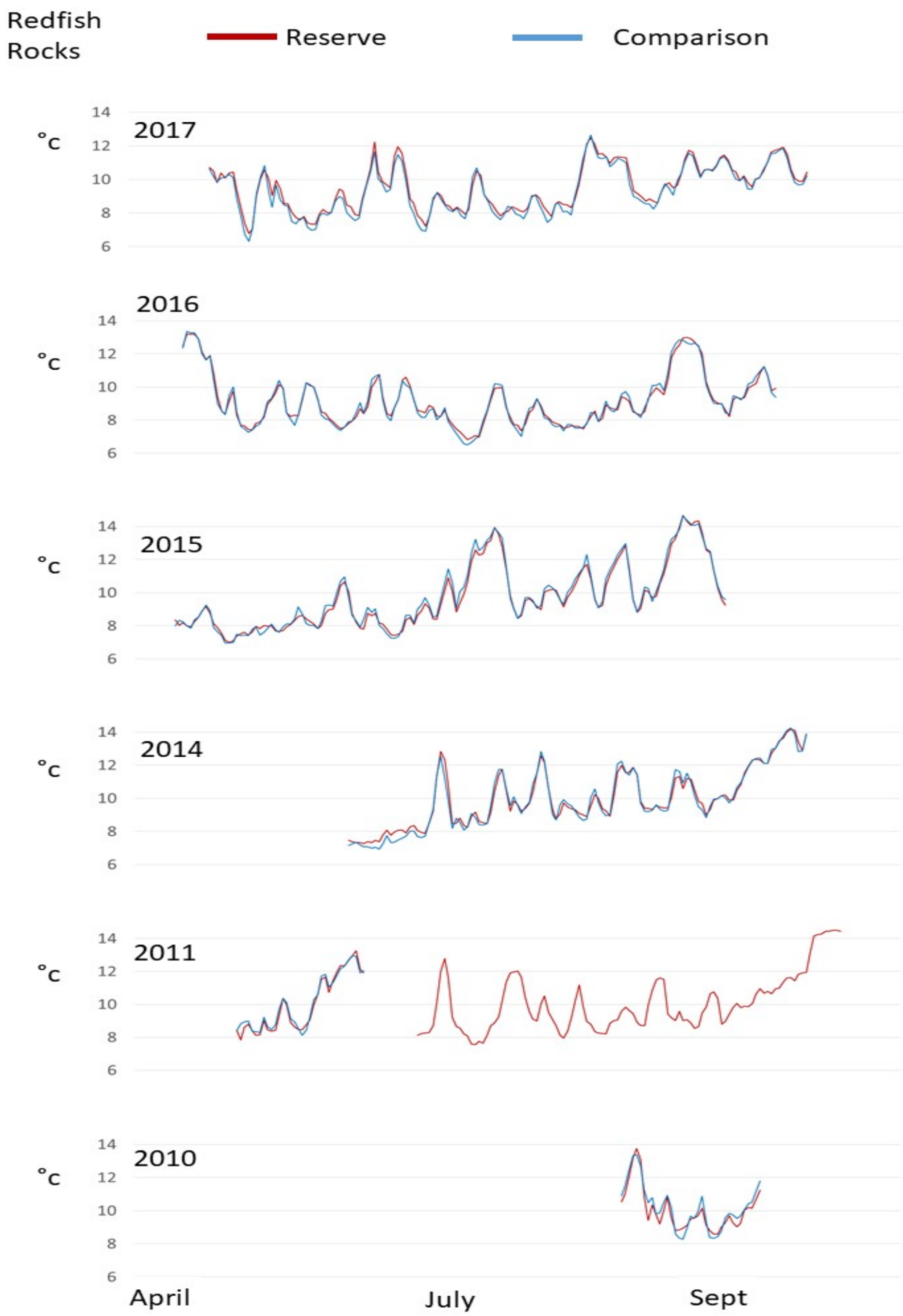


Figure 5.4: Temperature data from the Redfish Rocks Marine Reserve and Humbug Comparison Areas by year from April to September.

Climatology

The climatology plot for the RRMR is shown in Figure 5.5. All HOBO temperature sensors were located 1-3 m depth on moorings were located inside the reserve at 15 m depth, although the locations of deployment varied by year. Some years are unavailable due to the lack of a surface sensor at that time.

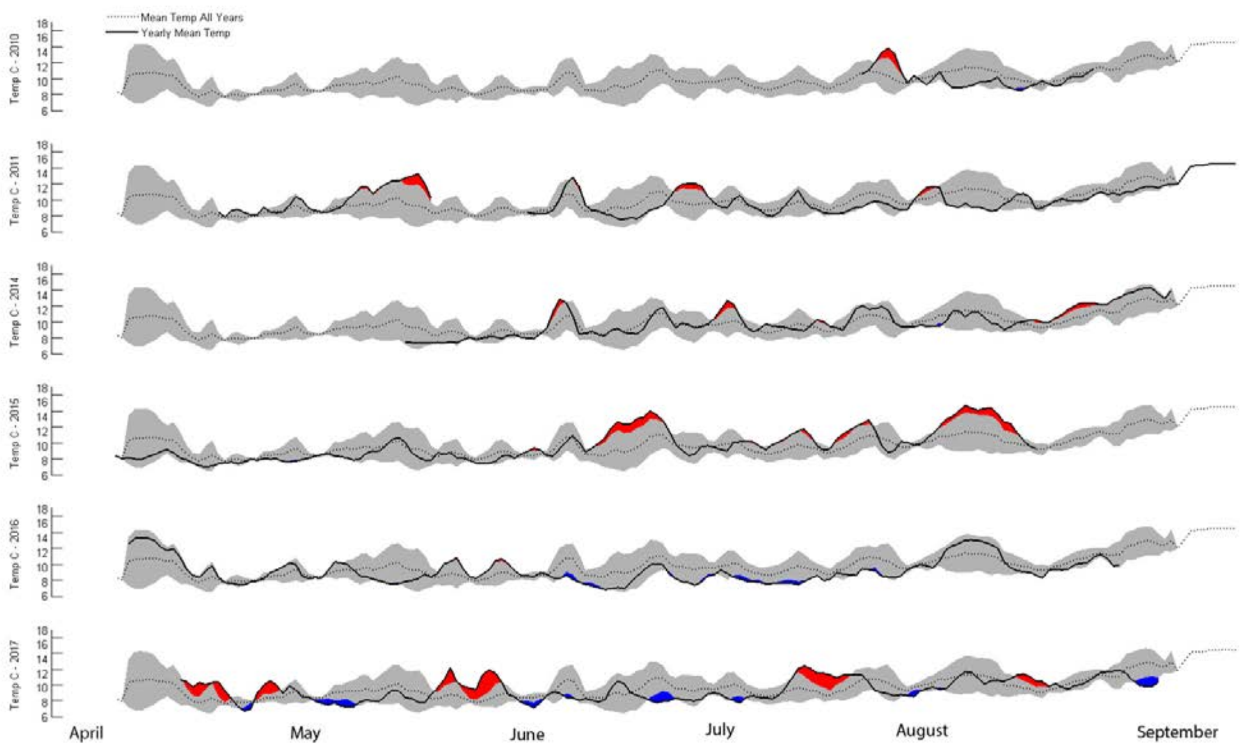


Figure 5.5. RRMR climatology series. Daily temperatures for a given year (solid black line), average daily temperature over all years (grey dashed line), and standard deviation over all years (gray shaded area) Data are from 2010-11 and 2014-17. HOBO sensors were not deployed in Redfish Rocks Marine Reserve in 2012-13. Red areas indicate temperatures warmer than normal. Blue shaded areas indicate temperatures colder than normal.

The climatology from Redfish Rocks Marine Reserve highlights that nearly all years the reserve experienced times of anomalously warm water temperatures, with the exception of 2016 (Figure 5.5). However the climatology is based on only a six year time-series. Only in 2016 and 2017 did the reserve experience colder than normal water temperatures; however they do not appear for an extended period of time. With the exception of 2017, most years have temperature that fall within the normal climatology for the Redfish Rocks Marine Reserve.

Otter Rock

Sensor Deployment Over Time (Effort)

Temperature and salinity are the two most consistent oceanographic variables collected in the Otter Rock and Cape Foulweather locations (Table 5.2). In the earlier years of data collection efforts were made to generate data on dissolved oxygen and light; however, these were not continued through the years.

*Table 5.2: Oceanographic variables and data collection by year for the Otter Rock Marine Reserve and the Cape Foulweather Comparison Area. O = ODFW; P = PISCO; * = intertidal data*

Site		Temperature	Salinity	DO	Chlorophyll	pH
Otter Rock Marine Reserve	2010	O	O	O	O	
	2011	O	O	O	O	
	2012					
	2013					
	2014	O	O			
	2015	O	O			
	2016	O	O			
	2017	O	O			P*
Cape Foulweather Comparison Area	2010	O				
	2011	O				
	2012					
	2013					
	2014	O	O			
	2015	O	O			
	2016	O	O			
	2017	O	O			

CT Sensor Results

CT data are available over a span of two years (2010-2011) at OR. The CT was deployed in OR from July-September 2010 (Figure 5.6) and June-September in 2011 (Figure 5.7).

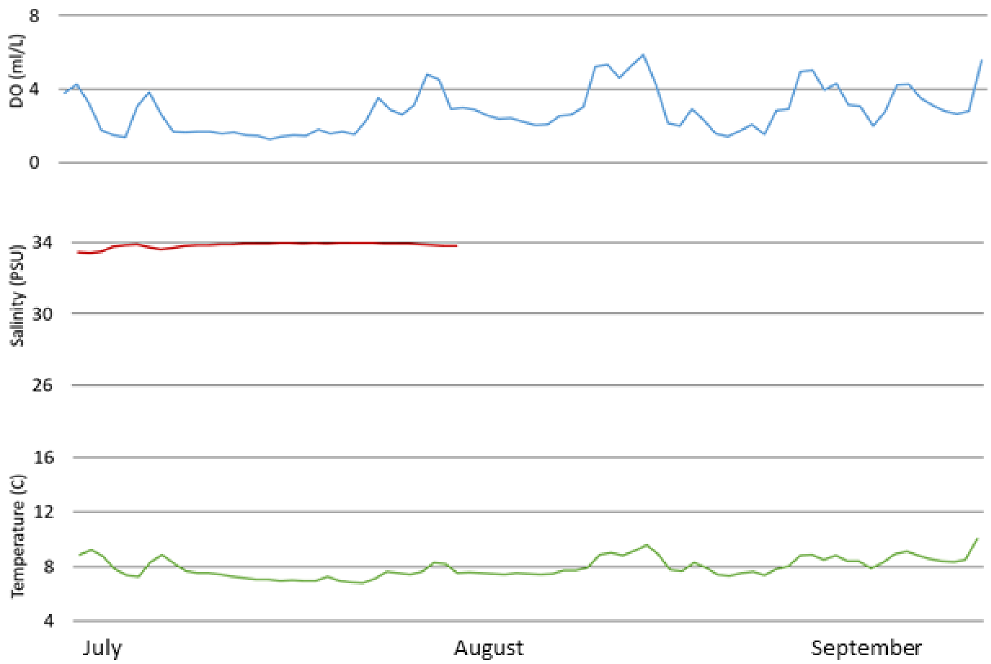


Figure 5.6. CT data from ORMR 2010. The instrument was on a mooring in 15m of water. The salinity sensor failed in August and no further data were collected.

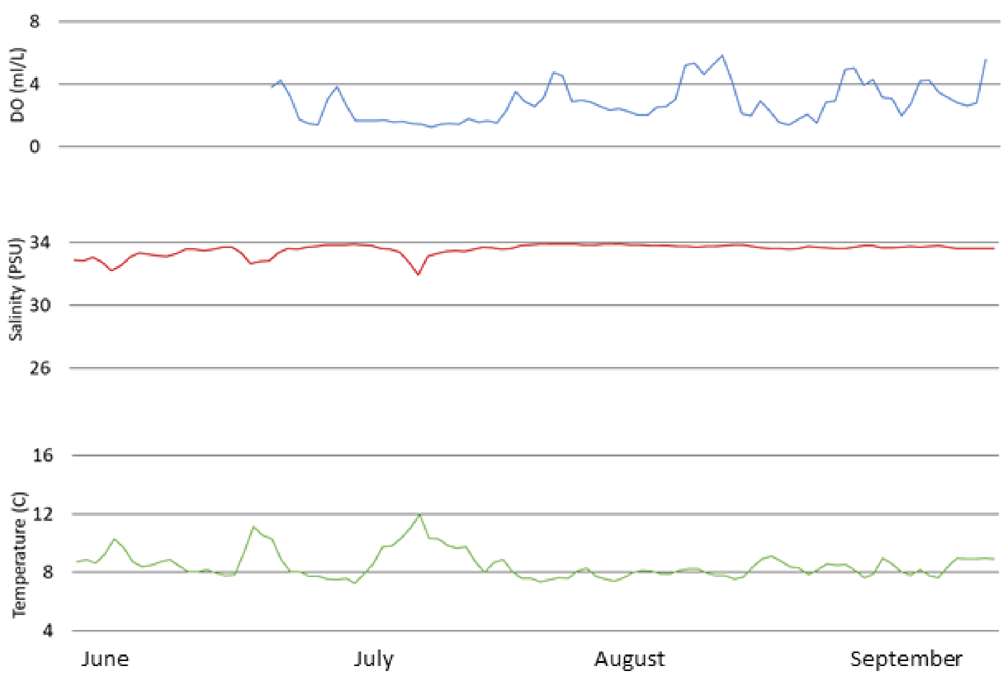


Figure 5.7. CT data from ORMR 2011. The instrument was on a mooring in 15m of water.

Temperature inside the reserve and in a nearby comparison area

The Marine Reserves program has continued to collect temperature data within the Otter Rock Marine Reserve and Cape Foulweather Comparison Area after the initial baseline. There has been similar temperatures found in both locations over the six years of data collection (Figure 5.8). Data used are available from 2010-11 from oceanographic moorings and 2014-17 from SMURF moorings. Surface (1-3m) HOBO sensor data from inside and outside the reserve are plotted together.

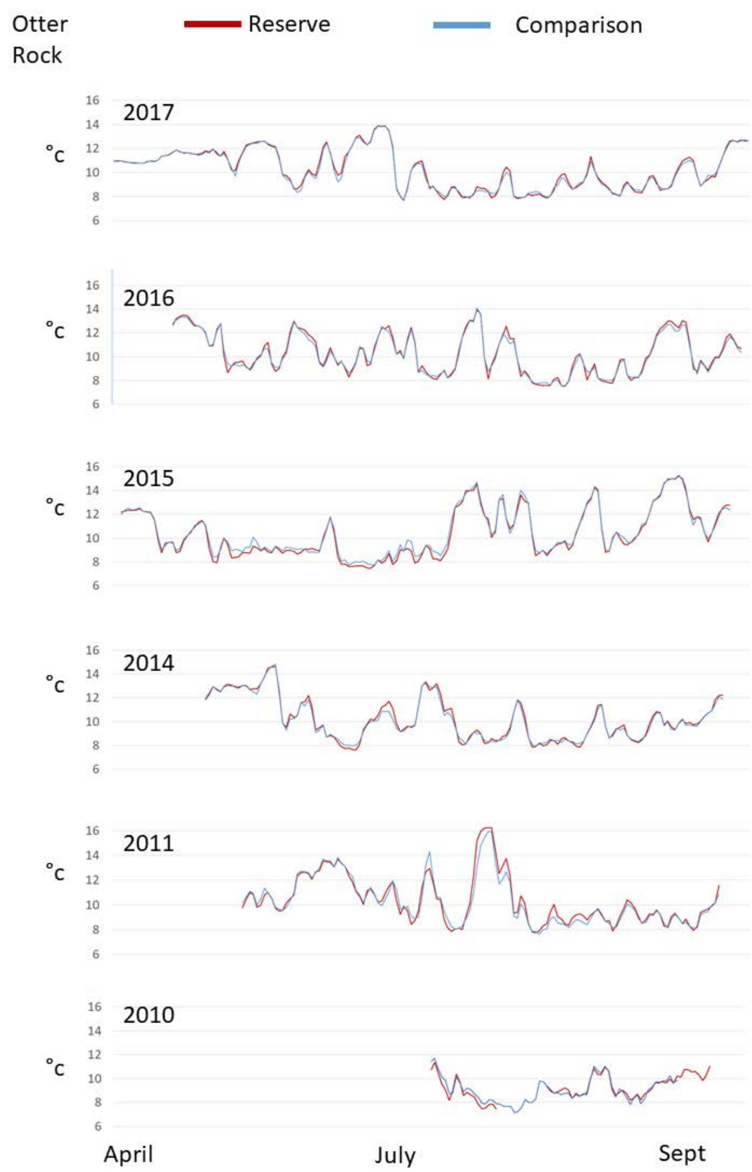


Figure 5.8: Temperature data from the Otter Rock Marine Reserve and Cape Foulweather Comparison Area by year from April to September.

Climatology

Using data from HOBO temperature sensors deployed at 1-3m below the surface, a series of climatology plots were produced (Figure 5.9). These plots used data from sensors deployed on oceanographic moorings (2010-2011) and on SMURF moorings (2014-2017). All moorings were located inside the reserve, although the locations of deployment varied by year. Some years are unavailable (2012-13) due to the lack of a surface sensor at that time.

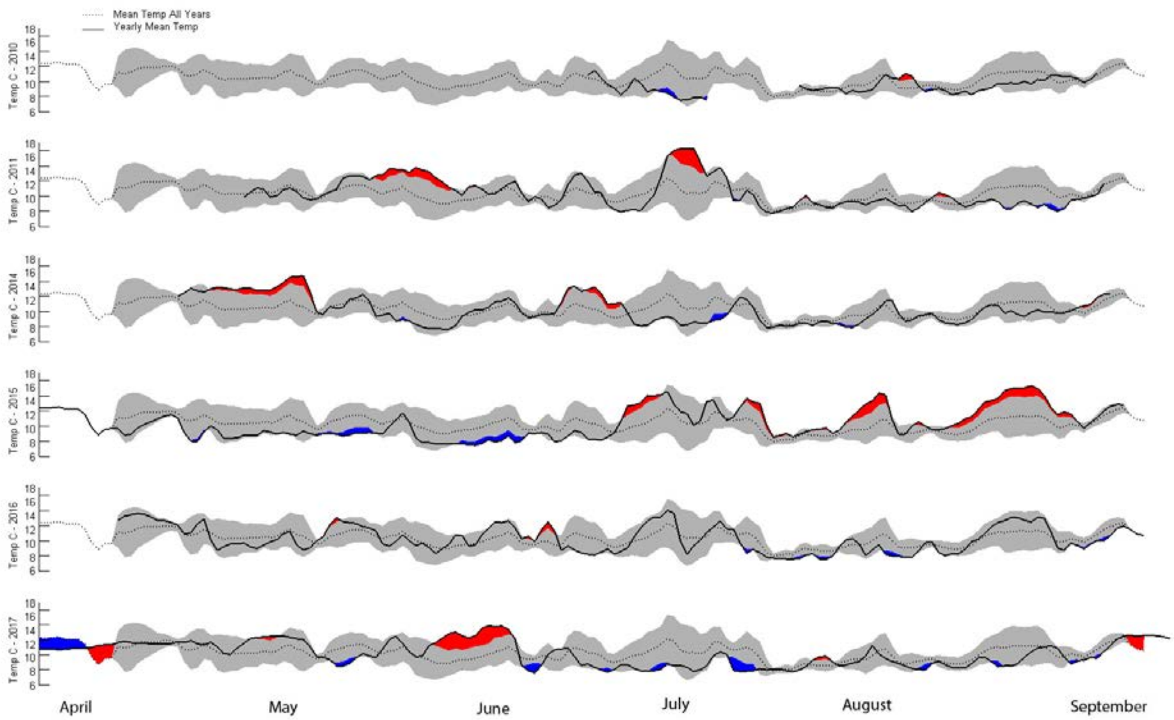


Figure 5.9: OOMR climatology series. Daily temperatures for a given year (solid black line), average daily temperature over all years (grey dashed line), and standard deviation over all years (grey shaded area). Data are from 2010-2011 and 2014-2017. HOBO sensors were not deployed at surface moorings in OR in 2012-13. Red areas indicate temperatures warmer than normal. Blue shaded areas indicate temperatures colder than normal.

The climatology from the Otter Rock Marine Reserve highlights that each year there are periods of anomalous warm and cold water masses (Figure 5.9). However the climatology is based on a short time series, only six years long. The years of 2011, 2014, and 2015 stand out as years the reserve experiences more warm episodes during our sampling period, whereas 2017 stands out as a year where the reserve experienced more colder than normal periods when compared to all other years.

Cascade Head

Sensor Deployment Over Time (Effort)

Oceanographic data collected by ODFW occurred in 2013-2014 in the Cascade Head Marine Reserve. PISCO mooring data facilitated some additional variables for the Cavalier Comparison area from 2012-2013 (Table 5.3). Note that although data were collected by both ODFW and PISCO in 2013, sampling was not concurrent (PISCO = Apr-Sept, ODFW = Oct-Dec). No oceanographic data have been collected in the Schooner Creek Comparison area.

*Table 5.3: Oceanographic variables and data collection by year for the Cascade Head Marine Reserve and Cavalier Comparison Area. O = ODFW; P = PISCO; * = intertidal data*

Site		Temperature	Salinity	DO	Chlorophyll	pH
Cascade Head Marine Reserve	2012					
	2013	O	O	O	O	
	2014	O	O	O	O	
	2015					
	2016					
	2017					
Cavalier Comparison Area	2012	P	P	P	P	P
	2013	P	P	P	P	P
	2014					
	2015					
	2016					
	2017					P*

CT Sensor Results

CT data are available over a span of two years (2013-2014) at CHMR. The CT was deployed continuously in CH from October 2013 through February 2014.

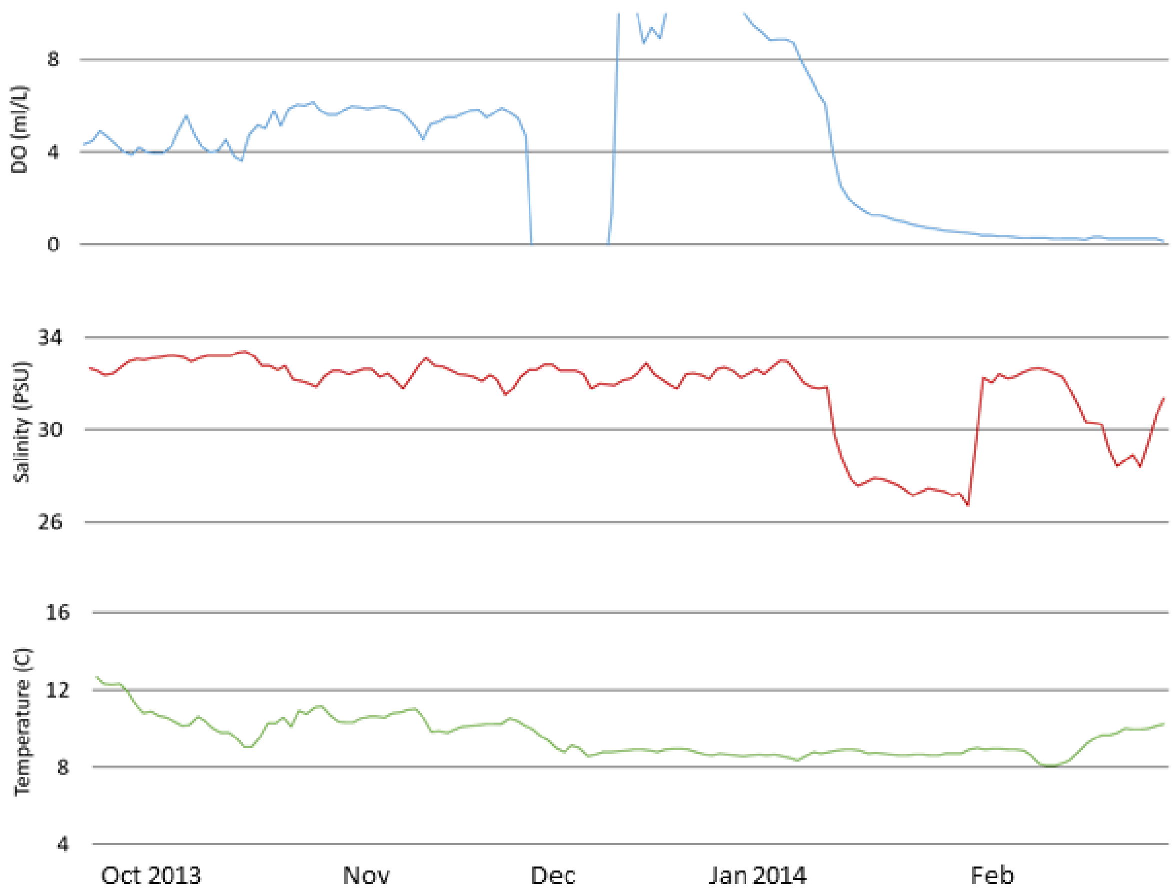


Figure 5.10. CT data from CHMR in 2013-2014. The sensor was on a BOP plate on the seafloor at a depth of 22m. The DO sensor most likely failed in November and subsequent readings are incorrect.

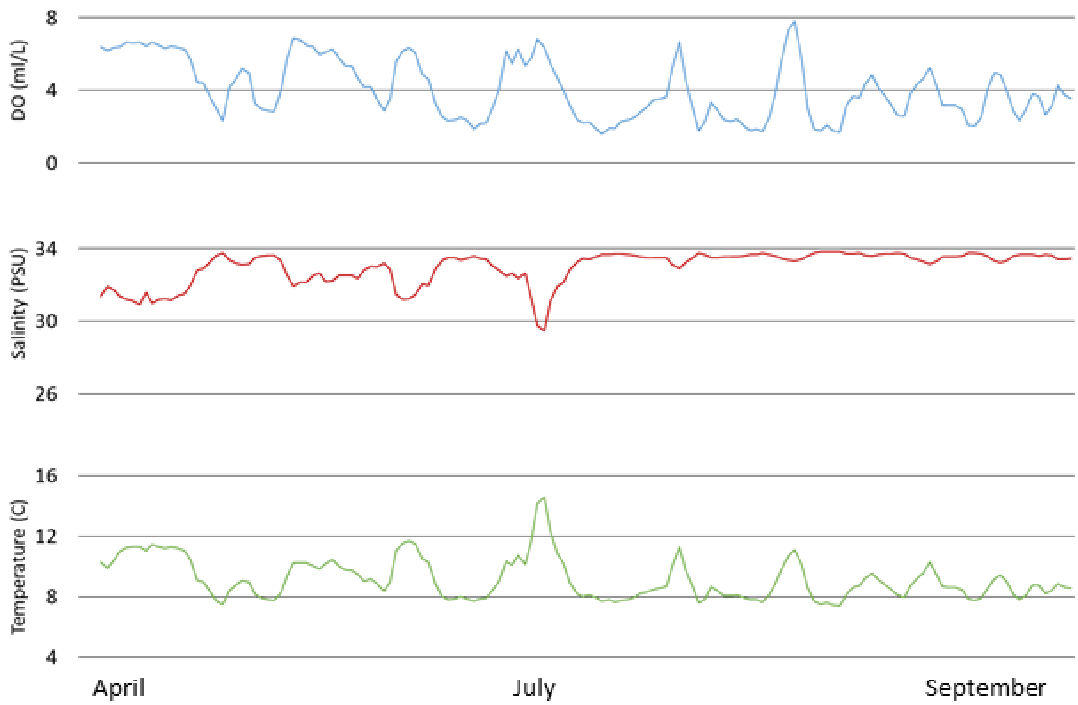


Figure 5.11. CT data from Cavalier CA in 2012. The sensors were sampling at 13m on a mooring in 15m water depth.

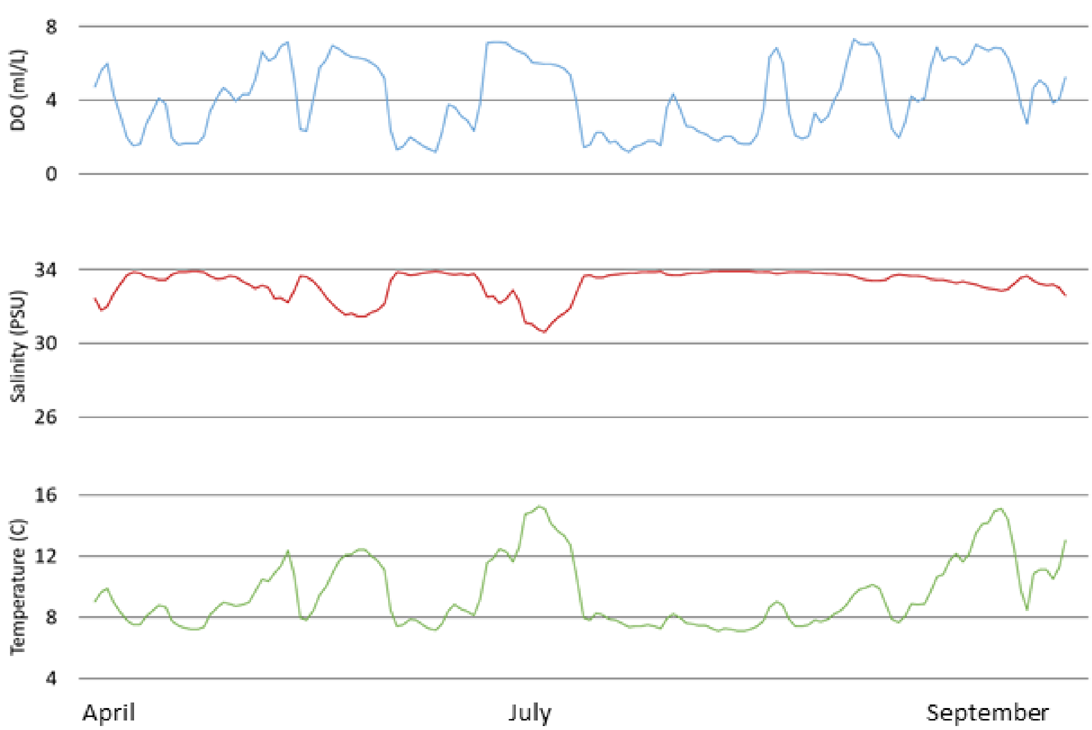


Figure 5.12. CT data from Cavalier CA in 2013. CT data from Cavalier CA in 2012. The sensors were sampling at 13m on a mooring in 15m water depth.

Cape Perpetua

Sensor Deployment Over Time (Effort)

All data from the Cape Perpetua Marine Reserve have been collected by PISCO (Table 5.4). However, multiple oceanographic variables have been collected since 1998, including the eight years of the Marine Reserves program. No oceanographic data have been collected in the Postage Stamp Comparison Area during this same time period.

*Table 5.4: Oceanographic variables and data collection by year for the Cape Perpetua Marine Reserve. P = PISCO data, * = Includes intertidal data*

Site		Temperature	Salinity	DO	Chlorophyll	pH
Cape Perpetua Marine Reserve	2012	P	P	P	P	P
	2013	P	P	P	P	P
	2014	P	P	P	P	P
	2015	P	P	P	P	P
	2016	P	P	P	P	P
	2017	P	P	P	P	P*

CT Sensor Results

CT data are available over in all years at CPMR. The CT was deployed each year by PISCO from April through September.

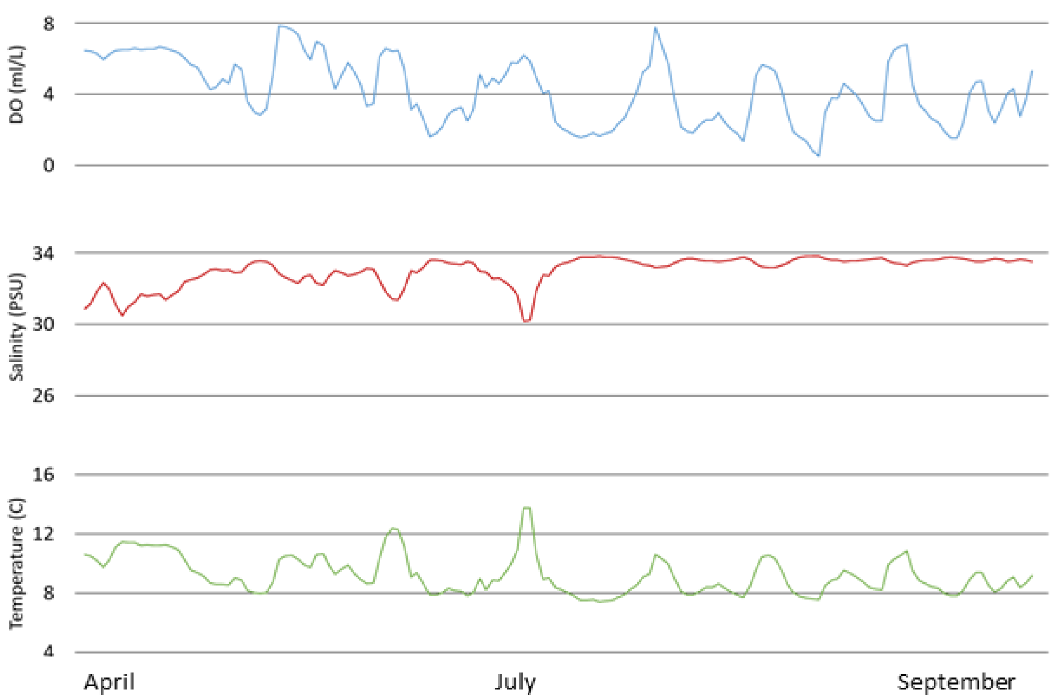


Figure 5.13. CT data from CP 2012. *The sensors were sampling at 13m on a mooring in 15m water depth.*

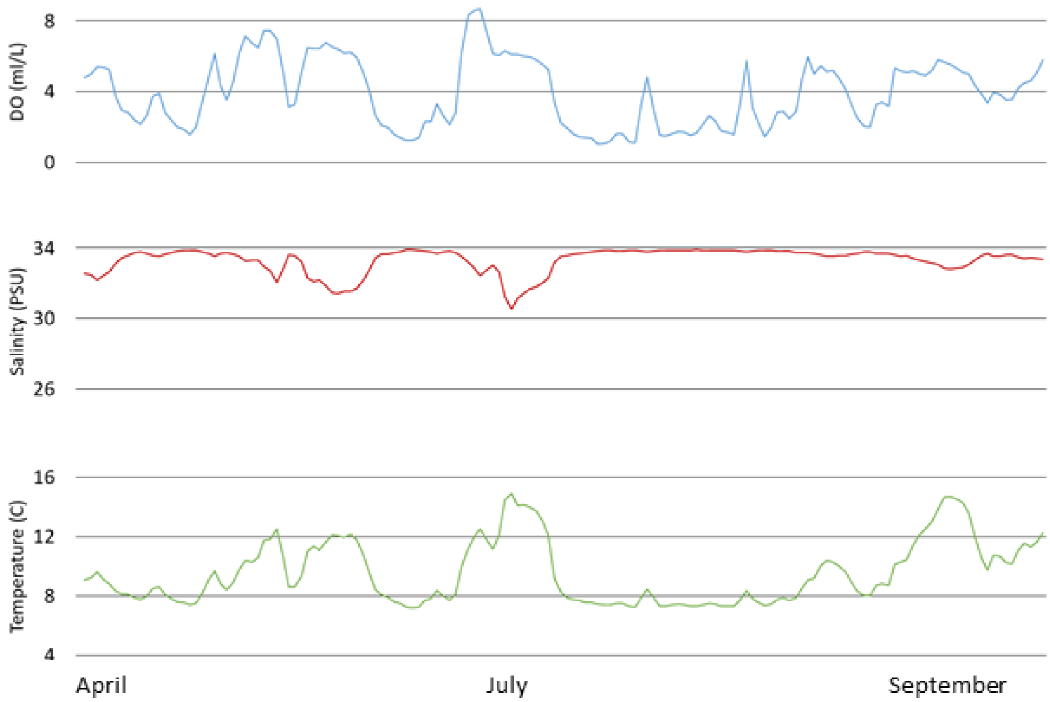


Figure 5.14: CT data from CP 2013. *The sensors were sampling at 13m on a mooring in 15m water depth.*

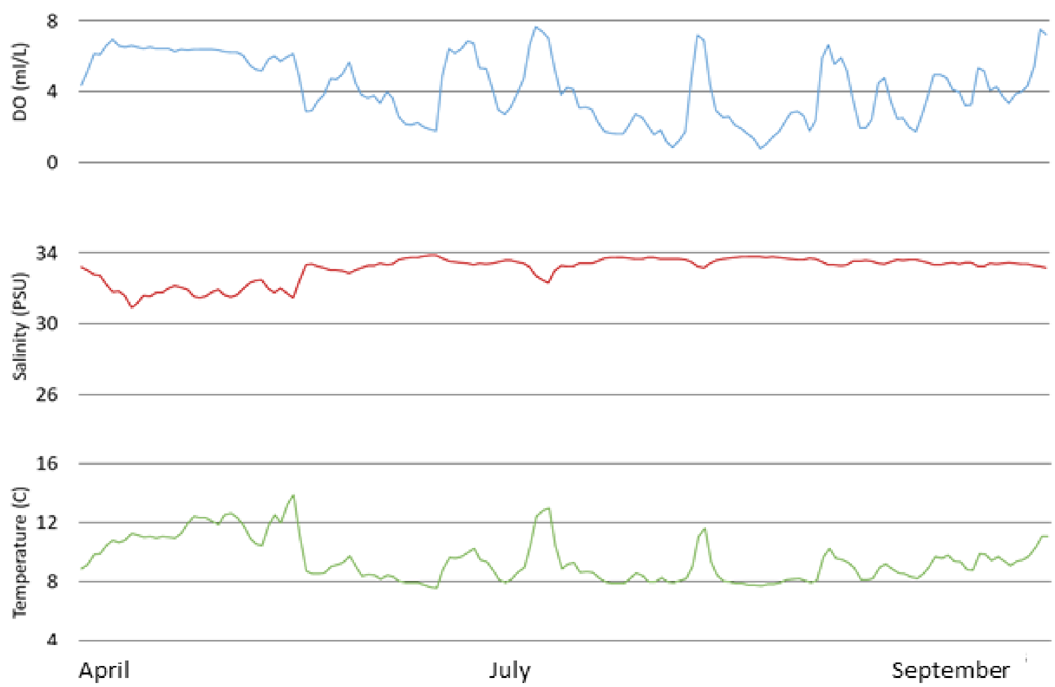


Figure 5.15: CT data from CP 2014. *The sensors were sampling at 13m on a mooring in 15m water depth.*

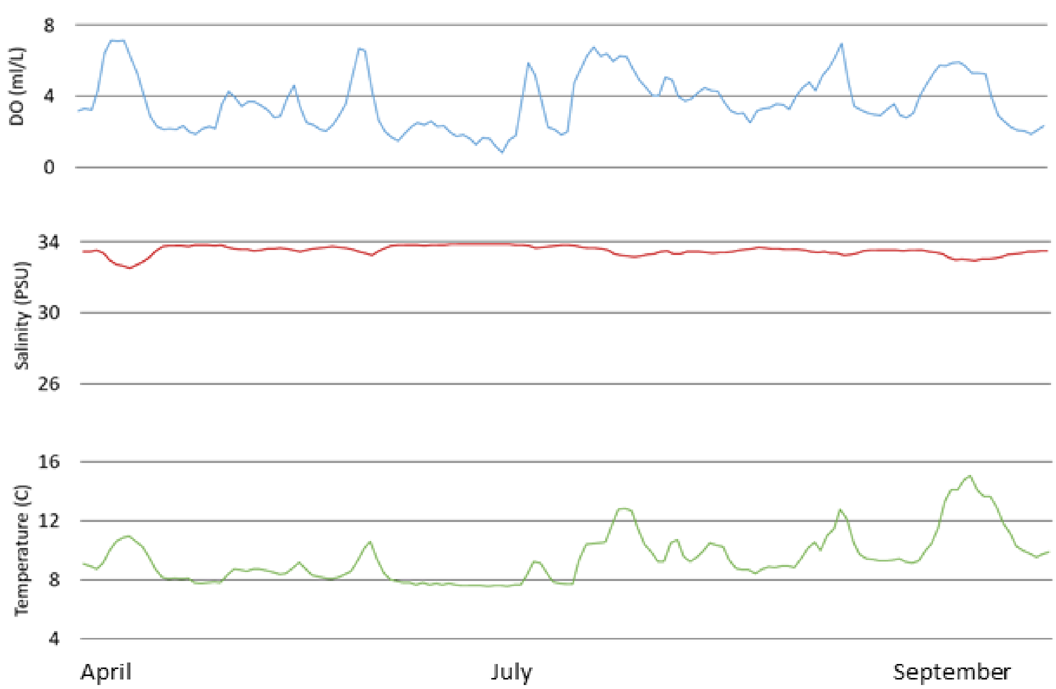


Figure 5.16: CT data from CP 2015. *The sensors were sampling at 13m on a mooring in 15m water depth.*

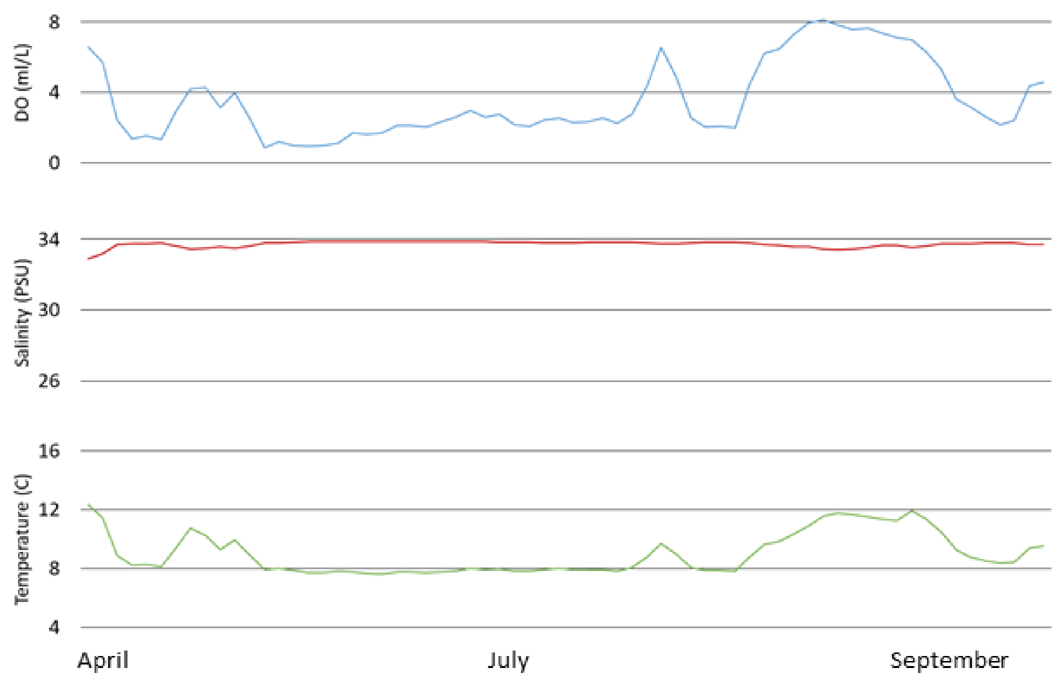


Figure 5.17: CT data from CP 2016. *The sensors were sampling at 13m on a mooring in 15m water depth.*

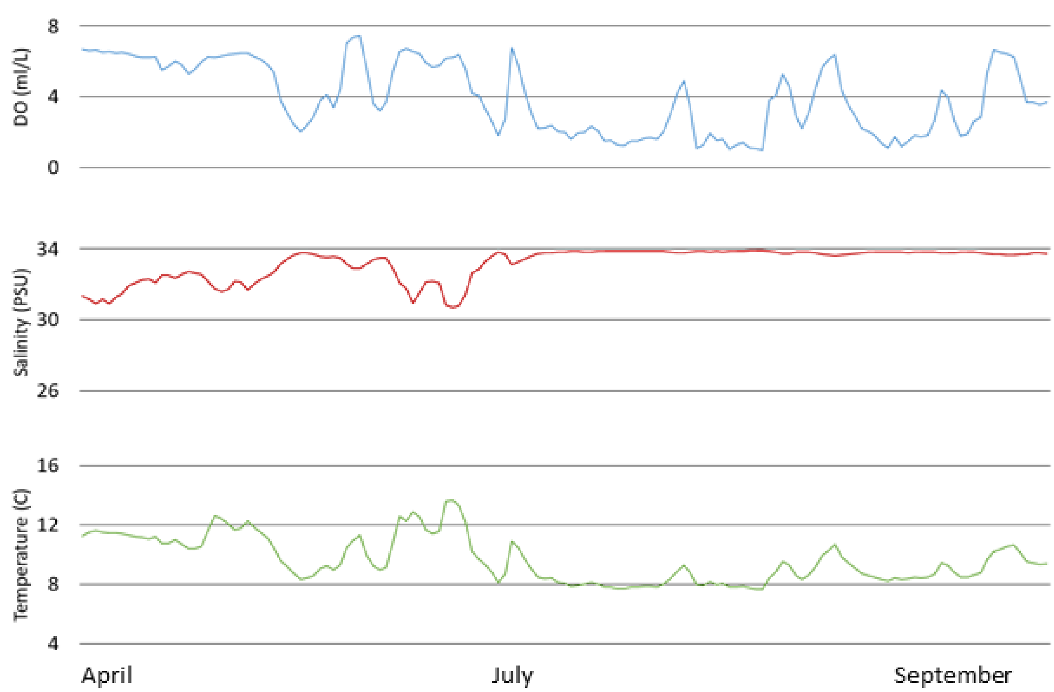


Figure 5.18: CT data from CP 2017. *The sensors were sampling at 13m on a mooring in 15m water depth.*

Climatology

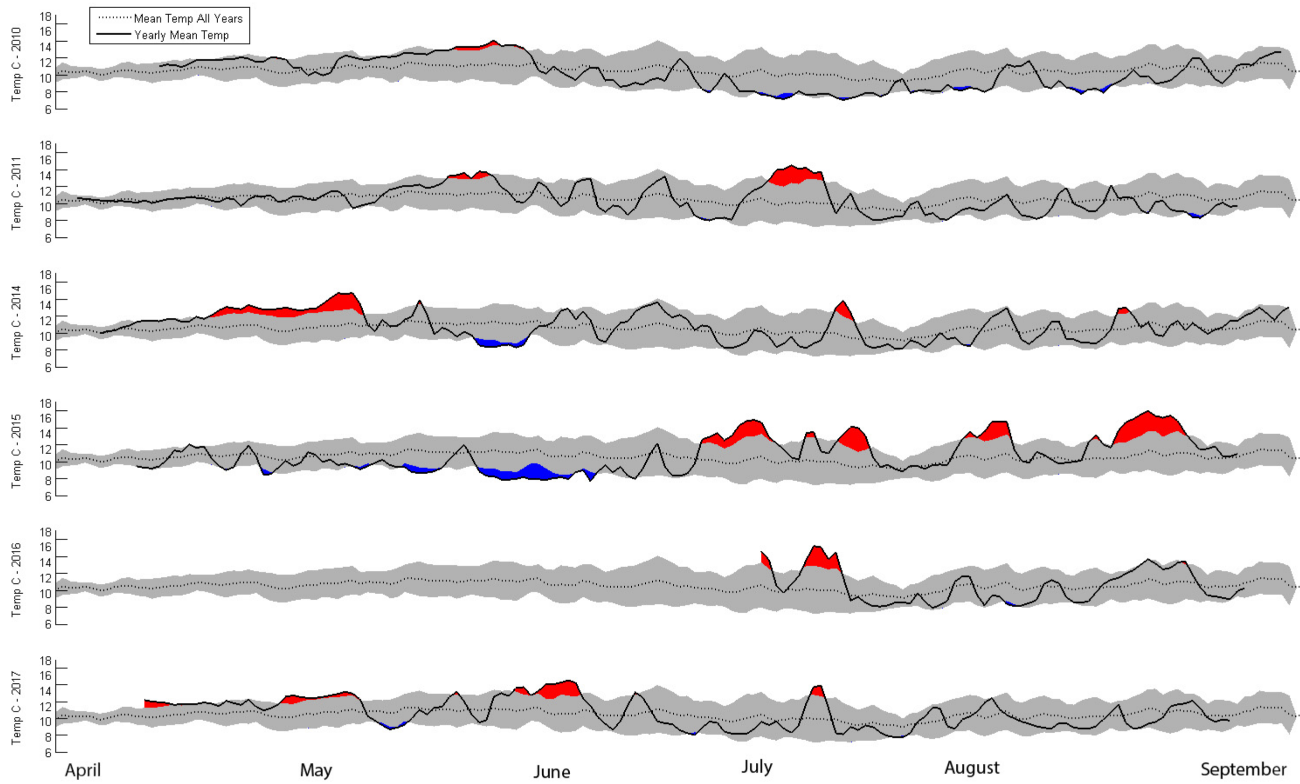


Figure 5.19: CPMR climatology series. Daily temperatures for a given year (solid black line), average daily temperature over all years (grey dashed line), and standard deviation over all years (grey shaded area). Data are from 1998-2017, although only 2010-2017 climatology graphs are shown. Red areas indicate temperatures warmer than normal. Blue shaded areas indicate temperatures colder than normal.

Cape Falcon

Cape Falcon is Oregon’s newest reserve (implementation in 2016). Currently there has been no oceanographic monitoring in Cape Falcon because of limited funding and capacity of the ODFW Marine Reserves Program.

Section 5:

Research Question 6: Are patterns or changes within the marine reserve consistent throughout the marine reserve system?

Oceanography

For each location along the OR coast where data were collected (see map) at similar depths (see Table), we plotted daily mean values across years to determine if there were any regional patterns in oceanographic conditions through time. Temperature, salinity and dissolved oxygen track well for all sites north of Cape Blanco (Figures 5A, 5B, 5C). The Redfish Rocks and Humbug sites, south of Cape Blanco, appear to track slightly differently for all variables, especially salinity (Figures 5A, 5B, 5C), as compared to the other four sites north of Cape Blanco.

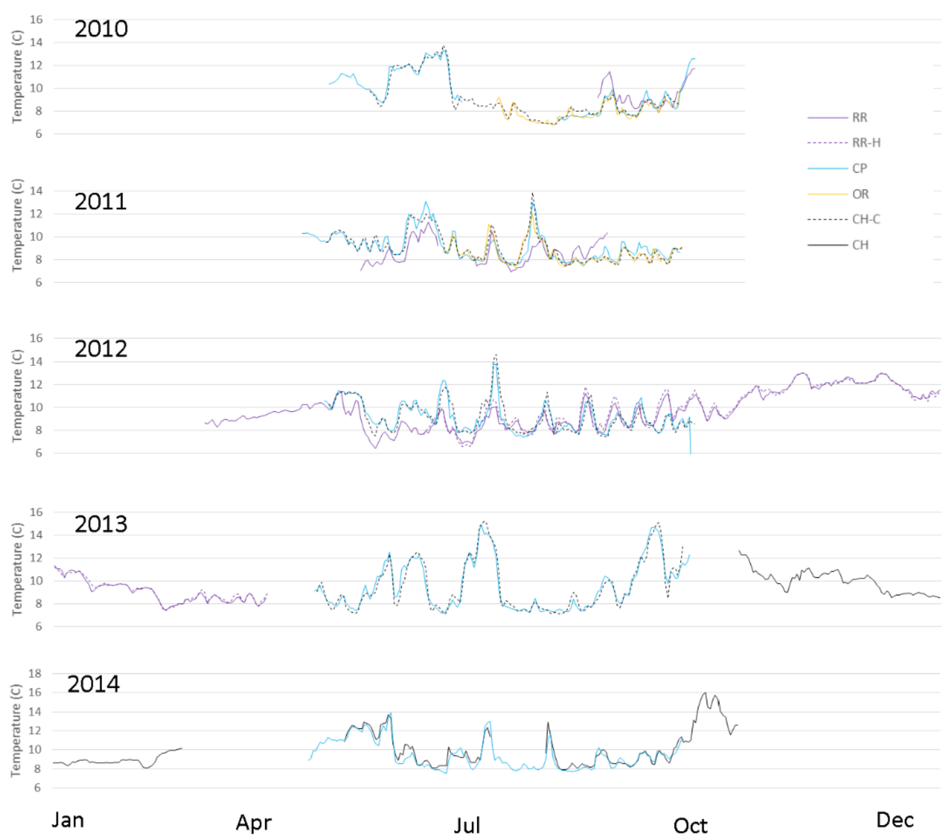


Figure 5A: Temperature data collected at 13-20 m depths by ODFW Marine Reserves Program and OSU PISCO from across the Oregon coast. CH-C and CP are collected by PISCO, all other data collected by ODFW. RR = Redfish Rocks, RR-H = Humbug Comparison Area, CP= Cape Perpetua, OR = Otter Rock, CH-C = Cavalier Comparison Area / Lincoln Beach, CH = Cascade Head.

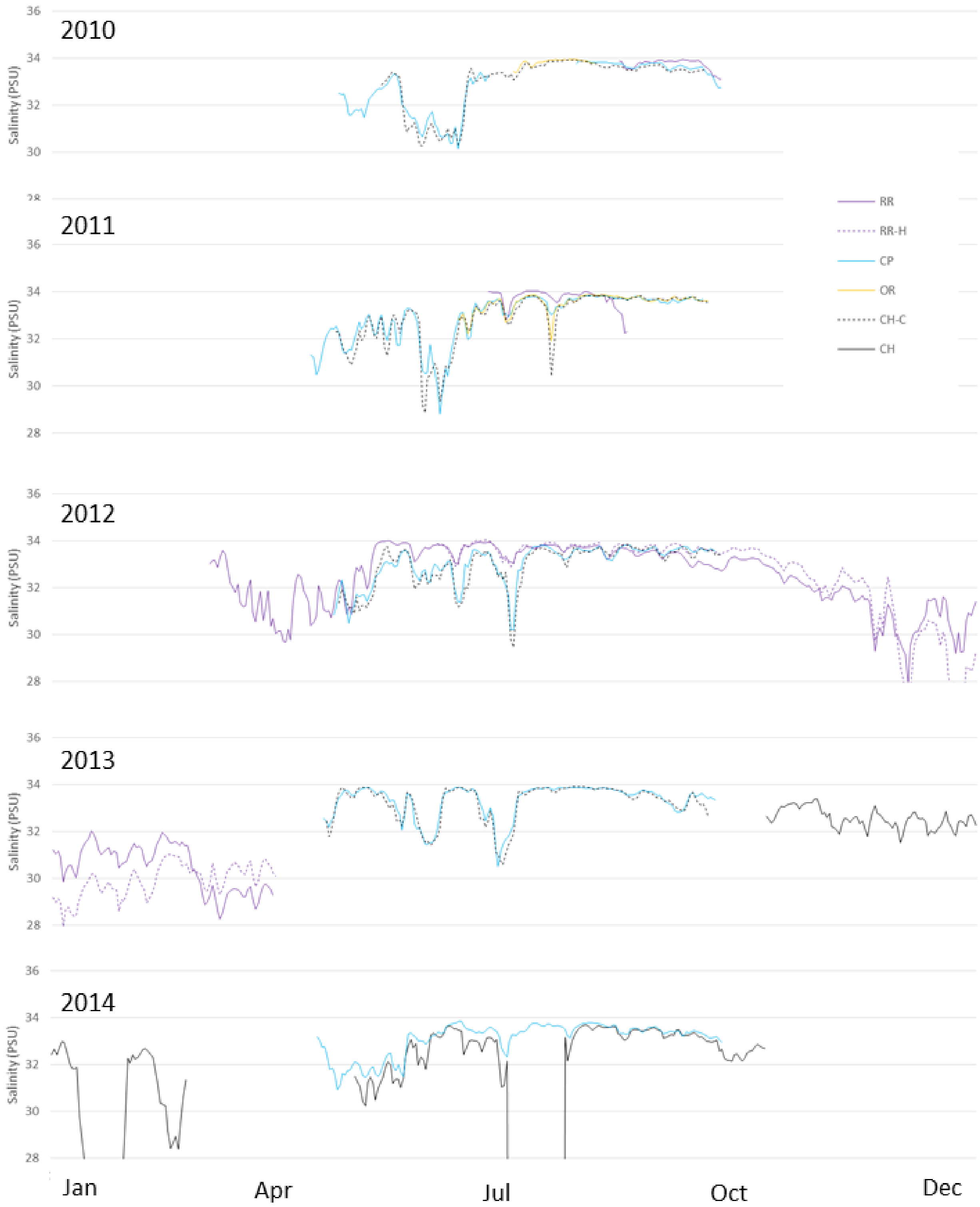


Figure 5B: Salinity data collected from six sites across the Oregon coast as available. Salinity taken from moorings at 13-20 m water depth. CH-C and CP are collected by PISCO, all other data collected by ODFW. Only the CP mooring was in place from 2015-17 so data are not displayed.

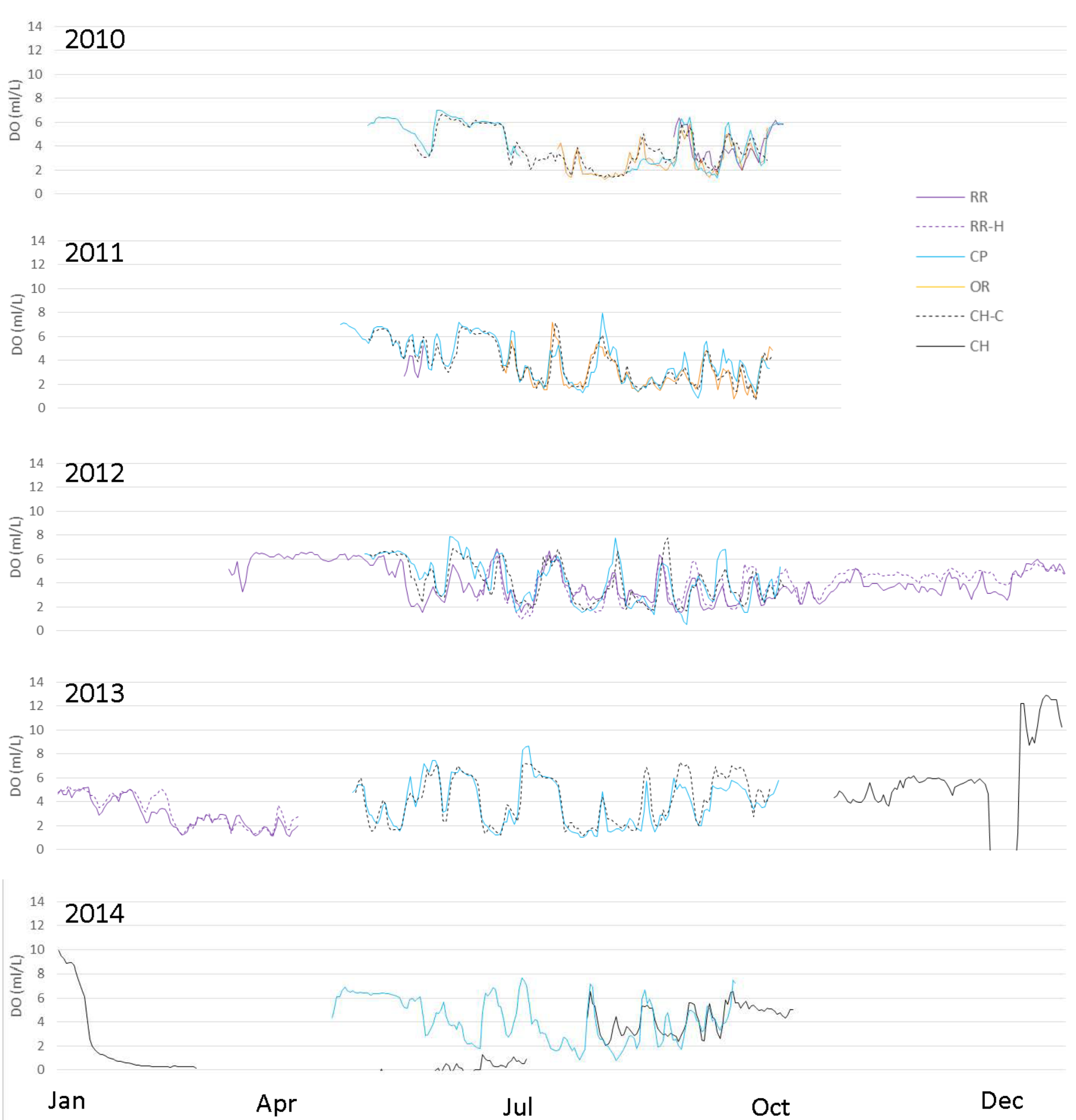


Figure 5C: Dissolved oxygen data collected from six sites across the Oregon coast as available. Dissolved oxygen taken from moorings at 13-20 m water depth. CH-C and CP are collected by PISCO, all other data collected by ODFW. Only the CP mooring was in place from 2015-17 so data are not displayed. We believe the data from late 2013 – July 2014 for the Cascade Head site should be removed.

Habitat

We are currently describing and characterizing the habitats in Oregon's Marine Reserves. Therefore we cannot evaluate whether habitat patterns are consistent throughout Oregon's Marine Reserves.

Invertebrates

We are currently describing and characterizing the invertebrates in Oregon's Marine Reserves. Therefore we cannot evaluate whether invertebrate patterns are consistent throughout Oregon's Marine Reserves.

Fish

We are currently describing and characterizing the fish communities in Oregon's Marine Reserves. Therefore we cannot evaluate whether fish patterns are consistent throughout Oregon's Marine Reserves. We can comment on juvenile fish research from the two reserves where this research occurs; a comparison of what we've learned is listed below.

Juvenile Fish Research

In total, 8,608 fishes were collected over the first 6 yrs of this research (Table 5A).

Table 5A. Fish recruits collected between 2012 and 2017 in northern and southern Oregon. Boccacio (*Sebastes paucispinus*), and tiger (*S. nigrocinctus*) rockfishes, kelp greenling (*Hexagrammos decagrammus*), slimy snailfish (*Liparis mucosus*). Species complex: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes. UnID contains rockfishes, snailfishes (*Liparis* spp.), and gobies (*Gobiesox* spp.) that could not be identified to species or species complex

		2012	2013	2014	2015	2016	2017
Northern Oregon	*Scorpaenichthys marmoratus*	24	127	65	241	267	46
	OYTB	1	16	125	13	279	90
	QGBCC	116	52	2	203	668	9
	RS	32	552	1	364	37	0
	Sebastes nigrocinctus	11	10	6	188	97	1
	Sebastes paucispinis	0	0	0	1	1	2
	Hexagrammos decagrammus	0	3	0	1	2	11
	Liparis mucosus	6	1	1	0	1	33
	UnID	5	4	2	2	8	21
	Total	**195**	**765**	**202**	**1,013**	**1,360**	**213**
Southern Oregon	*Scorpaenichthys marmoratus*			232	606	220	45
	OYTB			191	16	722	528
	QGBCC			18	256	305	16
	RS			0	878	542	1
	Sebastes nigrocinctus			0	27	110	0
	Sebastes paucispinis			0	18	1	1
	Hexagrammos decagrammus			10	27	23	10
	Liparis mucosus			1	6	1	1
	UnID			1	3	19	25
	Total			**453**	**1,837**	**1,943**	**627**

The five most abundant fish taxa sampled exhibit different settlement patterns across the settlement seasons (Fig. 5D).

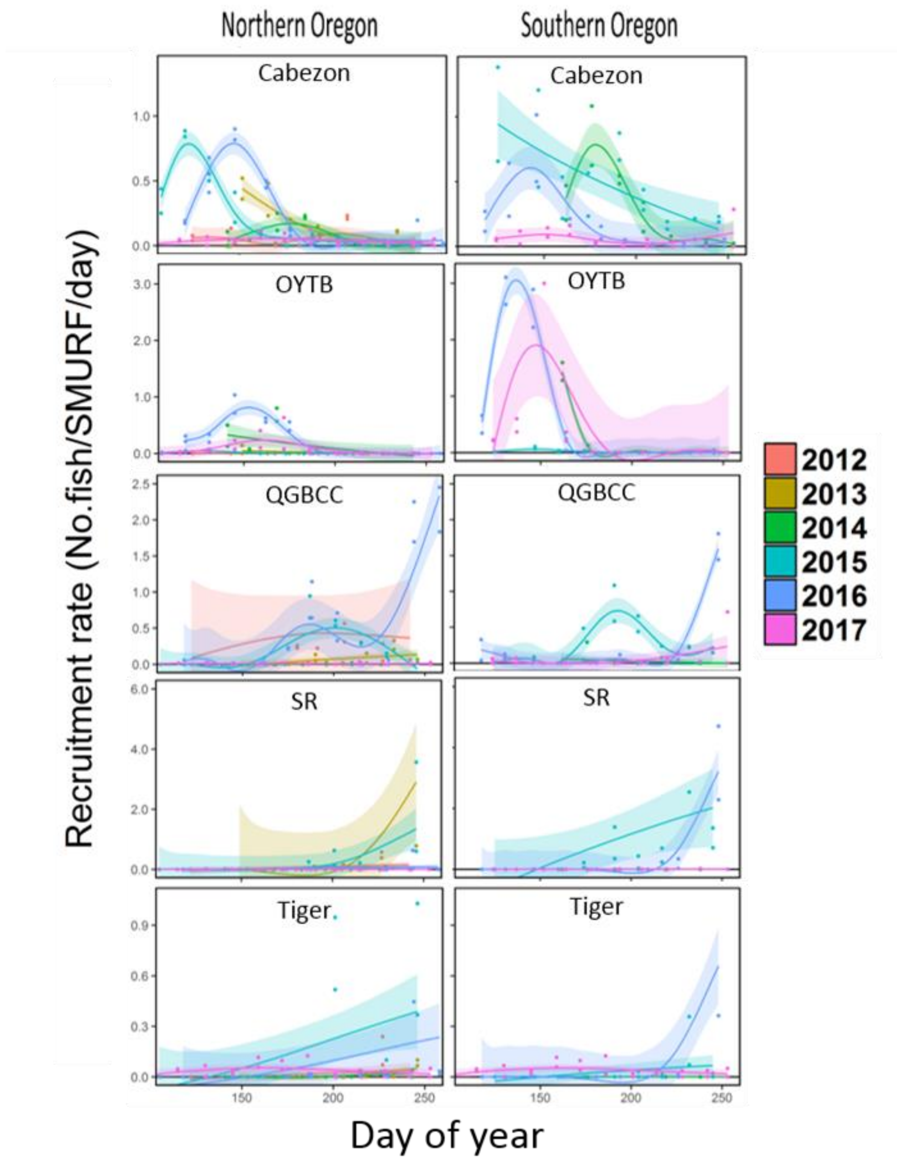


Fig. 5D Recruitment (settlement) of five fish taxa to northern and southern Oregon nearshore habitats during the settlement season (spring and summer) of 2012-2017. Settlement rate (N fish $SMURF^{-1}$ day^{-1}) was averaged over all the replicate SMURFs within each site (two sites per region). Data are available from 2014-2017 for southern Oregon, since sampling began in 2014. Shading indicates the 95% CI. Note different scales for the y-axis. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.

Cabezon settled throughout the season, but peaked between late April and late June. The highest settlement of OYTB occurred between May and early June, with very low numbers settling afterwards. Settlement of QGBCC peaked between June and August for most years, but there were additional early and late-season settlement pulses in 2016. In years where SR and tiger rockfish are abundant, these species tend to settle later in the settlement season, starting in July and increasing towards September, possibly peaking beyond the sampling season.

With the exception of cabezon, settlement of most sampled taxa has been highly variable across years (GLMM, $P < 0.05$), with annual means ranging 0-1.5 fish SMURF-1 day-1 in some taxa (Fig. 5E). Settlement rates have not differed significantly between the two regions for OYTB, QGBCC, and SR (GLMM, $P > 0.05$). However, cabezon have a significantly higher settlement rate in southern Oregon than in northern Oregon, while tiger rockfish have the opposite pattern (GLMM, $P < 0.05$).

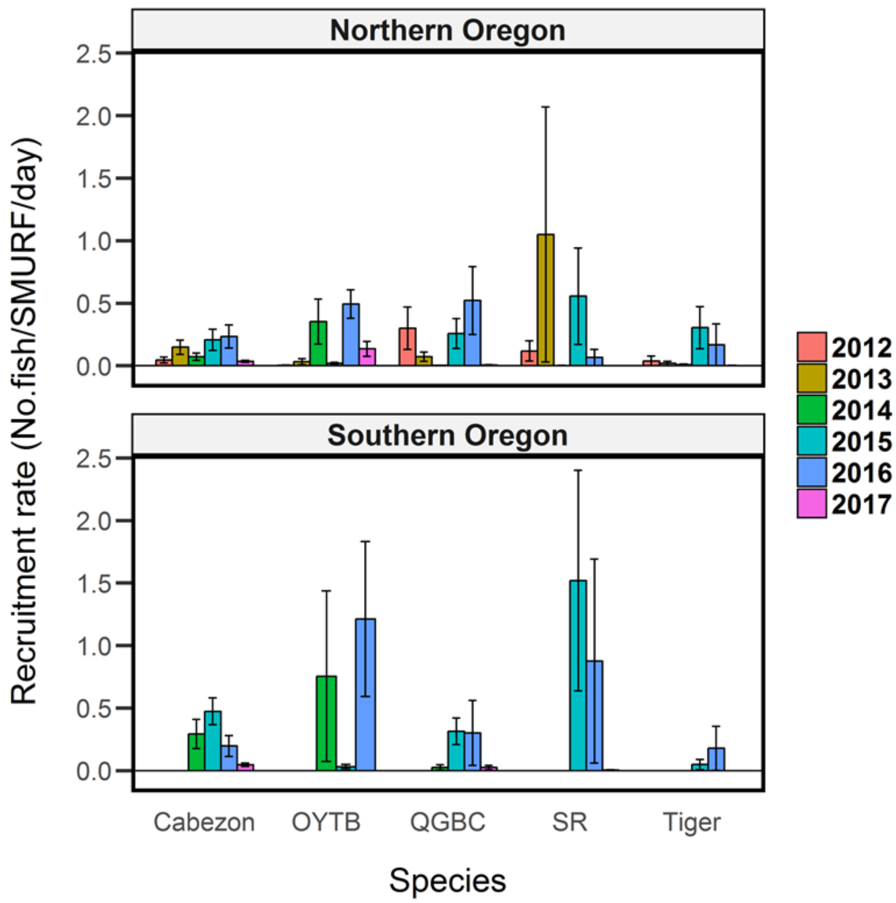


Fig. 5E Annual recruitment (settlement) of five fish taxa to northern and southern Oregon. Recruitment rate (N fish SMURF^{-1} day^{-1}) is averaged over all the replicate SMURFs within each region per year. Data are available from 2014-2017 for southern Oregon, when sampling began. Error bars indicate standard error. Number of sampling collections shown under bars. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.

Within each region, OYTB exhibit greater settlement to marine reserves than to unprotected comparison areas (Fig. F; GLMM, P < 0.05). Cabezon exhibit the opposite trend, but only in southern Oregon, with greater settlement to the unprotected area than to the marine reserve. Settlement of the remaining taxa has not differed significantly between reserves and non-reserve areas (GLMM, P > 0.05).

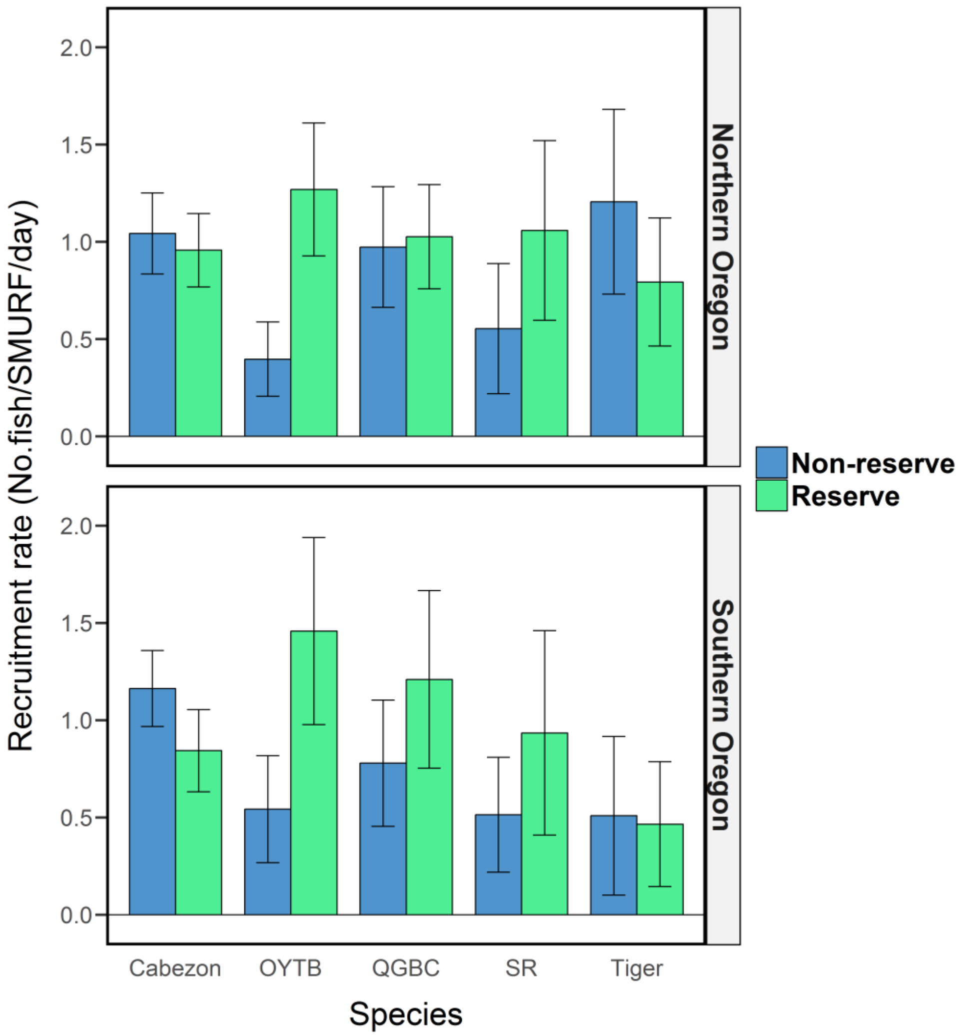


Fig. 5F Recruitment (settlement) rate of OYTB is greater in the marine reserves (green) of both regions over 2012-2017, while settlement of cabezon is greater in the non-reserve (blue) of southern Oregon. Settlement rate (N fish SMURF^{-1} day^{-1}) was averaged over all the replicate SMURFs within site and normalized by the annual mean settlement from each region to account for the year random effect. Error bars indicate standard error. Number of sampling collections shown under bars. Species complexes: OYTB = olive (*S. serranoides*), yellowtail (*S. fllavidus*), and black rockfishes (*S. melanops*); QGBCC = quillback (*S. maliger*), gopher (*S. carnatus*), black-and-yellow (*S. Chrysomelas*), copper (*S. caurinus*), and china rockfishes (*S. nebulosus*); SR = splitnose (*S. diploproa*) and redbanded (*S. babcocki*) rockfishes.

Species-Habitat Correlations

We are currently describing the habitat, invertebrate and fish communities in Oregon's Marine Reserves. Therefore we cannot evaluate whether species-habitat correlations are consistent throughout Oregon's Marine Reserves.

Prohibition of Human Activities & Changes in Community Structure

We are currently describing the species assemblages from our monitoring data along with those from fisheries dependent data. Therefore we cannot evaluate whether prohibiting human activities has led to similar changes in the structure of these communities across Oregon's Marine Reserves.

Section 5

Research Question 5: Does the prohibition of extractive activities change the community structure of the reserve?

Limited staff capacity has prevented us from summarizing available data for this report.

Species-Habitat Correlations

The ODFW's ecological monitoring program is tasked with understanding the species-habitat correlations at each site and how they change over time. Understanding the species-habitat correlations at each site requires a strong understanding of the species and habitats in Oregon's Marine Reserves. We are still learning about the species and habitats in Oregon's Marine Reserves, and therefore, are in the early stages of understanding species-habitat correlations. The available data are from the ROV, which describes the habitats where fish were observed in Redfish Rocks, Cascade Head and Cape Perpetua (Table 5.1). These data are being used to explore habitat suitability models in Oregon's Marine Reserves in collaboration with the ODFW Marine Habitat Program. For example, one project focusing on the Redfish Rocks area uses ROV data to identify bathymetric habitat variables associated with fish presence and create statistical models describing suitable habitat for several groundfish species including Kelp Greenling and China rockfish. However results are being developed and thus not reported here. A second area of exploration for species habitat correlations, also focused in the Redfish Rocks region, links longline data with bathymetric habitat maps to explore species habitat models for Cabezon. This work is an on-going collaboration with an OSU graduate student, and results will be reported at a later date.

Table 5.1: Available data describing fish-habitat associations from ROV surveys for three of Oregon's Marine Reserves.

	Years available
Redfish Rocks Marine Reserve	2010, 2016
Cascade Head Marine Reserve	2012, 2013, 2017
Cape Perpetua Marine Reserve	2017

Redfish Rocks

2010

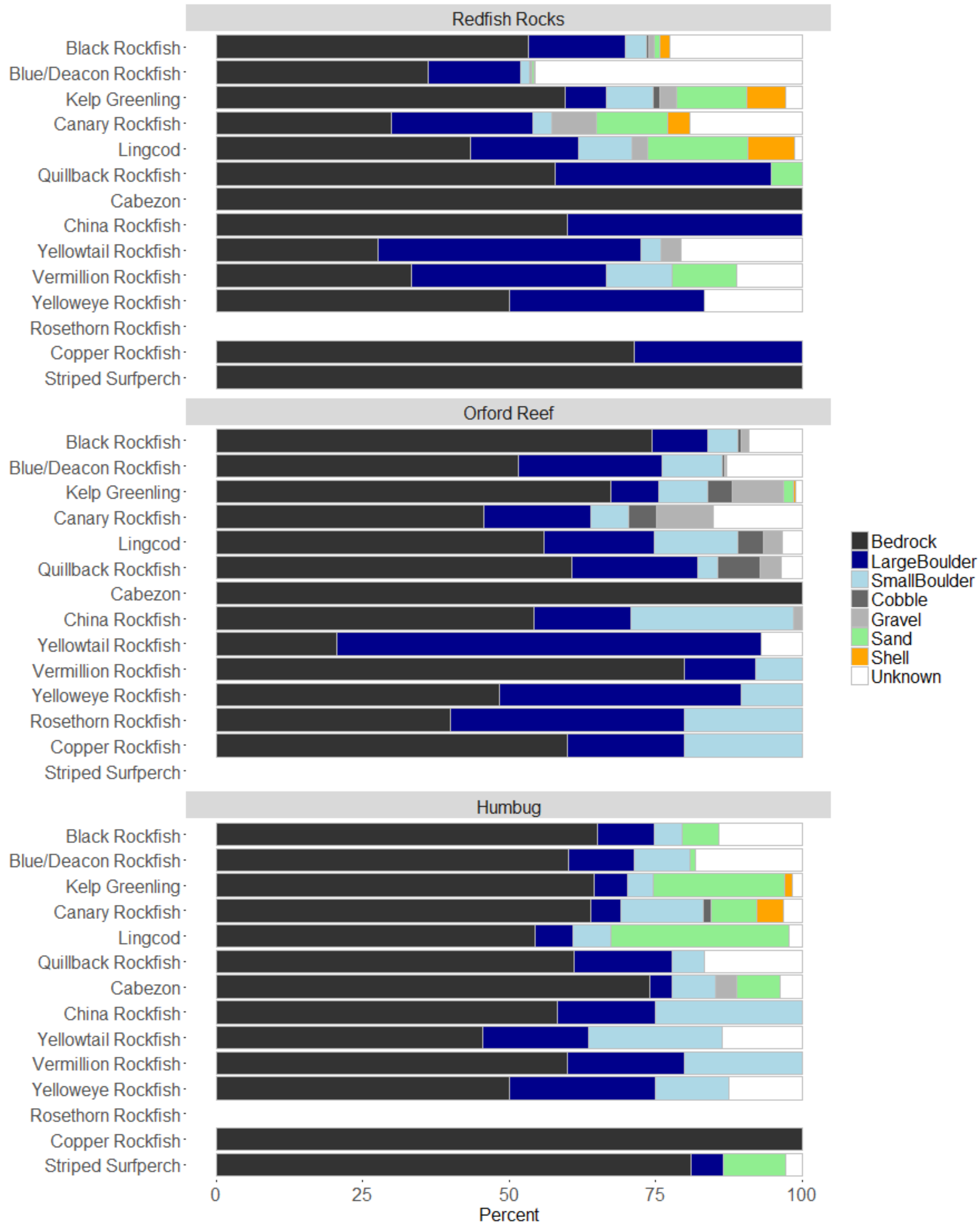


Figure 5.1: Percentage of fish observations by habitat type for the Redfish Rocks Marine Reserve, Orford Reef and Humbug Comparison Areas in 2010 from the ROV.

Table 5.2: Total number of individuals observed by the ROV for each species for the Redfish Rocks Marine Reserve, Orford Reef and Humbug Comparison Areas in 2010.

Species	Redfish Rocks	Orford Reef	Humbug	Total
Blue/Deacon Rockfish	1,809	1,712	1,036	4,557
Black Rockfish	930	211	1,004	2,145
Kelp Greenling	629	716	668	2,013
Canary Rockfish	157	125	155	437
Lingcod	76	91	138	305
China Rockfish	10	72	12	94
Yellowtail Rockfish	29	29	22	80
Quillback Rockfish	19	28	18	65
Yelloweye Rockfish	6	29	8	43
Vermillion Rockfish	9	25	5	39
Striped Surfperch	1	0	37	38
Cabezon	3	6	27	36
Rosethorn Rockfish	0	35	0	35
Copper Rockfish	7	5	3	15

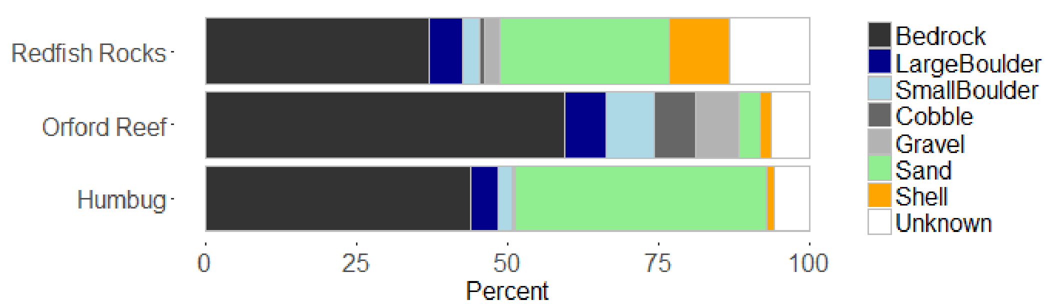


Figure 5.2: Primary Habitat relative frequency from the 2010 ROV substrate data in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data summarize the substrate covered by all transects in each location.

During 2010 in the Redfish Rocks Marine Reserve, approximately half the fish species were observed on hard substrates only, and half the fish were observed on both hard and soft bottom substrates (Figure 5.1; 5.2). All species were observed in some percentage on/over bedrock, and all with the exception of Cabezon and striped surf perch both with low numbers of observations (Table 5.2), were observed over large boulders. Seven species (Striped Surfperch, Copper, China, Black, Quillback Rockfishes, Cabezon, and Kelp Greenling) were all observed > 50% of the time over bedrock. Yellowtail rockfish appear to be using large boulder habitats in a higher percentage than the relative frequency of this habitat in transects surveyed. Only Lingcod, Canary Rockfish, Kelp Greenling and Black Rockfish were observed over shell. Kelp Greenling were observed over the most diverse number of substrates (7), whereas Cabezon and Striped Surfperch were observed over the least number of substrates (1). However Kelp Greenling had larger numbers of observations than both Cabezon and Striped Surfperch (Table 5.2).

Within the Orford Reef Comparison Area, all fish except Blue/Deacon Rockfish and Kelp Greenling were only observed on hard substrates (Figure 5.1; 5.2). Blue/Deacon Rockfish and Kelp Greenling were observed over soft bottom habitats. However, Yellowtail rockfish appear to be using large boulder habitats in a higher percentage than the relative frequency of this habitat in transects surveyed. Black, China, Copper, Quillback, Vermilion Rockfishes, Kelp Greenling, Lingcod, and Cabezon were all observed > 50% of the time over bedrock. Kelp Greenling were observed over the most diverse number of substrates (7) where as Cabezon were observed over the least number of substrates (1). However Kelp Greenling had larger numbers of observations than Cabezon (Table 5.2).

Within the Humbug Comparison Area, 6 fish species were observed only on hard substrates and 7 species were observed on both hard and soft bottom substrates (Figure 5.1; 5.2). All species except Yellowtail Rockfish were observed > 50% of the time over bedrock. Yellowtail rockfish appear to be using large boulder habitats in a higher percentage than the relative frequency of this habitat in transects surveyed, but observations are relatively low (Table 5.2). Only Kelp Greenling and Canary Rockfish were observed over sand and only Cabezon was observed partly over gravel. Canary Rockfish were observed over the most diverse number of substrates (6) whereas Copper Rockfish were observed over the least number of substrates (1). However Canary had larger numbers of observations than Copper Rockfishes (Table 5.2).

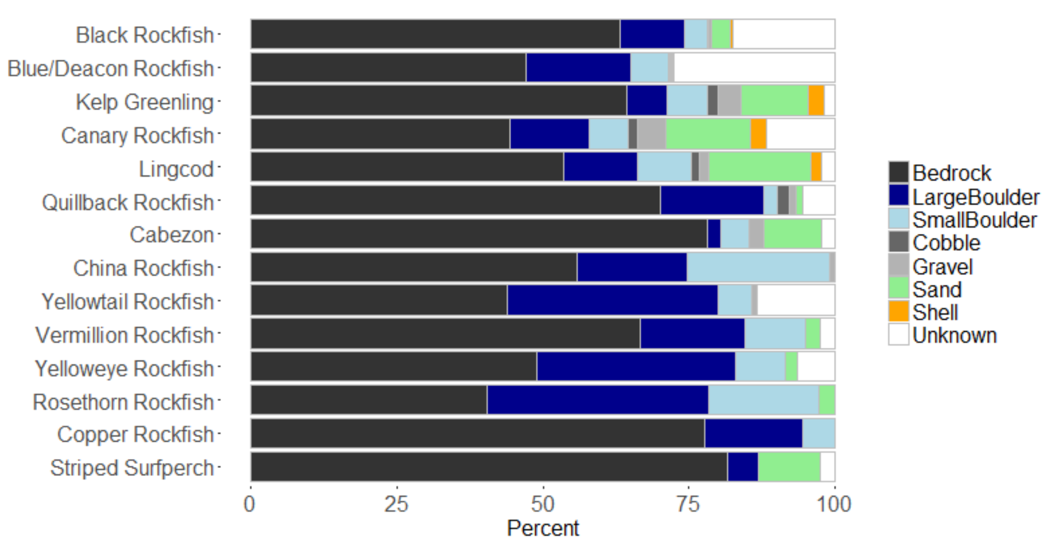


Figure 5.3: Percentage of fish observations by habitat type for the Redfish Rocks Region in 2010 from the ROV.

Combining observations for all sites, 13 of 14 species were observed on both hard and soft bottom habitats; only Copper Rockfish (with low numbers of observations) were exclusively found on hard substrates. (Figures 5.3, 5.4; Table 5.2). However, the majority of fish observations for all species occurred over hard bottom substrates (Figure 5.3). All species were observed in some percentage over bedrock and large boulder. Nine species (Striped Surfperch, Black, Copper, Vermilion, China, Quillback Rockfishes, Cabezon, Lingcod and Kelp Greenling) were observed > 50% of the time over bedrock. Yellowtail Rockfish appear to be using large boulder habitats in a higher percentage than the relative frequency of this habitat in transects surveyed. Only four species (China, Yellowtail, Copper and Blue/Deacon Rockfishes) were never observed over sand. All species but Striped Surfperch were also observed over small boulders. Lingcod, Canary Rockfish and Kelp Greenling were observed over the most diverse number of substrates (7), whereas Copper Rockfish and Striped Surfperch were observed over the least number of substrates (3).

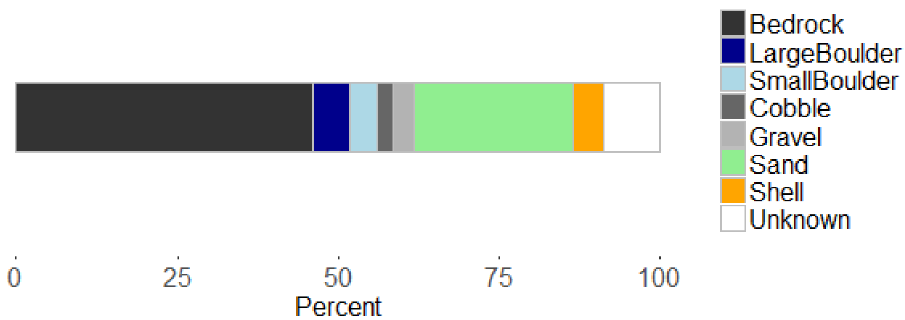


Figure 5.4: Relative frequency of each primary habitat observed in ROV transects at the Redfish Rocks region, in 2010, shown as percent of total linear transect distance. The region includes the Redfish Rocks Marine Reserve, Orford Reef Comparison Area and Humbug Comparison Area.

2016

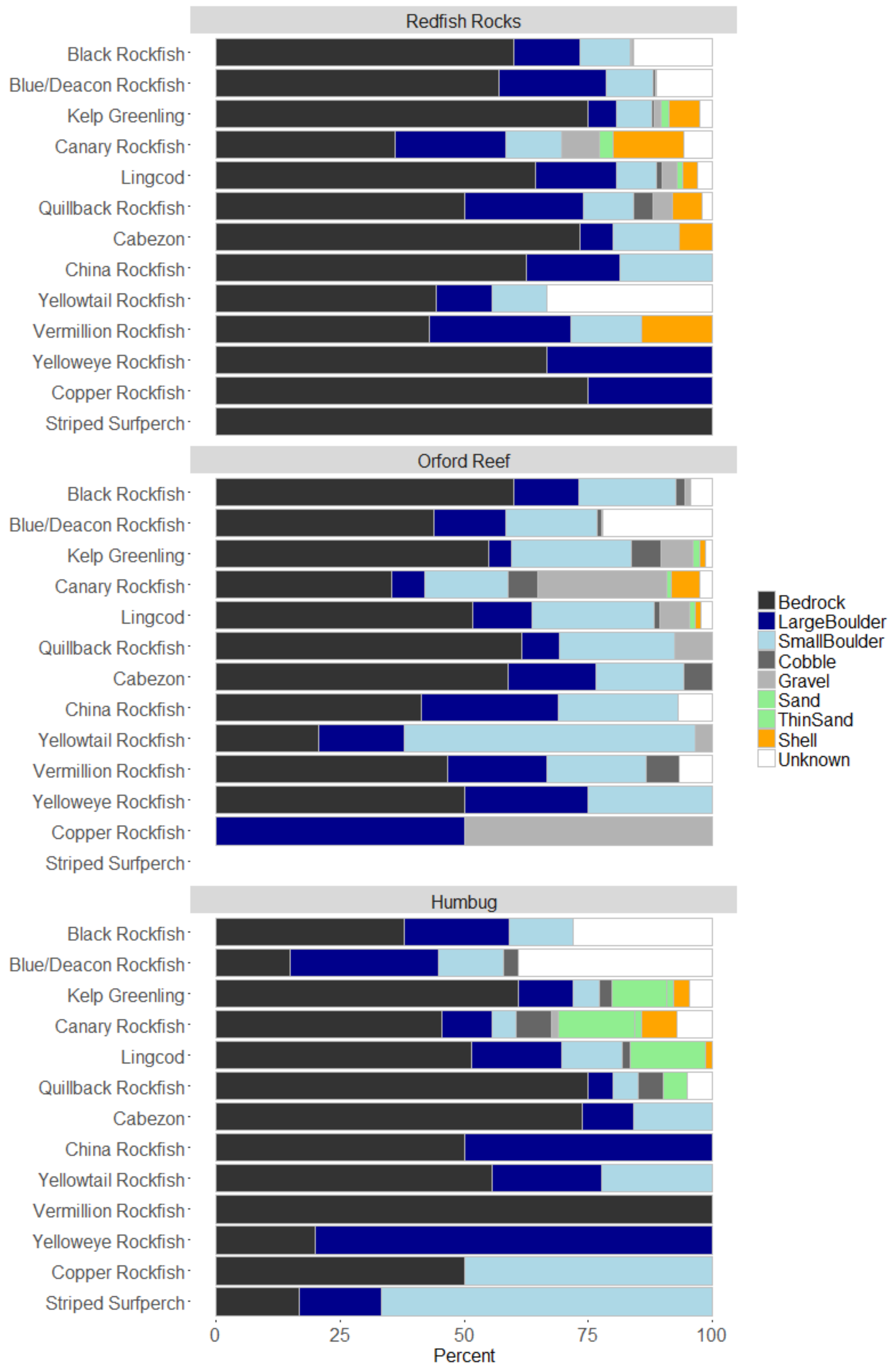


Figure 5.5: Percentage of fish observations by habitat type for the Redfish Rocks Marine Reserve, Orford Reef and Humbug Comparison Areas in 2016 from the ROV.

Table 5.3: Total number of individuals observed by the ROV for each species for the Redfish Rocks Marine Reserve, Orford Reef and Humbug Comparison Areas in 2016.

Species	Redfish Rocks	Orford Reef	Humbug	Total
Blue/Deacon Rockfish	378	994	268	1,640
Black Rockfish	676	294	349	1,319
Kelp Greenling	263	202	153	618
Canary Rockfish	194	119	167	480
Lingcod	98	85	66	249
Quillback Rockfish	50	26	20	96
Cabezon	15	17	19	51
China Rockfish	16	29	2	47
Yellowtail Rockfish	9	29	9	47
Vermillion Rockfish	7	15	2	24
Yelloweye Rockfish	3	12	5	20
Copper Rockfish	8	2	2	12
Striped Surfperch	2	0	6	8

In the 2016 ROV survey, 7 fish species were observed only on hard substrates and 6 species were observed on both hard and soft bottom substrates (Figures 5.5; 5.6) in the Redfish Rocks Marine Reserve. All species were observed with bedrock, and all except Striped Surfperch (with low sample size) were observed over large boulder (Figure 5.5, Table 5.3). Nine species were observed > 50% of the time over bedrock. Only Lingcod, Canary Rockfish, Kelp Greenling were observed over sand. Kelp Greenling and Lingcod were observed over the most diverse number of substrates (7), whereas Striped Surfperch were observed over the least number of substrates (1). However Kelp Greenling had larger numbers of observations than Striped Surfperch (Table 5.3).

In the Orford Reef Comparison Area, all species except Kelp Greenling, Canary Rockfish and Lingcod were observed only on hard substrates (Figure 5.5). Three species were observed over soft bottom habitats of sand and shell. This is relatively similar to the relative frequency of hard and soft bottom substrates surveyed in this area (Figure 5.6). Black, Quillback Rockfishes, Kelp Greenling, and Cabezon were all observed > 50% of the time over bedrock (Figure 5.5). All species were associated to some degree with large boulder. Copper Rockfish was the only species never observed over bedrock, but also had low numbers of observations (Table 5.3). Kelp Greenling, Canary Rockfish, and Lingcod were observed over the most diverse number of substrates (7) whereas Copper Rockfish (with low observations) were observed over the least number of substrates (2).

In the Humbug Comparison Area, 9 fish species were observed only on hard substrates and 4 fish species were observed on both hard and soft bottom substrates (Figure 5.5; 5.6). Six species were observed > 50% of the time over bedrock. Only four species were observed over sand and three species were observed over shell. Canary Rockfish were observed over the most diverse number of substrates (7) whereas Vermilion Rockfish (with low observations) were observed over the least number of substrates (1).

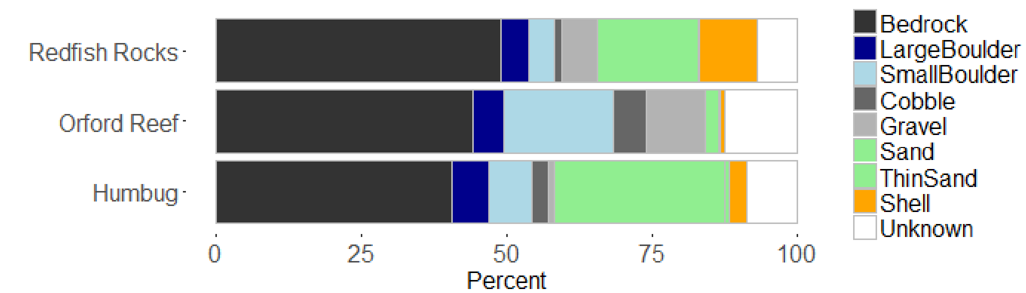


Figure 5.6: Primary Habitat relative frequency from the 2016 ROV substrate data in the Redfish Rocks Marine Reserve, and Orford and Humbug Comparison Areas. Data summarize the substrate covered by all transects in each location.

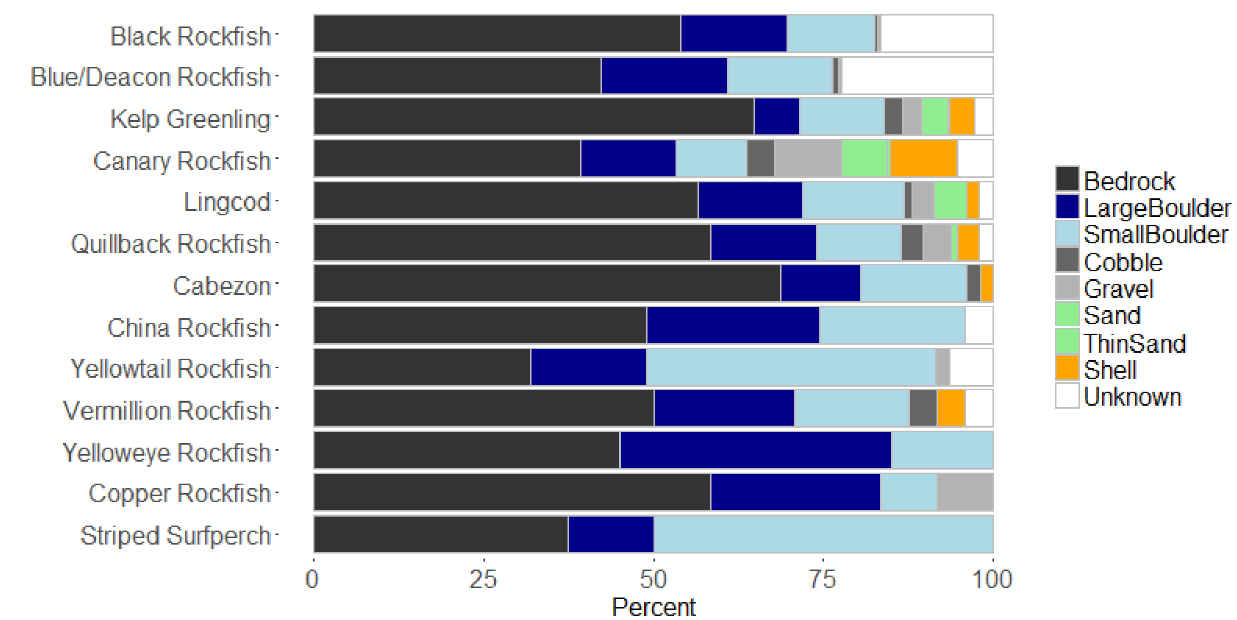


Figure 5.7: Percentage of fish observations by habitat type for all areas including the Redfish Rocks Marine Reserve, Orford Reef and Humbug Comparison Areas in 2016 from the ROV.

When considering all sites, six species were observed on both hard and soft bottom habitats (Figure 5.7). However, the majority of observations for all species had more than 75% of observations over hard bottom substrates (Figure 5.7). All species were observed in some percentage with bedrock, large and small boulder. Six species (Black, Copper, Quillback Rockfishes, Kelp Greenling, Lingcod, and Cabezon) were observed > 50% of the time over bedrock. Only four species (Kelp Greenling, Canary, Quillback Rockfishes, and Lingcod) were observed over sand. Kelp Greenling, Canary, Quillback Rockfishes, and Lingcod were observed over the most diverse number of substrates (7), whereas China, Yelloweye Rockfishes and Striped Surfperch were observed over the least number of substrates (3). However this may be associated with low numbers of observations for China, Yelloweye Rockfishes and Striped Surfperch (Table 5.3).

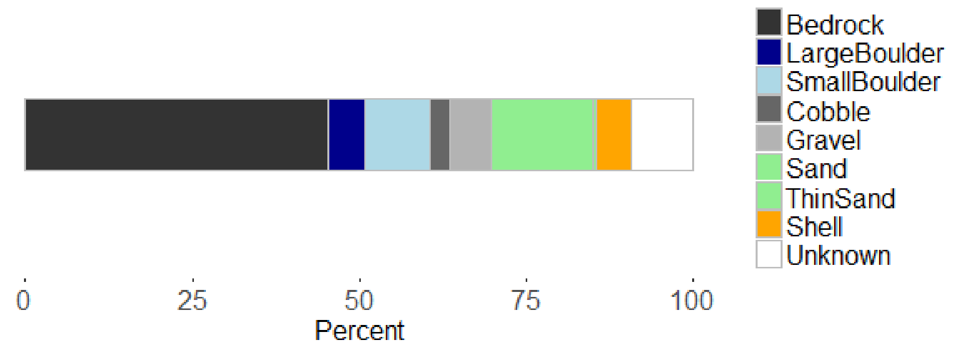


Figure 5.8: Relative frequency of each primary habitat observed in ROV transects at the Redfish Rocks Marine Reserve site, in 2016, shown as percent of total linear transect distance. The Redfish Rocks Marine Reserve site includes the Redfish Rocks Marine Reserve, Orford Reef Comparison Area and Humbug Comparison Area.

Cascade Head

2012

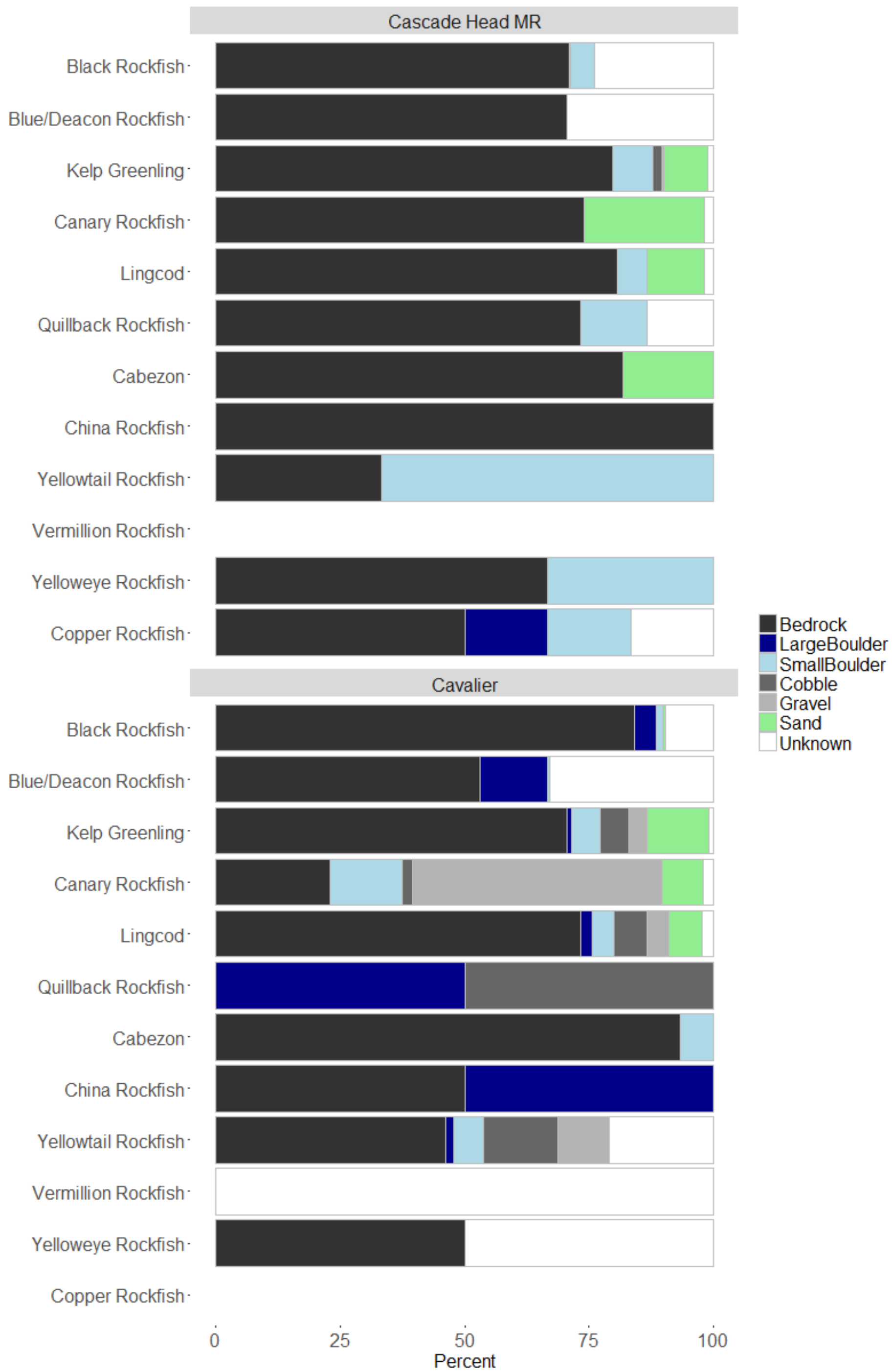


Figure 5.9: Percentage of fish observations by habitat type for the Cascade Head Marine Reserve and Cavalier Comparison Areas in 2012 from the ROV.

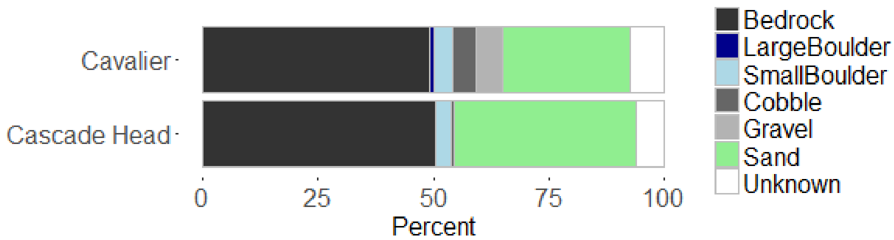


Figure 5.10: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve and Cavalier Comparison Area in 2012, shown as percent of total linear transect distance.

Table 5.4: Total number of individuals observed by the ROV for each species for the Cascade Head Marine Reserve and Cavalier Comparison Areas in 2012.

Species	Cascade Head MR	Cavalier	Total
Black Rockfish	445	448	893
Blue/Deacon Rockfish	228	462	690
Kelp Greenling	172	105	277
Canary Rockfish	54	48	102
Lingcod	52	45	97
Yellowtail Rockfish	12	67	79
Cabezon	11	15	26
Quillback Rockfish	15	2	17
Copper Rockfish	6	0	6
Yelloweye Rockfish	3	2	5
China Rockfish	1	2	3
Vermillion Rockfish	0	1	1

In 2012, in the Cascade Head Marine Reserve, 7 species were observed over hard substrates only, consisting mostly of bedrock (Figures 5.9; 5.10). All species were observed in some percentage with bedrock, but only Kelp Greenling, Canary Rockfish, Lingcod and Cabezon were observed over sand. Kelp Greenling were observed over the most diverse number of substrates (5), whereas China and Blue/Deacon Rockfishes were observed over the least number of substrates (1). This does not appear to be related to number of observations (Table 5.4).

In the Cavalier Comparison Area, the majority of fish species (7) were observed only on hard substrates (Figures 5.9; 5.10). Only three species were observed over hard and soft sand bottom habitats. Four species (Black Rockfish, Kelp Greenling, Lingcod, and Cabezon) were all observed > 50% of the time over bedrock. Most species were associated to some degree with large boulder, small boulder or both substrate types. Quillback Rockfish was the only species never observed over bedrock but it only had two observations (Table 5.4). Kelp Greenling and Lingcod (higher numbers of observations) were observed over the most diverse number of substrates (7) whereas Yelloweye Rockfish (low numbers of observations) were observed over the least number of substrates (1) (Table 5.4).

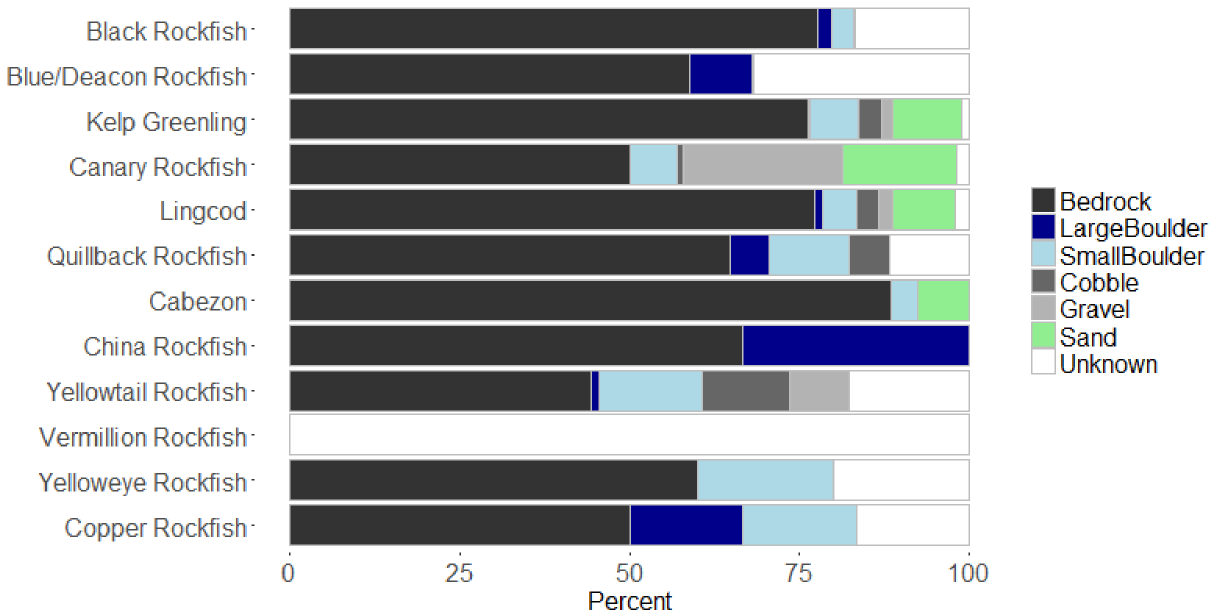


Figure 5.11: Percentage of fish observations by habitat type for all areas surveyed in 2012 combined, including the Cascade Head Marine Reserve and Cavalier Comparison Area.

Considering all sites in 2012, the majority of fish species (7) were observed on hard bottom substrates only (Figure 5.11). Only four species were observed on both hard and soft bottom habitats (Figure 5.11). All species (except Vermillion Rockfish) were observed in some percentage of bedrock. Eight species were observed > 50% of the time over bedrock. Only four species (Kelp Greenling, Canary Rockfish, Lingcod and Cabezon) were observed over sand. Lingcod were observed over the most diverse number of substrates (6), whereas Blue/Deacon Rockfish, Yelloweye Rockfish, and China Rockfish were observed over the least number of substrates (2). This does not appear to be related to number of observations (Table 5.4).

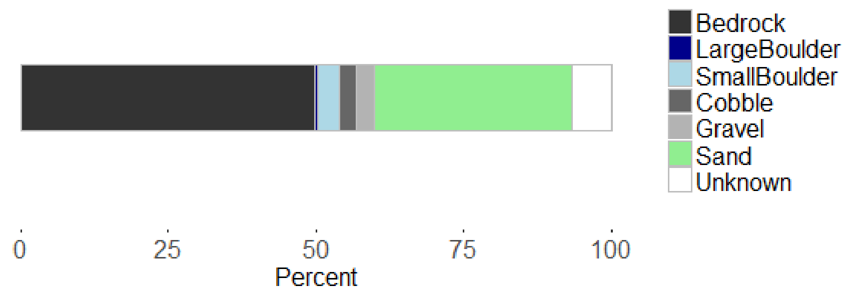


Figure 5.12: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve site, in 2012, shown as percent of total linear transect distance. The Cascade Head Marine Reserve site in 2012 included the Cascade Head Marine Reserve, and Cavalier Comparison Area.

2013

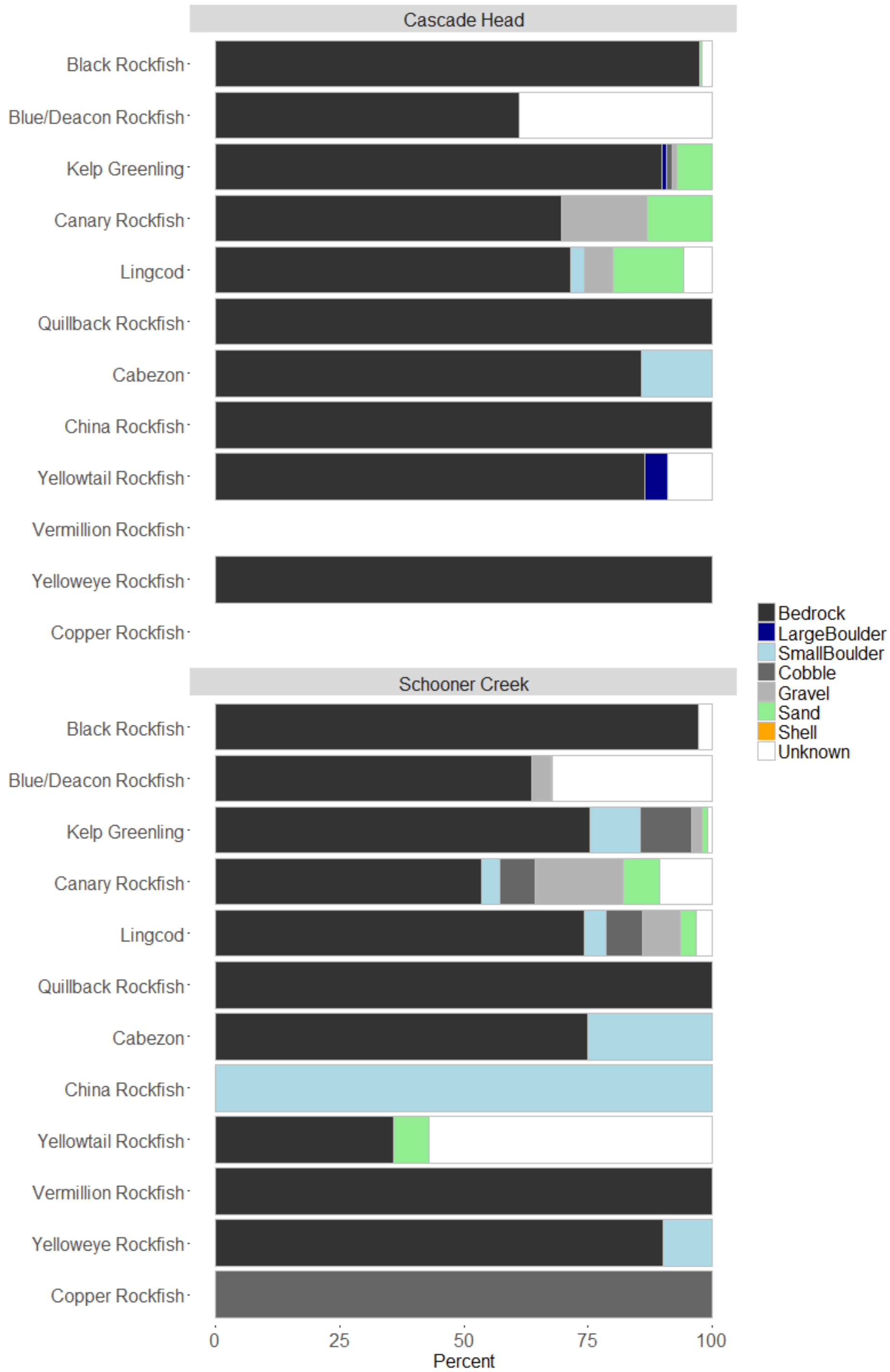


Figure 5.13: Percentage of fish observations by habitat type for the Cascade Head Marine Reserve and Schooner Creek Comparison Areas in 2013 from the ROV.

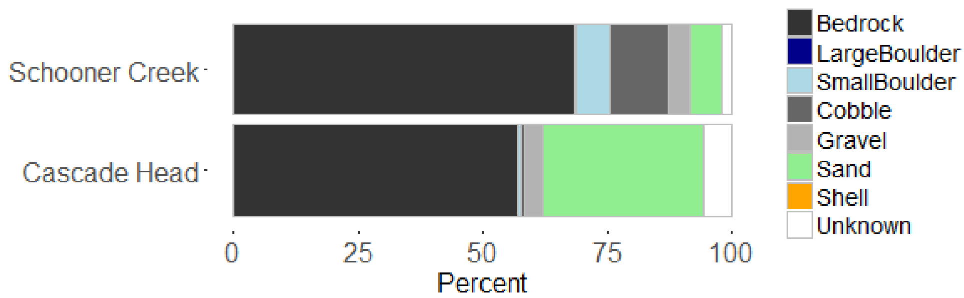


Figure 5.14: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve and Schooner Creek Comparison Area in 2013, shown as percent of total transect duration.

Table 5.5: Total number of individuals observed by the ROV for each species for the Cascade Head Marine Reserve and Cavalier Comparison Areas in 2013.

Species	Cascade Head	Schooner Creek	Total
Black Rockfish	395	104	499
Blue/Deacon Rockfish	49	320	369
Kelp Greenling	98	97	195
Lingcod	35	93	128
Canary Rockfish	23	28	51
Yellowtail Rockfish	22	14	36
Yelloweye Rockfish	1	10	11
Cabezon	7	4	11
Quillback Rockfish	5	5	10
China Rockfish	1	1	2
Copper Rockfish	0	1	1
Vermillion Rockfish	0	1	1

In 2013 in the Cascade Head Marine Reserve, the majority of fish species (10) were observed over hard substrates only, consisting mostly of bedrock (Figures 5.13; 5.14). All species were observed > 50% over bedrock, but only Kelp Greenling, Canary Rockfish, and Lingcod were observed over sand. Kelp Greenling were observed over the most diverse number of substrates (5), whereas Yelloweye, Quillback, China Rockfishes were observed over the least number of substrates (1). However these three species also had low numbers of observations (Table 5.5).

In the Schooner Creek Comparison Area, 75% of fish species (8) were observed only on hard substrates (Figures 5.13; 5.14). Only four species (Kelp Greenling, Canary Rockfish, Lingcod and Yellowtail Rockfish) were observed over hard and soft bottom habitats, which included only sand. Eight species were observed > 50% of the time over bedrock. Kelp Greenling, Canary Rockfish and Lingcod were observed over the most diverse number of substrates (5) whereas China, Quillback, Vermilion, and Copper Rockfishes were observed over the least number of substrates (1). However these three species also had low numbers of observations (Table 5.5).

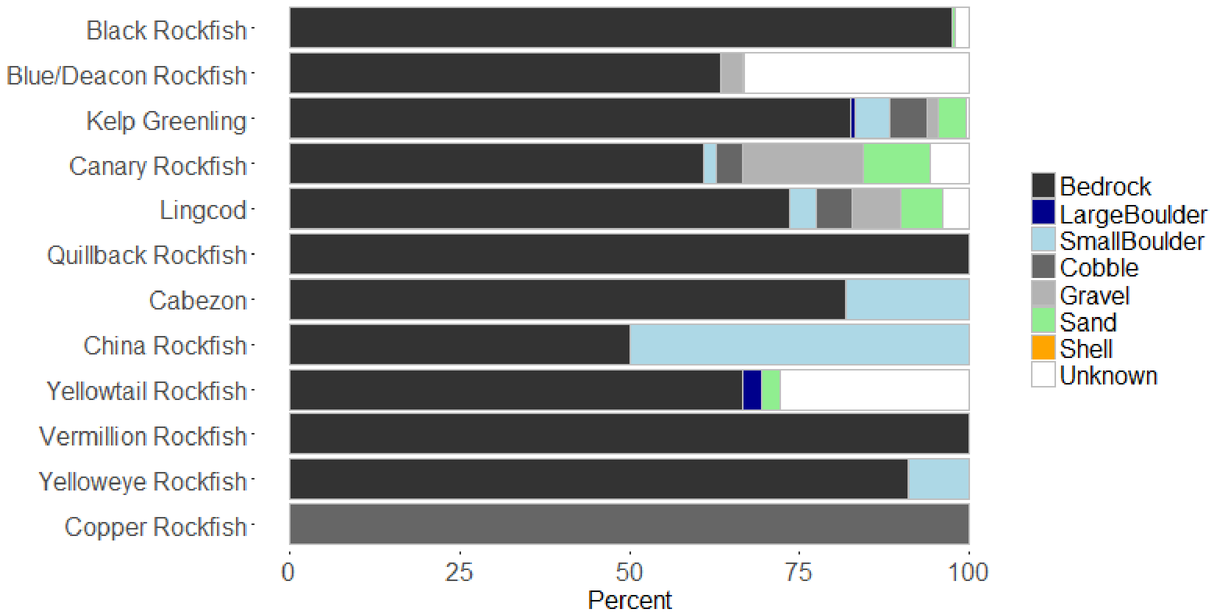


Figure 5.15: Percentage of fish observations by habitat type for all Cascade Head sites surveyed in 2013, including the Cascade Head Marine Reserve and Schooner Creek Comparison Area from the ROV.

When we consider all sites in 2013, the majority of fish species (7) were observed on hard bottom substrates only (Figure 5.15). Only five species (Black, Canary, Yellowtail Rockfishes, Kelp Greenling, and Lingcod) were observed on both hard and soft bottom habitats (Figure 5.15). All species except Copper Rockfish had the majority of observations over bedrock (Figure 5.15). Only five species (Black, Canary, Yellowtail Rockfishes, Kelp Greenling, and Lingcod) were observed over sand. Kelp Greenling were observed over the most diverse number of substrates (6), whereas Quillback, Vermilion, and Copper Rockfishes were observed over the least number of substrates (1). However these three species also had low numbers of observations (Table 5.5).

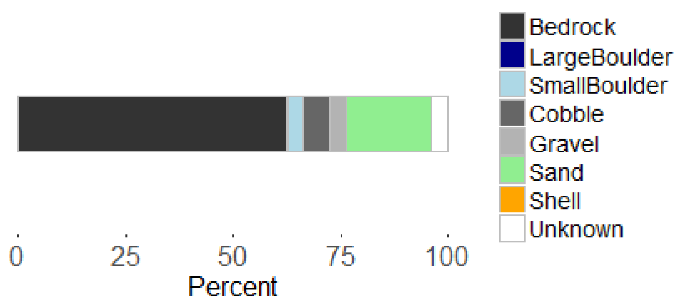


Figure 5.16: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head Marine Reserve site, in 2013, shown as percent of total transect duration. The Cascade Head Marine Reserve site in 2013 included the Cascade Head Marine Reserve, and Schooner Creek Comparison Area.

2017

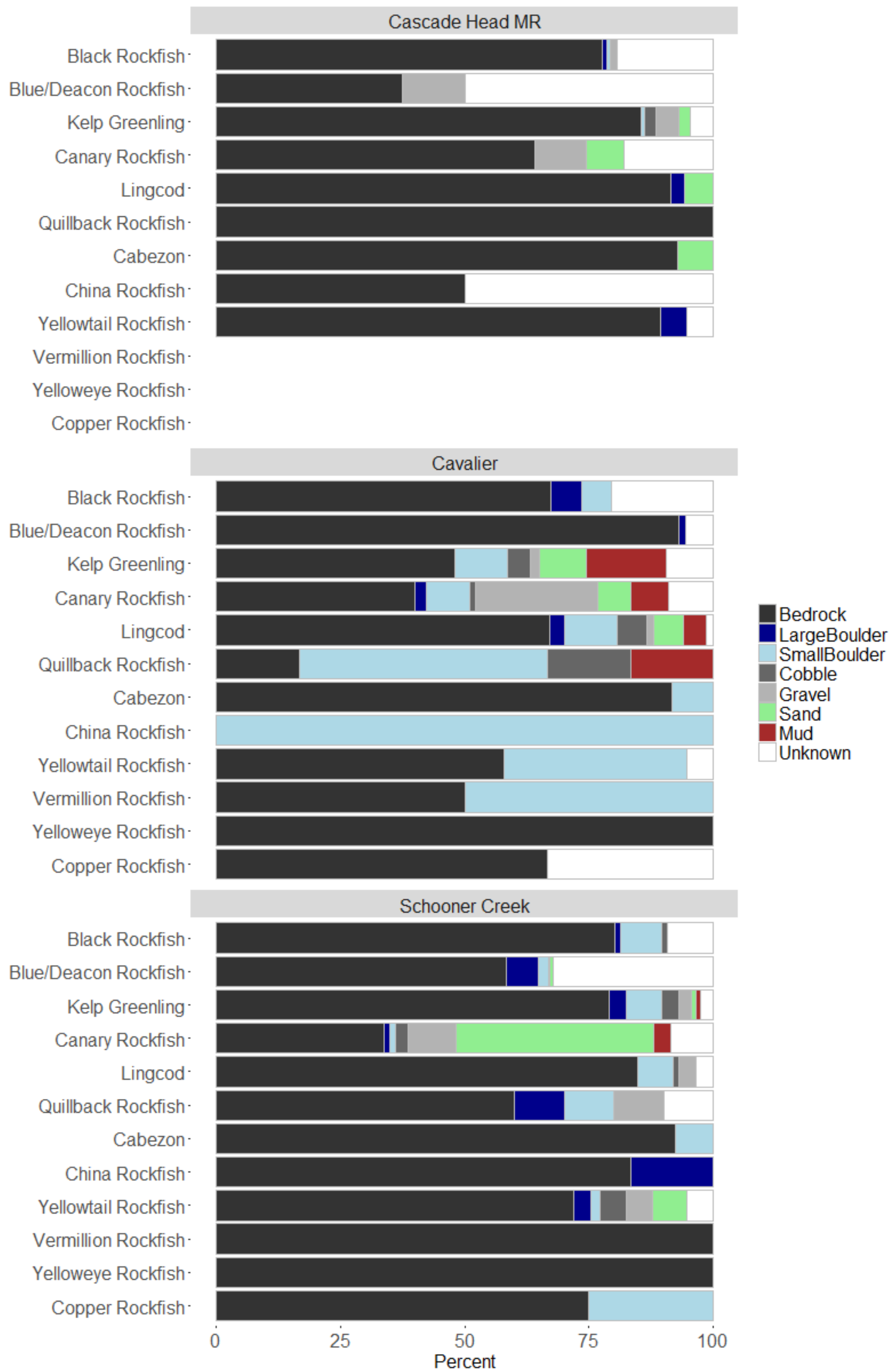


Figure 5.17: Percentage of fish observations by habitat type for the Cascade Head Marine Reserve, Schooner Creek and Cavalier Comparison Areas in 2017 from the ROV.

Table 5.6: Total number of individuals observed by the ROV for each species for the Cascade Head Marine Reserve and Cavalier Comparison Areas in 2013.

Species	Cascade Head MR	Cavalier	Schooner Creek	Total
Black Rockfish	135	299	86	520
Blue/Deacon Rockfish	8	73	313	394
Kelp Greenling	130	106	115	351
Canary Rockfish	39	90	83	212
Lingcod	35	67	86	188
Yellowtail Rockfish	19	19	57	95
Quillback Rockfish	7	6	10	23
Yelloweye Rockfish	0	1	2	3
Cabezon	14	12	13	39
Copper Rockfish	0	3	8	11
China Rockfish	2	2	6	10
Vermillion Rockfish	0	2	1	3

In 2017 in the Cascade Head Marine Reserve, the majority of fish were observed over hard substrates, consisting mostly of bedrock (Figure 5.16; 5.17). All species were observed in some percentage with bedrock, but only Kelp Greenling, Canary Rockfish, Lingcod and Cabezon were observed over sand. Kelp Greenling were observed over the most diverse number of substrates (5), whereas China Rockfish were observed over the least number of substrates (1). However China Rockfish also had low numbers of observations (Table 5.6).

In the Cavalier Comparison Area, 75% of fish species (8) were observed only on hard substrates (Figures 5.16; 5.17). Only four species were observed over hard and soft bottom habitats, which included both sand and mud. Six species (Black, Blue/Deacon, Yelloweye, Copper Rockfishes, Lingcod, and Cabezon) were all observed > 50% of the time over bedrock. Most species (9) were associated to some degree with small boulder (Figure 5.17, Table 5.6). China Rockfish was the only species never observed over bedrock. Canary Rockfish and Lingcod were observed over the most diverse number of substrates (7) whereas China, Yelloweye, Blue/Deacon, Copper Rockfishes were observed over the least number of substrates (1). For China, Yelloweye and Copper Rockfishes this may be related to low numbers of observations (Table 5.6).

In the Schooner Creek Comparison Area, six fish species were observed only on hard substrates (Figures 5.16; 5.17). All species except Canary Rockfish were observed > 50% of the time over bedrock. Only four species (Blue/Deacon, Canary, Yellowtail Rockfishes, and Kelp Greenling) were observed over hard and soft bottom habitats, which included both sand and mud. Only four species were observed over sand and two species were observed over mud. Kelp Greenling and Canary Rockfish were observed over the most diverse number of substrates (7) whereas Vermilion Rockfish and Yelloweye Rockfish were observed over the least number of substrates (1). However these two species also had low numbers of observations (Table 5.6).

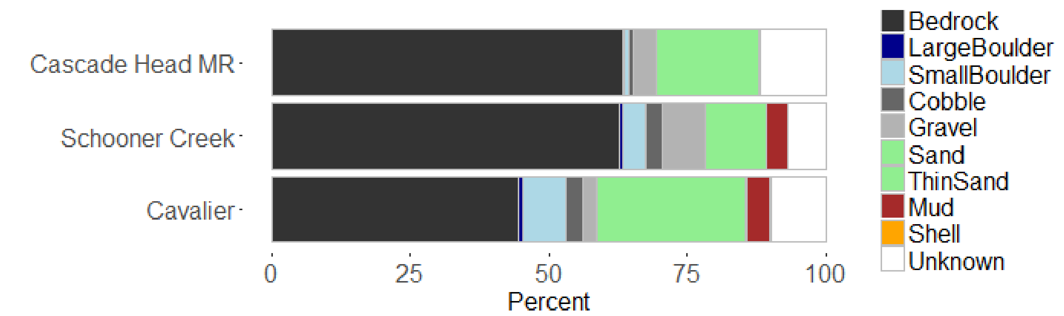


Figure 5.18: Primary Habitat relative frequency from the 2017 ROV substrate data in the Cascade Head Marine Reserve, and Schooner Creek and Cavalier Comparison Areas. Data summarize the substrate covered by all transects in each location.

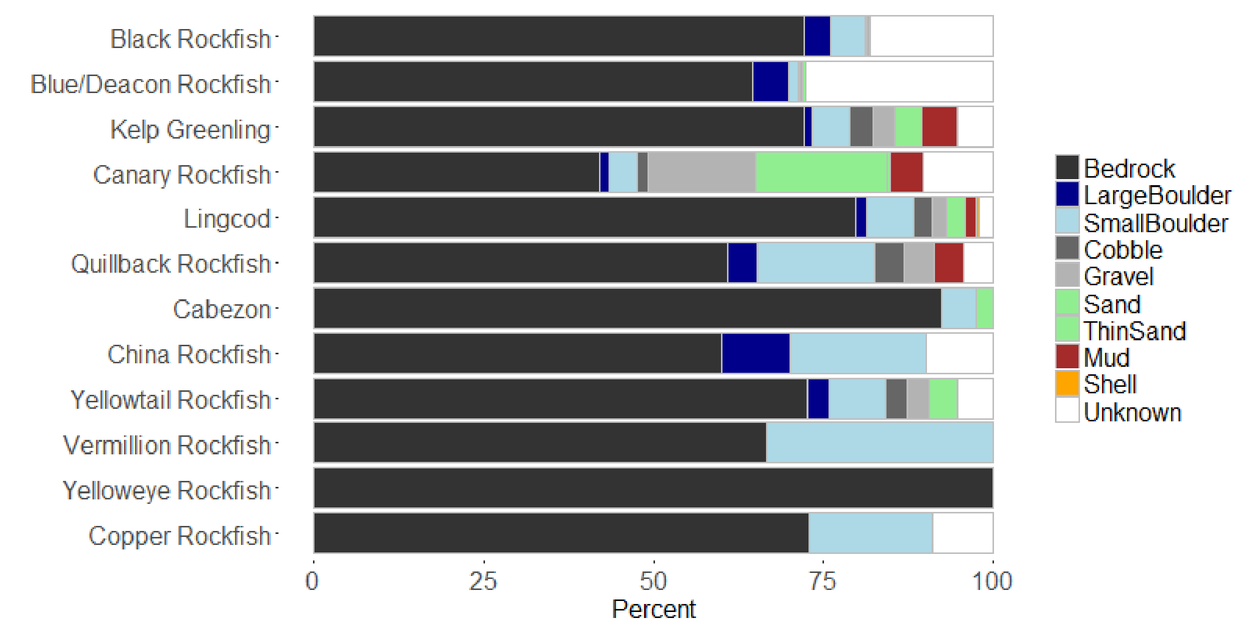


Figure 5.19: Percentage of fish observations by habitat type for all sites surveyed in 2017 combined, including the Cascade Head Marine Reserve, Schooner Creek and Cavalier Comparison Areas.

Considering all sites, the majority of fish species (7) were observed on both hard and soft bottom substrates (Figure 5.18; 5.19). Only four species (China, Vermillion, Yelloweye, and Copper Rockfishes) were observed on hard bottom only (Figure 5.19). All species except Canary Rockfish were observed > 50% of the time over bedrock (Figure 5.19). Only Lingcod were observed over shell, where as six species were observed over sand, mud or a combination of the two soft bottom habitats. Lingcod were observed over the most diverse number of substrates (8), whereas Yelloweye Rockfish were observed over the least number of substrates (1). However this may be caused by low numbers of observations of Yelloweye Rockfish (Table 5.6).

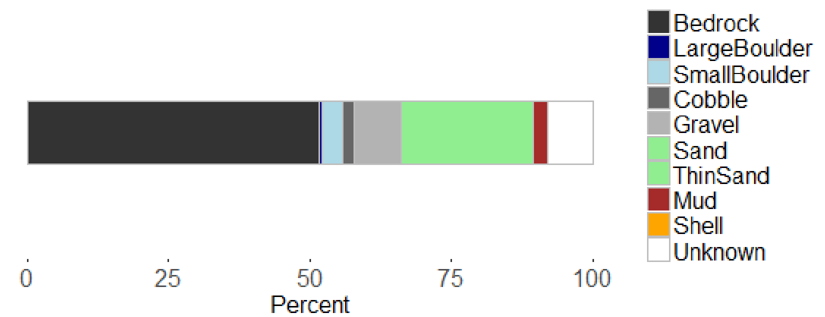


Figure 5.20: Relative frequency of each primary habitat observed in ROV transects at the Cascade Head region, in 2017, shown as percent of total linear transect distance. The Cascade Head region includes the Cascade Head Marine Reserve, Schooner Creek and Cavalier Comparison Areas.

Cape Perpetua

2017

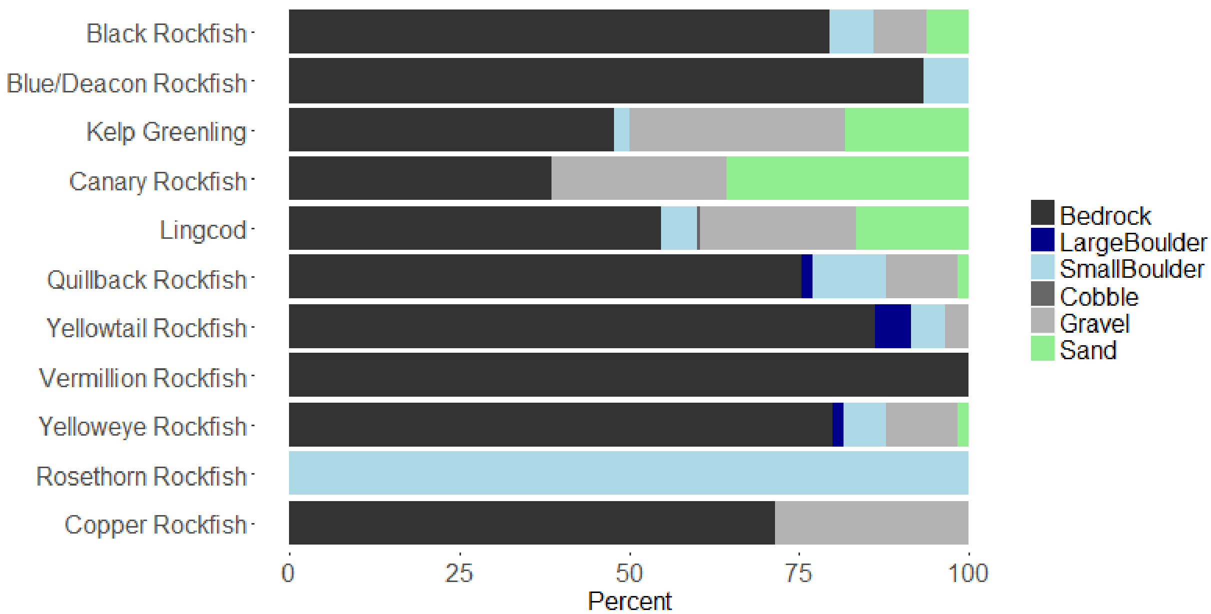


Figure 5.21: Percentage of fish observations by habitat type for the Cape Perpetua Marine Reserve in 2017 from the ROV.

At the Cape Perpetua Marine Reserve, four fish species were observed on only hard bottom habitats whereas the seven fish species were observed over both hard and soft bottom substrates (Figure 5.21). This is proportional to the relative frequency of hard and soft bottom habitats surveyed (Figure 5.22). Eight fish species were observed > 50% of the time over bedrock (Figure 5.21). Ten species were observed over small boulder, gravel or a combination of both. Very few species (3) were observed over large boulder. Lingcod, Quillback, Yellowtail and Yelloweye Rockfishes were observed over the most diverse number of substrates (5), whereas Rosethorn Rockfish were observed over the least number of substrates (1, small boulder). A table reporting the number of individuals by species observed in transects for Cape Perpetua is unavailable at this time.

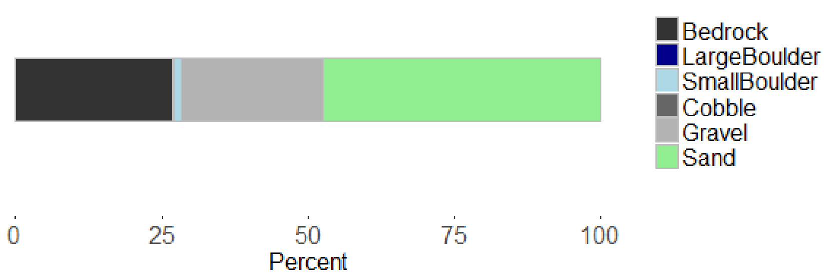


Figure 5.22: Relative frequency of each primary habitat observed in ROV transects at Cape Perpetua Marine Reserve in 2017, shown as percent of total linear transect distance.

Section 6. Programmatic Analysis: Resources, Trade-offs, and Contributions

In this section we provide an overview of the ODFW Marine Reserves Program's ecological monitoring: (a) staff and funding resources; (b) trade-offs made, given finite resources and program capacity; and (c) contributions to date. The intent is to provide Oregonians with a means of gauging value gained for dollars spent during the development of this new long-term monitoring program.

6.A Program Resources

ODFW is the lead agency responsible for overseeing the management and scientific monitoring of Oregon's five reserves. The ODFW Marine Reserves Program was created in 2009 when the Oregon Legislature approved an austerity program that provided staff and funding to support marine reserves planning and implementation.

The ODFW Marine Reserves Program staff and budget supports work pertaining to site management, ecological monitoring, human dimensions research, outreach, community engagement, and enforcement. Currently there are six full-time, permanent staff that comprise ODFW's program of which three staff are dedicated to ecological monitoring efforts.

Program staff and funding levels, and funding sources have evolved some over time since the program's inception. A detailed breakdown of program staff and funding levels, funding sources, and program expenditures per biennium are provided in Marine Reserves Program Budget and Expenditures by Biennium. Tables B-C in this section provide an overview of budgets and staffing specific to ecological monitoring during the program's history.

Budget
Table A provides an overview of the ODFW Marine Reserves Program budget by funding source per biennium. A portion of this budget each biennium supports ecological monitoring staff and monitoring work. The bulk of the program budget comes from state funding sources. Currently all state funds that support the program come from General Funds (i.e. taxpayer dollars).

Table B provides an overview of the portion of the program budget that has been dedicated to ecological monitoring efforts each biennium.

The majority of the ecological monitoring budget comes from state funds, but the program has been able to capitalize on federal State Wildlife Grants that have been awarded to ODFW through the US Fish and Wildlife Service. In some biennia these funds have greatly enhanced the monitoring budget. For instance, during the 2013-15, these grant funds constituted 20% of the monitoring budget and resulted in our largest monitoring budget to date which allowed us to conduct field work at all five reserves during that timeframe (see Table D). These grant funds are not a guaranteed source of funding, and for 2018 have not been made available to our program.

Staffing
Ecological monitoring staff were initially hired at the end of 2009, and monitoring work began in 2010. Table C provides an overview of our ecological monitoring staffing levels, broken out by year.

You will see that besides our full-time, permanent staff we have regularly relied on additional assistance from temporary workers (part-time), undergraduate student scholars (part-time), and post-graduate

Table A. Marine Reserves Program Budget

	2009 - 2011	**2011 - 2013**	**2013 - 2015**	**2015 - 2017**
State Funds	$ 977,955	$ 1,547,815	$ 1,674,878	$ 1,696,480
Federal Grants	$ 108,116	$ 84,181	$ 101,443	$ 62,454
Other Grants	$ 141,301	--	--	--
TOTAL	**$ 1.23 M**	**$ 1.63 M**	**$ 1.78 M**	**$ 1.76 M**

Table B. Ecological Monitoring - Budget

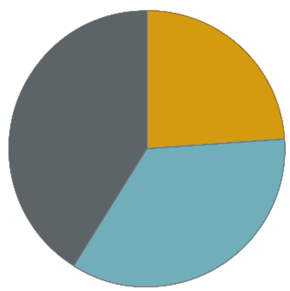
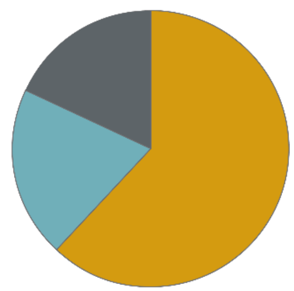
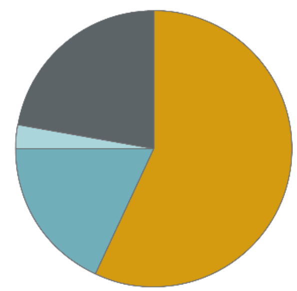
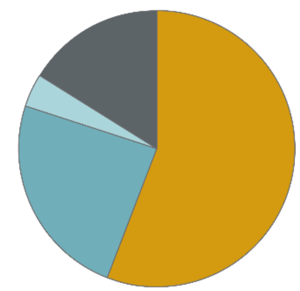
	2009 - 2011	2011 - 2013	2013 - 2015	2015 - 2017
Monitoring Budget	**$ 190,305**	**$ 290,537**	**$ 336,519**	**$ 274,107**
	State: $ 127k Grants: $ 64k	State: $ 210k Grants: $ 81k	State: $ 270k Grants: $ 67k	State: $ 258k Grants: $ 16k
Fishing Vessel Contracts Research Contracts Scholarships Equipment, Supplies, & Services				

Table C. Ecological Monitoring – Staffing

	2010	2011	2012	2013	2014	2015	2016	2017
ODFW Funded								
Full-time	2	2	2	2	3	3	3	3
Seasonal & Temps	1	2	2	3	3	1	1	
Post-Grad Fellows			1					
Student Scholars							1	1
Non-ODFW Funded								
Post-Grad Fellows		1			1	1	1	1
Student Scholars				1	1	2		
TOTAL	**3**	**5**	**5**	**6**	**8**	**7**	**6**	**5**

Table D. Sites Where ODFW Led Monitoring Was Conducted or Where Tool Testing/Trainings Were Performed by Year

	2010	2011	2012	2013	2014	2015	2016	2017
Redfish Rocks	Monitoring / Tool Testing or Training	Monitoring / Tool Testing or Training	Monitoring	Monitoring	Monitoring / Tool Testing or Training	Monitoring / Tool Testing or Training	Tool Testing or Training	Monitoring
Otter Rock	Monitoring / Tool Testing or Training	Monitoring / Tool Testing or Training	Monitoring / Tool Testing or Training	Tool Testing or Training	Tool Testing or Training	Monitoring	Tool Testing or Training	Monitoring / Tool Testing or Training
Cape Perpetua			Monitoring	Monitoring	Monitoring		Monitoring	
Cascade Head			Monitoring	Monitoring	Monitoring	Monitoring	Monitoring	Monitoring
Cape Falcon					Monitoring	Monitoring	Monitoring / Tool Testing or Training	Monitoring / Tool Testing or Training

Monitoring   Tool Testing or Training

fellows (full-time). You will also note that we have been successful in leveraging additional staffing resources by having some non-ODFW funded staff (staff not paid for out of the ODFW Marine Reserves Program budget). These staff have been provided through existing scholar and fellowship programs as well as through the development of a joint Oregon State University- ODFW post-graduate fellowship program. Scholars and fellows have been provided by the following programs in the past: Oregon Sea Grant Summer Scholars Program, Oregon Sea Grant Natural Resource Policy Fellowship, COSEE, and the NSF Research Experience for Undergraduates. Our program continues to contend with administrative hurdles in trying to take advantage of these types of non-ODFW funded staffing opportunities.

Besides our three permanent staff, additional staffing is not guaranteed every year.

6.B Capacity and Trade-Offs

Tables B and C illustrate the funding and staffing resources that have been available for ecological monitoring efforts. Table D illustrates which sites had monitoring work conducted, and/or was used for tool testing or trainings, each year. By looking across Tables B-D we are able to get a sense of the monitoring work able to be performed given resources available to ODFW.

In this section we discuss further the program's capacity and trade-offs that have been made in ecological monitoring given the program's finite resources and capacity.

Prioritization
Our intent has been to produce rigorous scientific monitoring and research that provides information that supports both nearshore ocean management and adaptive management of marine reserves, and will be of substance in the 2023 Marine Reserves Program evaluation.

With finite resources available, we have prioritized our monitoring and research activities based on:

- The marine reserve goals and objectives (OPAC 2008)
- Scientific accuracy
- Cost
- ODFW's in-house expertise and strengths

Trade-Offs Made to Date
Based on these priorities, and our program's resources and capacity, the following trade-offs have been made in the ecological monitoring of the reserves, in consultation with scientific experts and decision-makers:

Phased in Harvest Restrictions With limited staff and funding, in order to perform two years of comprehensive data collection at each site prior to closure in accord with our monitoring plans, the harvest restrictions were phased in for the sites as follows:

	Monitoring Began	Harvest Restrictions Began
Redfish Rocks	2010	2012
Otter Rock	2010	2012

Cape Perpetua	2012	2014
Cascade Head	2012	2014
Cape Falcon	2014	2016

We Don't Sample at Every Site Every Year Given limited staff and funding, and with the five reserve sites geographically spread out, ODFW has developed a staggered sampling approach. Schedules for sampling at each site are provided in our Ecological Monitoring Plan (ODFW 2017).

ODFW Focuses on Four Core Research Tools ODFW has narrowed our focus to four core research tools for collecting long-term monitoring data. These tools were determined, through methods development and testing during our first five years, to be the most reliable for collecting the metrics we are interested in, can be regularly employed given our staffing levels and budget, and build on ODFW staff expertise. These tools, described in more detail elsewhere in this report, include: (1) hook and line, (2) SCUBA, (3) video lander, and (4) Remotely Operated Vehicle (ROV).

Monitoring Efforts are Predominately Focused On and Around Rocky Habitats Most of the monitoring survey work is focused on areas of rocky and transitional habitats. These areas were prioritized since species that are most likely to be afforded direct protection in the current reserve sites, and those that are most likely to show an ecological response over time, are affiliated with rocky habitats. We are interested in expanding some of our monitoring efforts, particularly at the Cape Perpetua and Cape Falcon sites, to include more monitoring in soft bottom habitat areas with a special interest in Dungeness crab research. We are currently exploring ways in which we might be able to build collaborations, and bring in additional expertise and resources to expand our monitoring focus.

We Rely on Research Partners to Expand Monitoring Efforts We rely on partners to provide added expertise, tools, methods, personnel and often to bring in additional funds to supplement and expand ODFW's monitoring efforts. Our partners and collaborations are further noted below. ODFW has been able to provide some seed money to assist with our various partners' work, but most partners have also had existing or sought additional funding to conduct work.

We Use a Volunteer Scientific SCUBA Diving Team ODFW does not have a dive program and current agency policy prohibits ODFW staff from diving. However, we recognized early on that SCUBA surveys are an effective research method for collecting data in shallow rocky reef environments. In addition, SCUBA surveys are an ongoing tool being used in the monitoring of MPAs in California and would provide for complimentary data collection.

As a means around this hurdle, we have partnered with the Oregon Coast Aquarium and Oregon State University (OSU), who have established scientific diving programs and dedicated dive safety officers. These partners provide staff divers, and help us recruit and train volunteer AAUS certified divers to conduct our SCUBA visual surveys. ODFW provides some funds, via a research contract, to the Aquarium to support their dive staff who assist with conducting the surveys and in training volunteers. Both the Aquarium and OSU also provide in-kind support for our SCUBA surveys and trainings.

Oceanographic Data Collection Has Been Limited To date we have collected limited oceanographic data as part of our monitoring. This is due to a combination of high costs of purchasing and maintaining oceanographic equipment and of field work, and ODFW's lack of in-house expertise. We are fortunate that Oregon has academic institutions with oceanographic expertise. We are currently exploring collaborations with academic research to try and fill this gap in monitoring.

Analysis: What Would It Take to Monitor Every Site Every Year
Based on our past expenditures, staffing levels, and monitoring efforts accomplished in any given year we conducted an analysis to estimate the resources that would be needed to conduct monitoring at every site, every year.

We estimate a cost of approximately $46,627 per site per year (in 2018 dollars) and about 1.8 staff per site. To conduct monitoring at all five sites every year we estimate it would require:

- 9 ecological staff: 4 full-time permanent, 1 full-time post-graduate fellow, 4 part-time
- An ecological monitoring budget of $233,133 per year ($466,266 per biennium)

6.C Research Partners and Collaborations

Oregon's marine reserve mandates provide that "cooperative and collaborative research will be encouraged as well as utilization of fishing vessels as research platforms" (OPAC 2008). Here we highlight our collaborations with research partners that contribute to our long-term marine reserves monitoring and research efforts. We also include a summary of fishing vessel contracts we've had to date with fishermen who have participated in our monitoring efforts.

Monitoring Collaborations

Here we highlight four ongoing monitoring collaborations that expand and contribute to our long-term monitoring of marine reserves. More detailed descriptions of these projects are available in our Deeper Understanding: Ecological Research Studies document, which provides a running list of ecological monitoring and research studies being conducted by ODFW and research collaborators.

1) **Standard Monitoring Unit for the Recruitment of Fishes (SMURFs)**
   Lead: Dr. Kirsten Grorud-Colvert, Oregon State University (OSU)
   Collaborators: OSU, ODFW, Oregon Coast Aquarium
   Purpose: Quantify abundance and diversity of pelagic juvenile fishes settling into the nearshore habitats.

2) **Rocky Intertidal Long-term Biodiversity**
   Lead: Pete Raimondi, PISCO/MARINe-UC Santa Cruz
   Bruce Menge, PISCO-OSU
   Collaborators: UC Santa Cruz, OSU, PISCO, ODFW
   Purpose: Monitor community structure of target assemblages. Quantify abundances and sizes of key species. Record biodiversity hotspots, species-habitat associations, invertebrate larval recruitment, and effect of oceanographic factors on intertidal communities.

3) **Sea Star Wasting**
   Lead: Bruce Menge, PISCO-OSU

Dick VanderSchaff, The Nature Conservancy

Collaborators: OSU, The Nature Conservancy, ODFW

Purpose: Observe prevalence of sea star wasting disease on Ochre Sea Stars and track recruitment of juvenile stars into the intertidal.

4) **Rocky Reef SCUBA Surveys**

Lead: ODFW

Collaborators: ODFW, Oregon Coast Aquarium, OSU, PISCO

Purpose: Diver based, underwater visual census (UVC) methods to identify and count macroalgal, invertebrate, and fish communities.

Nearshore Research Collaborations

Here we highlight four research collaborations that have been conducted to help expand our understanding of Oregon's nearshore ecosystem, as well as support nearshore management and adaptive management of marine reserves. More detailed descriptions of these projects are available in our Deeper Understanding: Ecological Research Studies document.

1) **Lingcod Biomarker Study**

Lead: Dr. Aaron Galloway, University of Oregon

Collaborators: University of Oregon, ODFW

Purpose: Conduct limited fatty acid and isotopic biomarker analysis of targeted fish species for trophic inferences.

2) **Harbor Seal Foraging Study**

Lead: Shea Steingass, OSU

Collaborators: OSU, ODFW

Purpose: Research aimed at understanding the ecological roles of seals inside and outside of marine reserves in Oregon, using tracking data and by examining dietary composition for harbor seals using stable isotopes.

3) **Telemetry Study of Nearshore Rockfish in Redfish Rocks Marine Reserve**

Lead: Scott Heppell and Tom Calvanese, OSU

Collaborators: OSU, ODFW, Redfish Rocks Community Team

Purpose: Acoustic telemetry study to look at movement behaviors of adult fish targeted for protection and to elucidate details of rockfish habitat associations.

4) **Nereocystis Genetics**

Lead: Robert San-Miguel, University of Wisconsin-Milwaukee

Collaborators: University of Wisconsin-Milwaukee, ODFW

Purpose: To understanding the population genetic structure across Nereocystis' entire geographic range by contributing samples from three sites along the Oregon coast.

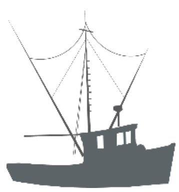
Fishing Vessel Contracts and Collaborations

We regularly contract with local fishing vessels to assist in our ecological monitoring surveys. Working with fishermen allows us to use their expertise in vessel operations, as well as in working with different gear types and in building equipment. We collaborate with local fishermen in order to improve our monitoring efforts and learn from their years of experience with, and in depth local knowledge of, the ocean.

Our collaborations with fishermen have even resulted in a peer reviewed publication based on a pilot study comparing hook and line vs longline gear -- initially proposed, and conducted in close cooperation with, a local commercial fisherman from Port Orford. The outcomes from this pilot study have resulted in us now supplementing our hook and line surveys with longlining for the Redfish Rocks Marine Reserve.

Table E is a summary of vessel contracts we’ve had with fishermen between 2010 and 2017, broken out by vessels’ home ports.

Table E. Summary of Fishing Vessel Contracts, from 2010 – 2017, Broken Out by Home Port



34
Vessel Contracts
$ 555 k

Fishing Vessel Contracts 2010 - 2017		No. Contracts
Garibaldi	$ 44,605	3
Depoe Bay	$ 95,702	6
Newport	$ 169,963	8
Port Orford	$ 186,124	13
Gold Beach	$ 58,644	4
TOTAL	**$ 555,038**	**34**

6.D Program Contributions

Here we highlight some of the ODFW Marine Reserves Program’s contributions to date stemming from our ecological monitoring efforts.

2 Journal Publications

- Brittany E. Huntington & Jessica L. Watson (2017) Tailoring Ecological Monitoring to Individual Marine Reserves: Comparing Longline to Hook-and-Line Gear to Monitor Fish Species, *Marine and Coastal Fisheries*, 9:1, 432-440.
- Watson, JL and BE Huntington (2016) Assessing the performance of a cost-effective video lander for estimating relative abundance and diversity of nearshore fish assemblages. *J. Exp. Mar. Biol. Ecol.* 483 (2016) 104–111.

3 Reports

- Lawrence K, Watson J, Huntington B. (2016) A Method for Quantifying Biogenic Habitat from Stationary Underwater Video. *ODFW Information Report Series*, Fish. No. 2016-04. 20p
- Ecological Monitoring Report 2012-2013 (ODFW 2015)
- Ecological Monitoring Report 2010-2012 (ODFW 2014)

Methods Development and Knowledge Sharing

The ODFW Marine Reserves Program's ecological monitoring is the first ecosystem-focused, long-term monitoring program to be conducted in Oregon's nearshore marine environment. We have built upon advances in sampling technology and gear to design robust and contemporary survey tools that will function well in Oregon's challenging nearshore environment. This has included studies specially designed to test and improve our research tools.

Our methods development and testing has led to some significant contributions in sharing knowledge about research tools for use in nearshore marine environments. This has included the two journal publications described previously. It has also included ODFW staff creating several ongoing, research discussion groups that are focused on nearshore research tools and/or MPA monitoring surveys. These are listserv discussion groups that allow group members to pose questions or ideas to the group for feedback and discussion. They include researchers from across the U.S. West Coast as well as internationally. In some instances the groups have also participated in in-person workshops. To date ODFW has formed discussion groups for: hook and line surveys, SCUBA surveys, and underwater visual survey tools. All three groups are currently active.

Our intent in discussions with other U.S. West Coast researchers is to develop and conduct surveys that produce complimentary data for the California Current System, so that they have greater management applicability beyond just Oregon.

$30,000 in Scholarships Supporting Graduate Student Research

We have awarded six scholarships that support graduate student research conducted in or on Oregon's marine reserves. Research projects have included juvenile fish recruitment research, harbor seal foraging research, intertidal sea star research, and methods development for habitat assessments.

Creation of a Joint OSU-ODFW Fellowship Program

Created in 2014, in collaboration with OSU. This is an ongoing post-graduate fellowship program offered by the OSU Marine Studies Initiate. Each fellowships lasts for two years and the fellow works in conjunction with ODFW staff and academic researchers. The fellow serves as a liaison between academia and ODFW; provides analytical support to ODFW; conducts field work as part of marine reserves ecological monitoring; furthers development of scientific methods that may have applications across the U.S. West Coast in long-term monitoring efforts; and assists with marine reserves and science communications.

To date we have had two fellows go through this program. We will again be recruiting a new fellow, to begin in the fall of 2018. ODFW and OSU are continuing to seek additional funding to support continuation of this program.

Creation of a SCUBA Tank Air Fill Station in Port Orford

The Redfish Rocks Community Team was successful in obtaining a grant from Travel Oregon to install and create an SCUBA tank air fill station, located at the Port Orford OSU Field Station. The ODFW Marine Reserves Program provided cash match and a letter of support for this community project. The air fill station is significant in that it provides support for both scientific and recreational diving on Oregon's south coast, including the Redfish Rocks Marine Reserve. Prior to this project, the closest location to fill tanks was in Coos Bay adding significant travel and logistical costs to research dive surveys.

6.E Challenges and Lessons Learned In Developing a Long-term Monitoring Program

This type of ecosystem-focused, long-term monitoring in Oregon's nearshore marine environment has been a new endeavor. Developing a long-term nearshore monitoring program has proven challenging, with many lessons learned along the way. Here we share some brief thoughts on lessons learned and some of the next steps we are contemplating as a program looking forward.

Lessons Learned and Looking Forward

During these first seven years we have looked heavily to expert advice from Oregon and other west coast scientists, as well as fishermen, to help us develop and continue to tune our monitoring tools and approach. We have had to adapt methods and research tools that are being used further offshore, or in waters of our neighboring states, that more regularly experience calmer sea states and better underwater visibility conditions. Based on methods and tool testing, some of our initial approaches did not yield robust data and have been dropped from our monitoring efforts.

We note that these types of robust, long-term monitoring programs take time to develop and there are to be missteps along the way. Learning and adapting are a necessary component of developing a robust program.

For next steps, we are looking to work with STAC to determine what gaps in monitoring should be addressed before the 2023 Program evaluation. We will also be maintaining discussions with our colleagues in California as they continue to develop and tune their long-term monitoring approach for California's extensive network of MPAs.

Marine reserves ecological monitoring to date has relied heavily on additional expertise and resources, in addition to those provided by the ODFW Marine Reserves Program. For the 2023 Program evaluation, we are looking to assess and quantify the true costs of marine reserves implementation beyond just those provided by the ODFW Marine Reserves Program.