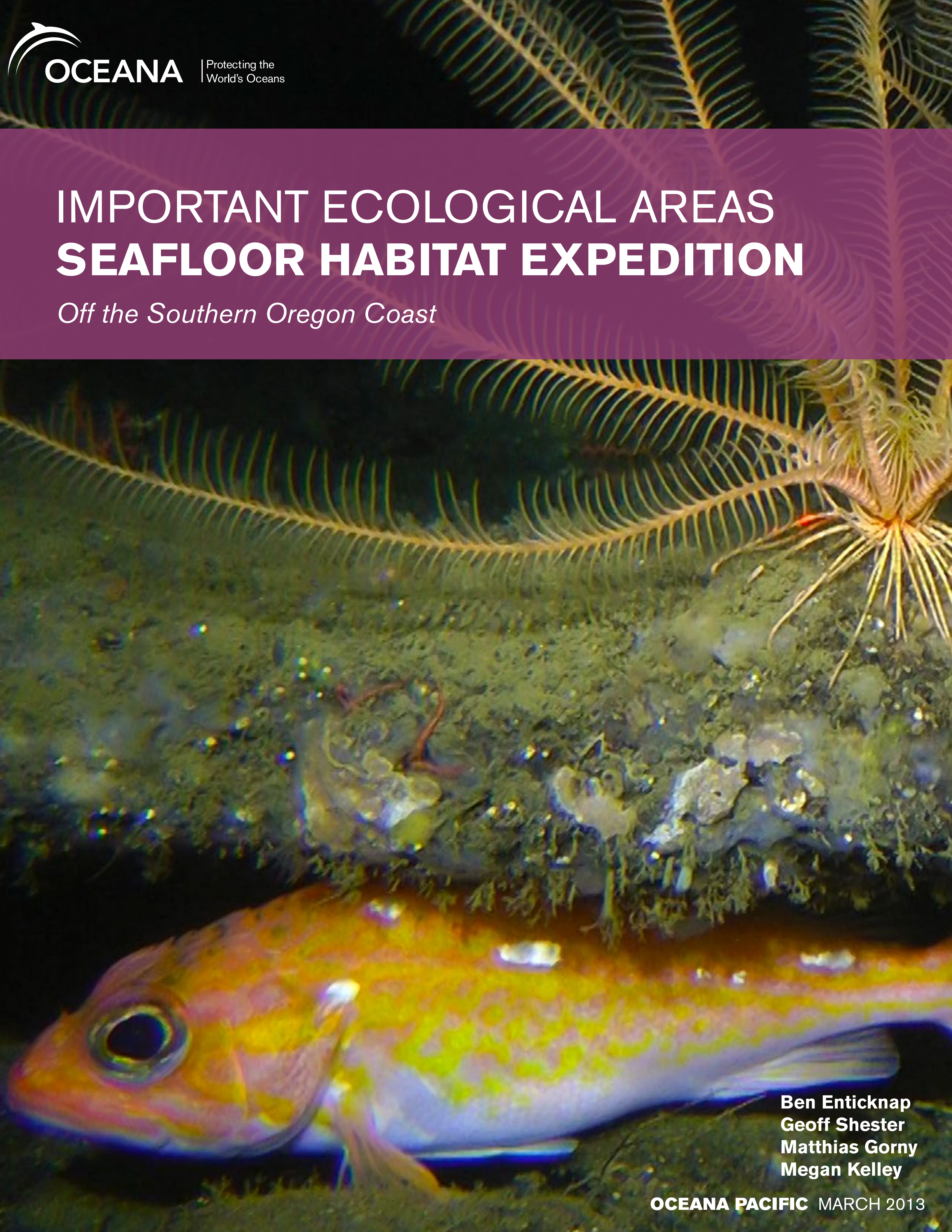

OCEANA | Protecting the World's Oceans

IMPORTANT ECOLOGICAL AREAS
SEAFLOOR HABITAT EXPEDITION

Off the Southern Oregon Coast

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Megan Kelley

OCEANA PACIFIC MARCH 2013

CONTENTS

“Only the ocean remains as the last great unexplored portion of our globe; so it is to the sea that [we] must turn to meet the last great challenge of exploration this side of outer space.”
H.B. Stewart, Deep Challenge (1966)

The authors would like to give special recognition to Susan Murray, Deputy Vice President, Pacific, for her leadership and her commitment to identifying and protecting Important Ecological Areas in the Northeast Pacific and Arctic Oceans. Oceana staff Jon Warrenchuk, Whit Sheard and Cayleigh Allen provided able assistance at sea, and Mike Levine, Mike Hirshfield, Jim Simon, Eric Bilsky, and Lianne Holzer assisted with expedition planning. We thank James Lindholm and personnel at the California State University Monterey Bay for assistance with video analysis methods and species identifications. A special thanks to our internal scientific reviewers Jon Warrenchuk, Chris Krenz and Mike Hirshfield, plus our external reviewers Dave Fox, Jeff Short, and Brian Tissot, who provided valuable technical review of the methods and results. We thank Captain Bob Pedro of the R/V Miss Linda and his crew for providing a safe platform for our surveys and for his uncanny ability to stay on position.

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Graphic Designer: Jenny Jones

Cover Photo: Rosy rockfish, crinoids, and sponge at Coquille Bank
Left Insert Page: Inshore Cape Arago: lingcod
This Page: Inshore Cape Arago Reef: gorgonian coral

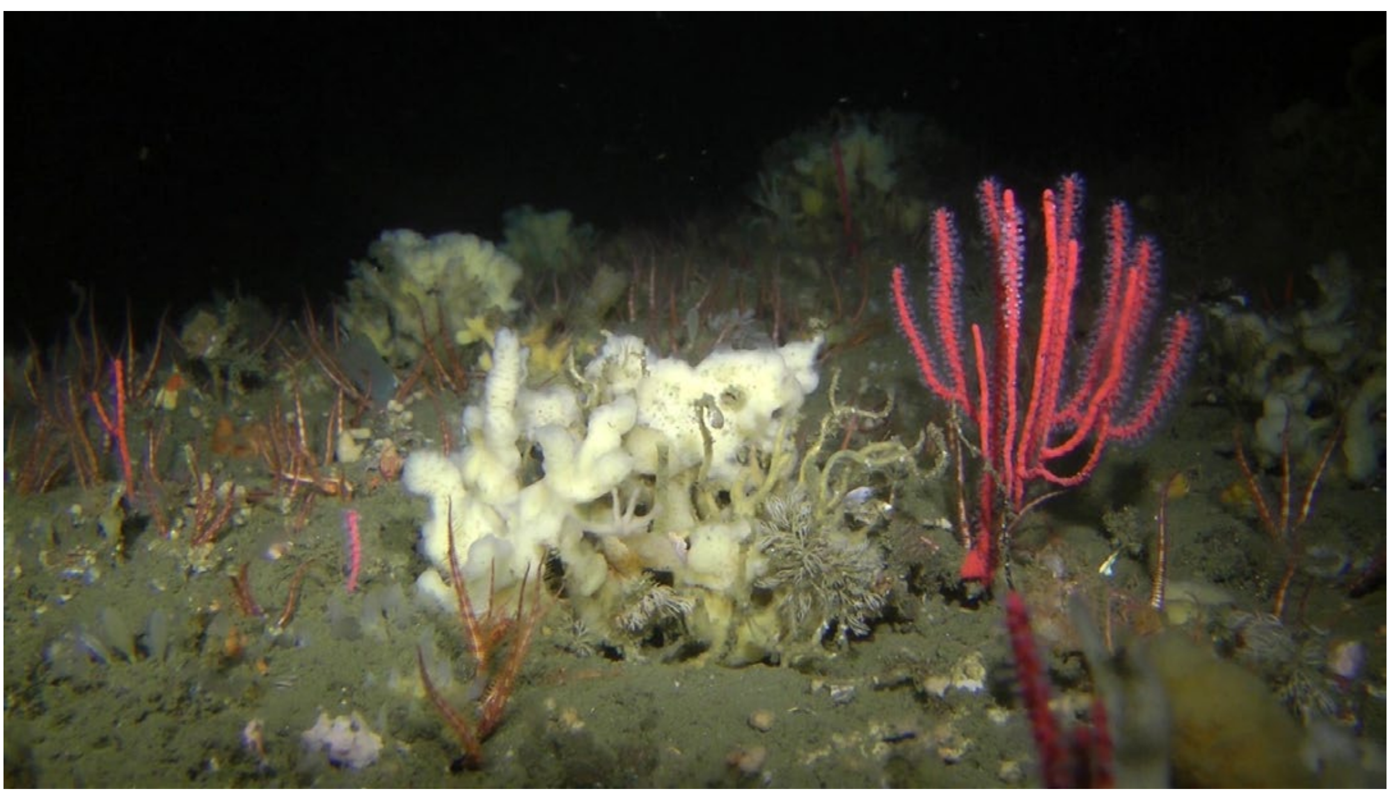
ABSTRACT

IMPORTANT ECOLOGICAL AREAS

In June 2011 Oceana conducted a five day research expedition in the Pacific Ocean waters off southern Oregon to document and characterize seafloor habitats and their associated biological communities, and to help inform and advance the long-term conservation and management of Important Ecological Areas. Using a Remotely Operated Vehicle (ROV) mounted with a high definition camera, we recorded 13.5 hours of video of the seafloor during the course of 17 dives, across six geographic study areas and in depths ranging from 28 to 228 meters. This study characterizes and compares the physical and biological structure at each area and the associated fish species identified through a combination of continuous and interval video analysis.

Areas surveyed off Cape Arago southwest of Coos Bay, and inshore and offshore Coquille Reef west of Bandon had never before been surveyed with underwater cameras. Our findings represent the first *in situ* observations of these unique habitats. We documented three orders of cold-water corals at 15 of 17 dives and sponges at 16 of 17 dives, significantly adding to the direct observations of coral and sponge locations in this region of the Pacific Ocean. We also documented many other invertebrates such as crinoids, anemones, tunicates and bryozoans that add to the biogenic structure of these areas. The physical structure of the habitats surveyed ranged from high relief hard rocky reef to low relief soft sediments.

Overall, we observed 2,299 individual fish, 900 of which we identified as federally managed fish species, principally rockfishes belonging to the genus *Sebastes*. In total, these fish represented 18 different fish species/species groups, 13 of which are federally managed species. The most abundant species observed was widow rockfish (*S. entomelas*), all of these fish were seen during the course of one dive in the offshore Cape Arago area. We documented overfished canary rockfish (*S. pinniger*) and yelloweye rockfish (*S. ruberrimus*) at all three inshore reefs surveyed and in the offshore Cape Arago area.



Offshore Cape Arago: a diverse seafloor including corals, sponges, and brittle stars

The nearshore and offshore reefs and banks surveyed both in state and federal waters are biologically diverse, contain sensitive structure forming invertebrates, and are clearly essential fish habitat for managed fish species. The Coquille Bank area is currently closed to bottom trawling but the other areas surveyed warrant consideration as conservation areas as part of the National Marine Fisheries Service and Pacific Fishery Management Council five-year review of groundfish essential fish habitat designations and protections. These areas should also be considered for designation and protection as Important Ecological Areas (IEAs) in any future state or federal marine spatial planning and marine protected area processes. IEAs like these are geographic areas that have distinguishing ecological characteristics such as high productivity or biological diversity, are important for maintaining habitat heterogeneity or the viability of a species, or contribute disproportionately to an ecosystem's health, including its function, structure, or resilience (Ayers et al. 2010, CEQ 2010).

Oceana scientists Ben Enticknap and Geoff Shester deploying the ROV

Offshore Coquille Bank: shrimp

INTRODUCTION

The Pacific Ocean off Oregon is part of the California Current Large Marine Ecosystem, which is known for strong seasonal upwelling with areas of high productivity, and which supports a wide variety of fish, seabirds and large marine mammals. Yet relatively little is known about the biological communities in some of the richest and most diverse habitat areas–the living seafloor. Globally, an estimated 98% of all marine species live in or on the seafloor (Thurman and Burton, 2001). Rocky reefs and living structure-forming invertebrates like corals and sponges create a foundation for marine biodiversity. These habitats are also spatially limited, sensitive, and vulnerable to degradation.

Seafloor habitats are especially vulnerable to fishing impacts, principally the impacts of bottom trawling. Bottom trawls, with weighted nets and large steel doors, are dragged along the seafloor off the U.S. West Coast to catch groundfish species and ocean shrimp. At the same time, however, they catch an abundance of other marine life as bycatch; damage communities of corals, sponges and other habitat forming invertebrates; as well as alter the physical structure of seafloor habitats (e.g. Puig et al. 2012, Hannah et al. 2009, Hixon and Tissot 2007, Auster and Langton 1999). Bottom trawling has been widely shown to reduce habitat complexity, productivity and alter ecological communities (NRC 2002).

There have been significant efforts in recent years to map and characterize seafloor habitats off the Oregon coast (Goldfinger 2010, Weeks and Merems 2004, Merems 2003), identify Important Ecological Areas (Oceana 2010), and protect marine habitats in both federal and state waters off Oregon (NMFS 2006, ODFW 2012, Shester and Warrenchuk 2007). These efforts are due to the growing understanding of the importance of seafloor habitats to biological diversity and their importance as essential fish habitat for managed fish species. In 2006 the Pacific Fishery Management Council and National Marine Fisheries Service closed select areas to bottom trawling in federal waters off Oregon and froze the bottom trawl footprint so that waters greater than 1,280 meters depth (700 fathoms) are closed to this gear (Figure 10). Various Important Ecological Areas within the footprint remain unprotected. Similarly, the State of Oregon recently completed a decade long process to build a limited network of marine reserves and protected areas, yet there is a major gap in that network for the southern Oregon coast. The Pacific Fishery Management Council is now conducting a 5-year review of its groundfish essential fish habitat (EFH) designation and conservation measures.

Here we describe and characterize the seafloor habitats and associated biological communities at six areas off the southern Oregon Coast. One offshore area, Coquille Bank, is within a designated EFH conservation area that is closed to bottom trawling and all others are outside of any marine protected areas. We collected 13.5 hours of high definition video during 17 dives with a Remotely Operated Vehicle (ROV). The analysis of that video and the findings presented here are useful for managers and policymakers to identify important, sensitive and unique habitats and protect them through spatial management measures.

Inshore Cape Arago: Juvenile yelloweye rockfish, boulder and sponge

Inshore Cape Arago: gorgonian coral

This expedition was part of a larger effort by Oceana to identify, map and characterize Important Ecological Areas (IEAs) in the California Current Large Marine Ecosystem. Other regions we surveyed to date include Monterey Bay, California (Shester et al. 2012) and the San Juan Islands in Puget Sound, Washington. IEAs are geographically delineated areas which by themselves or in a network have distinguishing ecological characteristics, are important for maintaining habitat heterogeneity or the viability of a species, or contribute disproportionately to an ecosystem's health, including its productivity, biodiversity, function, structure, or resilience. Examples of IEAs include migration routes, subsistence areas, sensitive seafloor habitats, breeding and spawning areas, foraging areas, and areas of high primary productivity. The goal of the IEA approach is to preserve the health, productivity, biodiversity and resilience of marine ecosystems while providing for ecologically sustainable fisheries and other economic endeavors, traditional subsistence uses, and viable marine-dependent communities (Ayers et al. 2010).

STUDY GOAL AND OBJECTIVES

The overall goal of this study is to identify and document Important Ecological Areas off the southern Oregon coast to help inform the long-term conservation and management of marine habitats and biodiversity in this region of the Northeast Pacific. The objectives of this research are to:

1. **survey and characterize the distribution and relative abundance of coral and sponge communities at sites where occurrences have not been documented,**
2. **quantify associations of federally managed groundfish species with physical and biological habitat features,**
3. **characterize habitats in areas open and closed to bottom trawling, and**
4. **add additional observations of corals and sponges to the National Oceanic Atmospheric Administration (NOAA) database on the occurrence of these biogenic habitat features.**

Offshore Cape Arago: Canary rockfish

Offshore Cape Arago: branching sponge with shrimp

METHODS

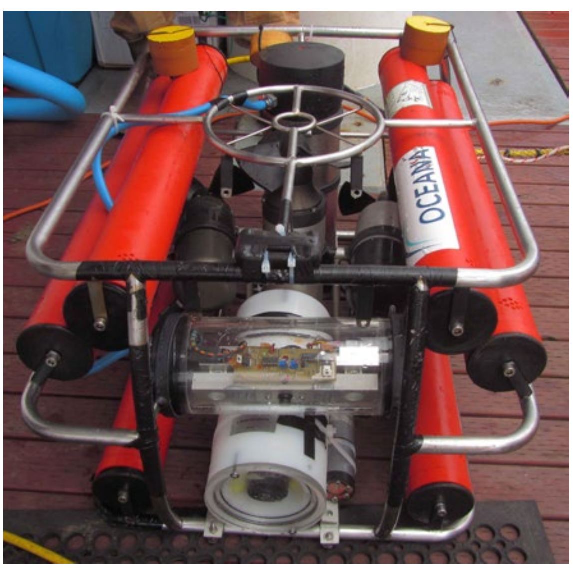
ROV Survey

Aboard the R/V Miss Linda, we conducted 17 ROV dives off the coast of southern Oregon at depths ranging from 28 to 228 meters. We targeted areas at different depth ranges and distances from shore suspected to have hard substrate based on Geographic Information System (GIS) analyses using surficial geologic habitat data (OSU 2008), preliminary habitat classification maps generated with multibeam/ backscatter surveys (now finalized, see OSU ATSML 2011) or locations identified by NOAA trawl surveys as too complex for research trawls (Zimmerman 2003).
The 17 dives were completed within six geographic areas:

1. Inshore Cape Arago (the Cape Arago-Seven Devils Reef) (dives 1, 13, and 14);
2. Offshore Cape Arago (dives 2, 3, 8, 15, 16, and 17);
3. Inshore Coquille Reef (dive 5);
4. Offshore Coquille Reef (dives 6 and 7);
5. Orford Reef (dive 4); and
6. Coquille Bank (aka Bandon High Spot) (dives 9, 10, 11, and 12).

For the purpose of this study, the areas were delineated based on commonly known geographic features (e.g. Orford Reef, Coquille Bank, Cape Arago-Seven Devils) and the inshore/ offshore areas were delineated by the three nautical mile Oregon Territorial Sea boundary.

We collected 13.5 hours of high definition video of the seafloor using a Mariscope FO-II ROV equipped with 2 cameras, 4 lights, and a single sizing laser set at 15 cm from the center of the video screen. One camera was connected by an optical umbilical cable to the surface, feeding the ROV operator and scientists aboard the research vessel real time data used for navigating the ROV. The second camera, a high definition camera mounted under the ROV, recorded the seafloor in 1080p high definition at 30 frames per second. This camera was mounted facing forward inside a waterproof housing oriented horizontally with the plane of the bottom of the ROV. We alternated between using a Cannon VIXIA HF21 and a Panasonic HDC-HS700 that were exchanged periodically between dives so that the video files could be downloaded and secured without delaying any ROV dives, and to minimize the risk of losing data in the event of a technical malfunction. The high definition video was used for all video analysis.



The team's Mariscope-FOII ROV was deployed to capture high-definition underwater footage

TABLE 1. Coordinates at the start of each dive and depth range (meters).

Dive	Latitude	Longitude	Depth Range (meters)
1	43.24045	-124.43915	40
2	43.24822	-124.50383	72
3	43.22597	-124.49865	55
4	42.75603	-124.61458	63-69
5	43.14405	-124.47712	39
6	43.14583	-124.56882	96-98
7	43.13808	-124.60670	118
8	43.22133	-124.56517	80-82
9	43.02567	-124.80933	126-128
10	43.01682	-124.85030	205-210
11	43.98783	-124.81342	127-129
12	43.07847	-124.85647	226-228
13	43.23267	-124.43650	28-34
14	43.24802	-124.44815	38-41
15	43.24930	-124.48390	60
16	43.25367	-124.52750	10-81
17	43.29483	-124.52400	99-100

FIGURE 1. Dive locations depicted by red points, dive number, and corresponding study area groupings.

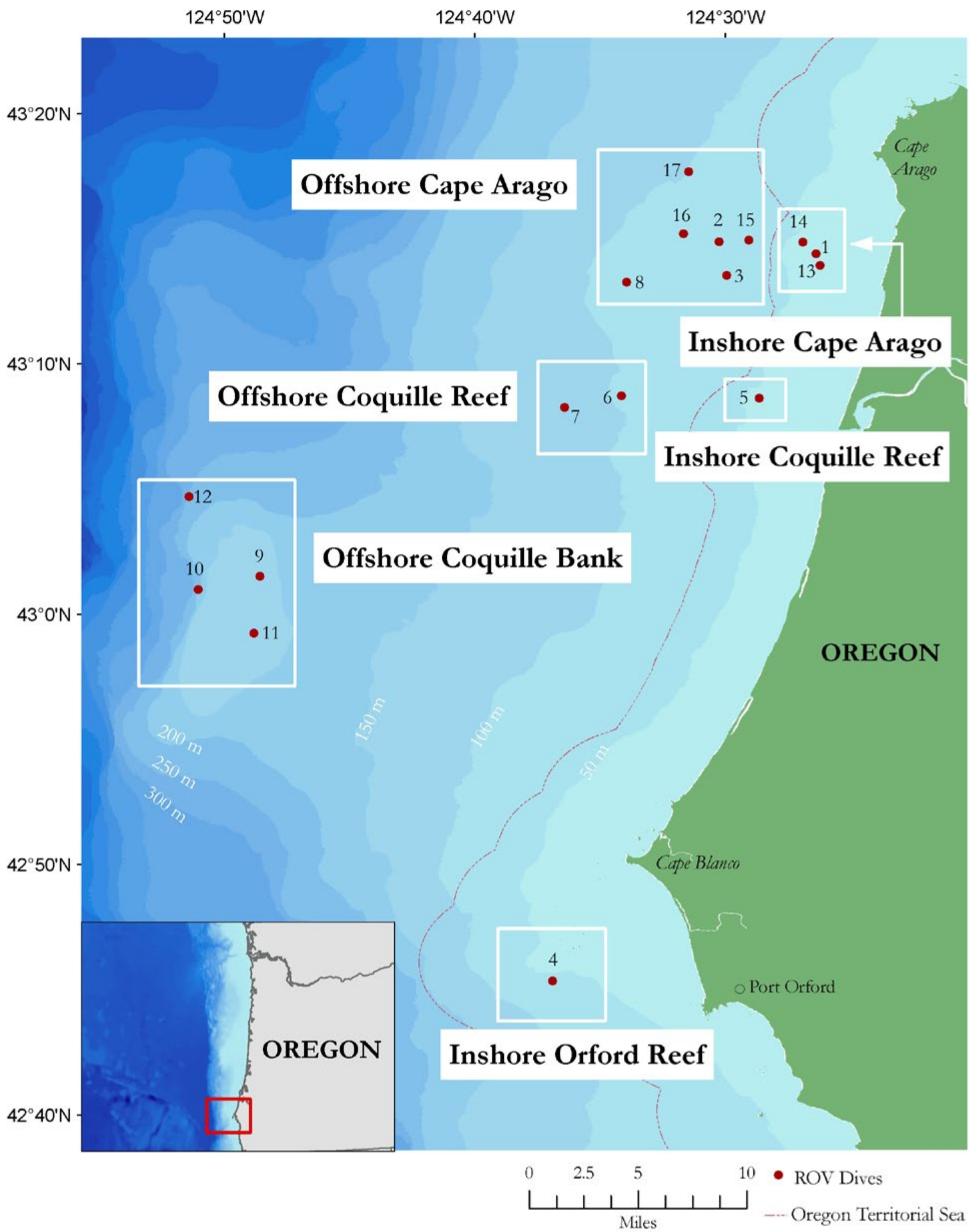
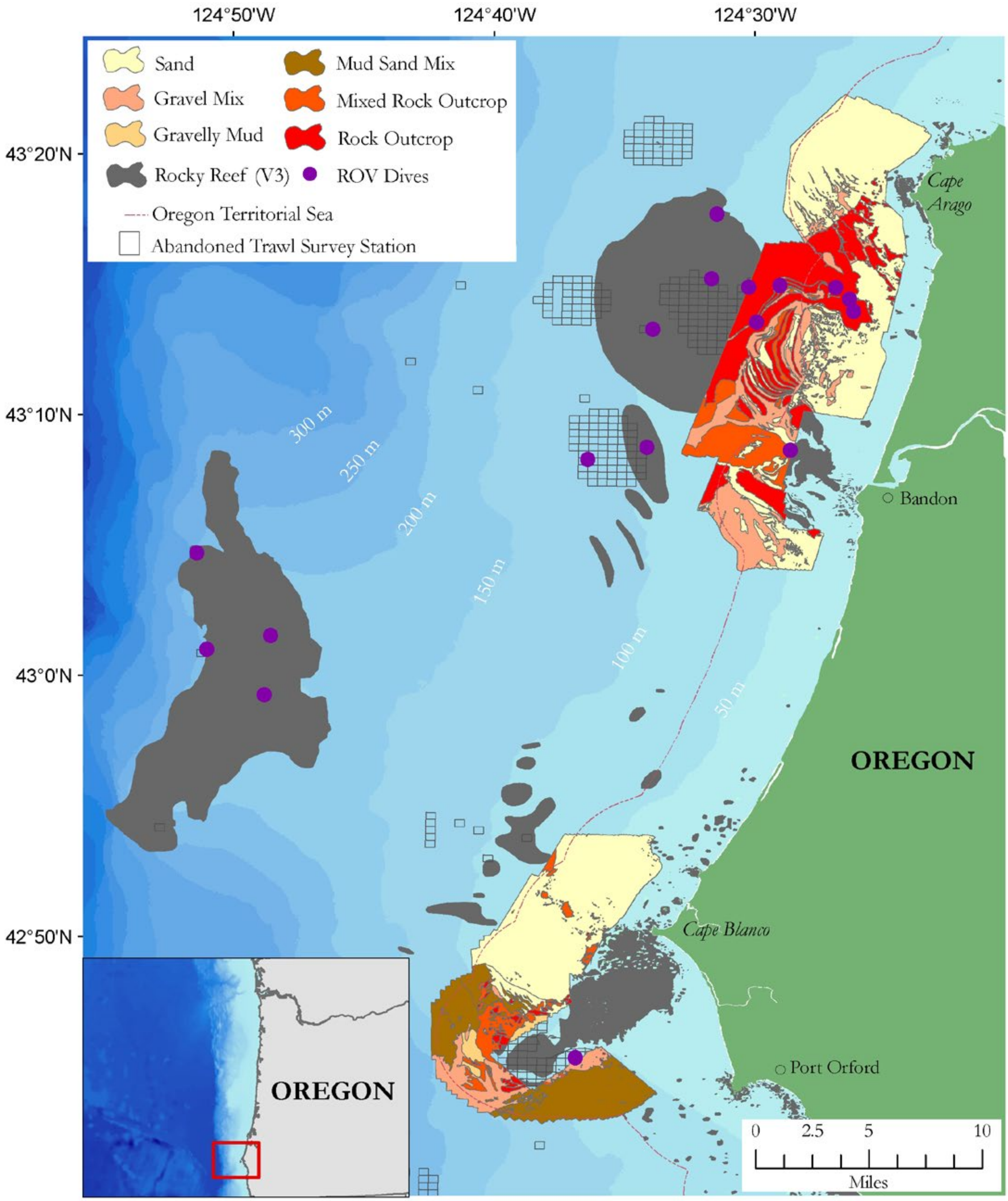


FIGURE 2. Dive sites overlaid with criteria used to select those sites, including: habitat classification maps (showing final data from OSU ATSML 2011), surficial geologic habitat data version 3 (OSU 2008) and abandoned trawl survey stations (Zimmerman 2003).



The research vessel's GPS was used to track where the ROV started each dive. After deploying the ROV off the stern ramp of the vessel, we would quickly dive it to the seafloor. Once at the seafloor, we utilized a roving diver technique which involves freely surveying the study area and recording all observations on high definition video for subsequent video analysis. We normally operated the ROV at a speed of roughly 0.2 knots (~0.36 km/hour) and occasionally we would land the ROV on the seafloor to stop and closely inspect features of particular interest. This roving diver technique allows for close examination of fish and invertebrate species and physical habitat features. While the ROV provides real time depth, compass bearing, and heading information for navigation, we did not have an underwater position system necessary for tracking the exact location of the ROV relative to the position of the boat. Using the compass heading of the ROV, we were able to navigate without covering the same ground twice.

While the survey was underway, the captain monitored the position of the vessel throughout the dive and made every effort to hold position. Each dive lasted between 30 minutes and 1.5 hours each. The only dive where the vessel drifted substantially was dive #4 at Orford Reef when we were operating in a 12 foot swell and 20 to 25 knot winds. There the vessel drifted approximately 0.25 km between deploying the ROV and retrieving it at the end of the dive.

VIDEO ANALYSIS

The roving diver method we used is complementary to visual transect surveys (Schmitt et al. 2002) and consistent with our study objectives. We analyzed the video to identify and describe the physical and biological habitats present as well as the fish species utilizing these areas. Fish identification and quantification with this technique gives an indication of rare versus common species within survey areas but not quantitative abundance or biomass. Since our interest was in surveying areas likely to contain rocky habitat, the habitat classification analyses are likely biased towards rocky habitats and the biogenic features present, rather than a random sampling of representative habitat types in the region. Our survey methods and video analysis methods were designed so that no areas within a dive were surveyed twice or double counted.

A. Continuous Analysis:

Fish Identification and Quantification

We analyzed video continuously from start to end point of each dive and all fish species were counted and identified to the lowest possible taxonomic level. Species listed in the Federal Groundfish Fishery Management Plan (FMP) were noted. Some species were difficult to distinguish on video and were assigned to broader species groupings such as Olive and Yellowtail Rockfish. Fishes that were unidentifiable, due to a lack of identifying characteristics or poor video quality, were labeled into the categories of unidentified rockfish, unidentified flatfish, young of the year (YOY) rockfish, and unidentified fish, and included in the non-FMP category. For every fish observed, the corresponding time, and the number of individuals of each species were recorded. Representative still images and video clips were extracted for each species, as well as for all individuals for which there was uncertainty about identification. All fish not clearly identifiable were subsequently reviewed by outside experts affiliated with the Institute for Applied Marine Ecology at California State University, Monterey Bay for positive identification.

B. Interval Analysis:

Information on the primary and secondary substrate types, relief and structure forming invertebrates was recorded for a single frame at intervals of 30 seconds for the entirety of each dive. In areas where data could not be extracted, video was played until data could be collected and the 30 second intervals resumed from that point forward. Further, data was only collected from a frame if there was no overlap with the previous frame to ensure habitat features were not double counted.

Habitat Classification: Physical Substrate and Relief

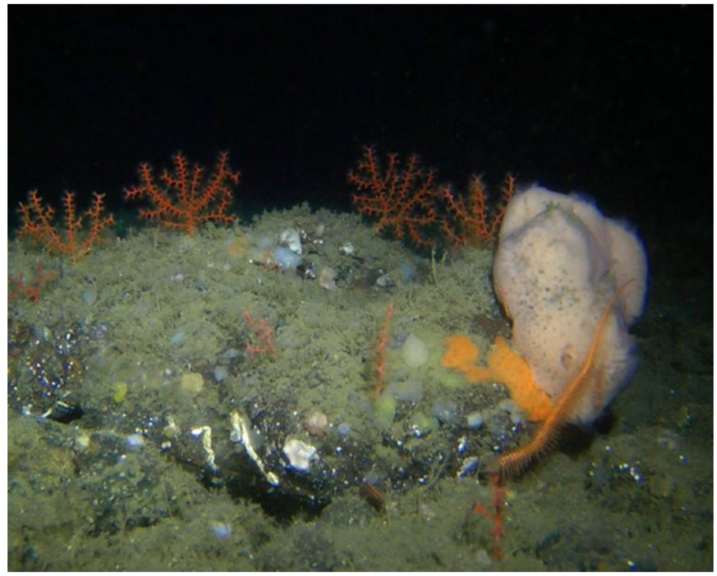
Dives 1-5 did not have a sizing laser therefore, substrate was classified into three broad categories: hard, mixed, and soft. The rest of the dives, 6-17, had a sizing laser affixed to the ROV 15 cm from the center of the screen. Substrate was classified at a finer scale for these dives and included five categories following the classifications of Greene et al. (1999) (Table 2). Substrate classifications were separated into primary (>50% of the frame) and secondary (at least 20% of the remaining frame), resulting in two substrate classifications for each 30 second sampling interval (Tissot et al. 2008). To compare substrate composition across different dives, all substrate was compared using the broader-scale classifications. Physical relief was classified as low (<1m), moderate (1m - 2m), and high (>2m) (Tissot et al. 2006).

Offshore Cape Arago: a canary rockfish hides alongside a sea anemone

TABLE 2. Description of substrate types based on availability of a sizing laser. With the sizing laser we were able to make fine-scale substrate classifications, which fall within the broader substrate categories of hard and soft.

WITHOUT SIZING LASER		WITH SIZING LASER	
SUBSTRATE CLASSIFICATION	DESCRIPTION	SUBSTRATE CLASSIFICATION	DESCRIPTION
Hard	Rock, including all grain sizes, from bedrock to cobble	Bedrock	Continuous flat rock
		Boulder	Individual rocks greater than 20 cm
		Cobble	Individual rocks smaller than 20 cm
Mixed	A combination of hard and soft substrates within one frame		
Soft	Soft sediment, including sand and mud	Sand	Grains visible, generally lighter color
		Mud	Grains not visible, generally darker color and in deeper water

Orford Reef: a basket star



Coquille Bank: gorgonian coral and sponge

Habitat Classification: Structure-forming Macro-invertebrates

We included structure-forming macro-invertebrates into the habitat classification due to their addition to habitat complexity (Auster et al. 2003; Tissot et al. 2006; Tissot et al. 2007). We seperated them into two broad categories: high (breaks the plain of the seafloor and extends into the water column, such as *Metridium sp*., crinoids, etc.) and low (small, or encrusting organisms that do not substantially break the plane of the seafloor, such as cup corals, encrusting sponges, burrowing brittle stars, etc.). Highly mobile invertebrates such as arthropods were not included, while primarily sessile invertebrates such as anemones and crinoids (feather stars) were included. The two categories of structure forming macro-invertebrates were recorded as being either present or absent for every 30 second sampling interval.

Sponge and Coral Identification

We recorded sponges and corals along with the habitat characteristics at 30 second intervals. Sponges were identified using broad morphology categories including: barrel, foliose, mound, branching, shelf, vase, and other (NOAA 2011). These broad categories were used to be consistent with those defined by NOAA and because no physical samples were collected for sponges; therefore, identification to species was not possible. Corals were identified to order including: *Alcyonacea* (soft corals), *Antipatharia* (black corals), *Gorgonacea* (sea whips, sea fans), *Pennatulacea* (sea pens), *Scleractinia* (cup corals), *Stylasterina* (branching hydrocorals), and Unidentified Corals (anything that does not fit into the other groupings) (PaCOOS [date unknown]). These categories were used to be consistent with NOAA's West Coast coral and sponge database where coral and sponge records have been collected during slope and shelf trawl surveys since 1977.

We recorded the presence of each category of coral and sponge at each 30 second interval of video. Sponge and coral presence was converted to an overall percentage of observations to compare relative occurrence among different dives. Since sponges and corals were observed at intervals, rather than continuously, it is likely that the presence of some categories were missed on each dive. To identify the co-occurrence of groundfish species with each category of corals and sponges, we noted the presence/absence of managed groundfish species on dives where we documented coral and sponge. This is considered "level 1" distribution data under NOAA essential fish habitat regulatory guidelines (50 CFR 600.815).

RESULTS

Overall, we observed 2,299 individual fish, 900 of which are federal Groundfish FMP species (Table 3). A total of 1,399 non-FMP and unidentified fish species were also recorded over all dives (Table 4). At least thirty-one percent of the unidentified rockfish were likely blue or black rockfish (*S. melanops*), which closely resemble each other, but we were unable to make a clear identification between the two due to poor video quality. These rockfish were often indistinguishable because they were just out of range of the ROV lights or out of range of the camera focus. Three orders of corals and six types of sponge morphologies were observed (Table 5).

TABLE 3. List of all FMP species observed for each study area.

FISH	SCIENTIFIC NAME	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF
Blue Rockfish	*Sebastes mystinus*	X	X	
Canary Rockfish	*Sebastes pinniger*	X	X	X
China Rockfish	*Sebastes nebulosus*	X		
Greenstriped Rockfish	*Sebastes elongatus*		X	
Olive/Yellowtail Rockfish	*Sebastes serranoides/flavidus*	X	X	X
Quillback Rockfish	*Sebastes maliger*	X	X	X
Rosy Rockfish	*Sebastes rosaceus*		X	X
Tiger Rockfish	*Sebastes nigrocinctus*		X	
Widow Rockfish	*Sebastes entomelas*		X	
Yelloweye Rockfish	*Sebastes ruberrimus*	X	X	X
Rex Sole	*Glyptocephalus zachirus*		X	
Kelp Greenling	*Hexagrammos decagrammus*	X	X	X
Lingcod	*Ophiodon elongatus*	X	X	X

TABLE 4. Non-FMP fishes observed for each study area.

FISH	SCIENTIFIC NAME	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF
Blackeye Goby	*Rhinogobiops nicholsii*		X	
Eelpout	*Zoarcidae*			
Hagfish	*Eptatretus stoutii*			
Poacher	*Agonidae*			
Ronquil	*Bathymasteridae*		X	
Unidentified Fish		X	X	X
Unidentified Flatfish			X	
Unidentified Rockfish*	*Sebastes sp.*	X	X	X
Y.O.Y. Rockfish	*Sebastes sp.*			

* 31 percent of unidentified rockfish were likely either blue or black rockfish but were not distinguishable due to poor video quality of the fish being too far in the distance to discern to make a positive species ID.

Inshore Cape Arago: sea anemones

OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL NUMBER OF OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
			16	4
	X		119	8
			2	1
		X	5	3
	X		45	6
	X		20	8
		X	17	4
			4	1
			571	1
	X		20	5
			1	1
X	X		38	9
X	X		42	9

OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL NUMBER OF OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
			1	1
		X	13	1
		X	1	1
		X	4	1
X	X	X	44	8
X	X	X	118	17
X	X	X	49	7
X	X	X	1144	12
	X		25	1

TABLE 5. List of corals and sponges observed for each study area.

CORALS	INSHORE CAPE ARAGO	OFFSHORE CAPE ARAGO	INSHORE COQUILLE REEF	OFFSHORE COQUILLE REEF	INSHORE ORFORD REEF	OFFSHORE COQUILLE BANK	TOTAL % OF FRAMES WITH OBSERVATIONS	NUMBER OF DIVES WITH OBSERVATIONS
Gorgonacea	X	X	X	X	X	X	20	14
Scleractinia	X	X	X		X		8	8
Stylasterina	X	X	X		X		2	5
SPONGES								
Barrel						X	1	3
Foliose	X	X	X	X		X	13	13
Mound	X	X	X	X	X	X	12	14
Branching	X	X	X	X	X	X	30	13
Shelf		X					0	1
Vase						X	0	1
Unidentified	X	X	X		X		2	8

TABLE 6. Co-occurrence of managed groundfish species with each category of corals and sponges on the same dive, indicating where groundfish were observed in habitats containing respective corals and sponges.

		Greenstriped Rockfish	Widow Rockfish	Quillback Rockfish	Blue Rockfish	China Rockfish	Tiger Rockfish	Canary Rockfish	Rosy Rockfish	Olive/ Yellowtail Rockfish	Yelloweye Rockfish	Rex Sole	Kelp Greenling	Lingcod	# Groundfish Species
CORAL (Order)	Gorgonacea	X	X	X	X	X	X	X	X	X	X		X	X	12
	Scleractinia		X	X	X	X	X	X	X	X	X		X	X	11
	Stylasterina		X	X	X	X	X	X	X	X	X		X	X	11
SPONGE (Morphology)	Barrel	X							X						2
	Foliose	X	X	X	X	X	X	X	X	X	X		X	X	12
	Mound	X	X	X	X	X	X	X	X	X	X		X	X	12
	Branching	X	X	X	X	X	X	X	X	X	X		X	X	12
	Shelf		X	X	X		X	X	X	X	X		X	X	10
	Vase														0
	Unidentified Sponge		X	X	X	X	X	X	X	X	X	X	X	X	12

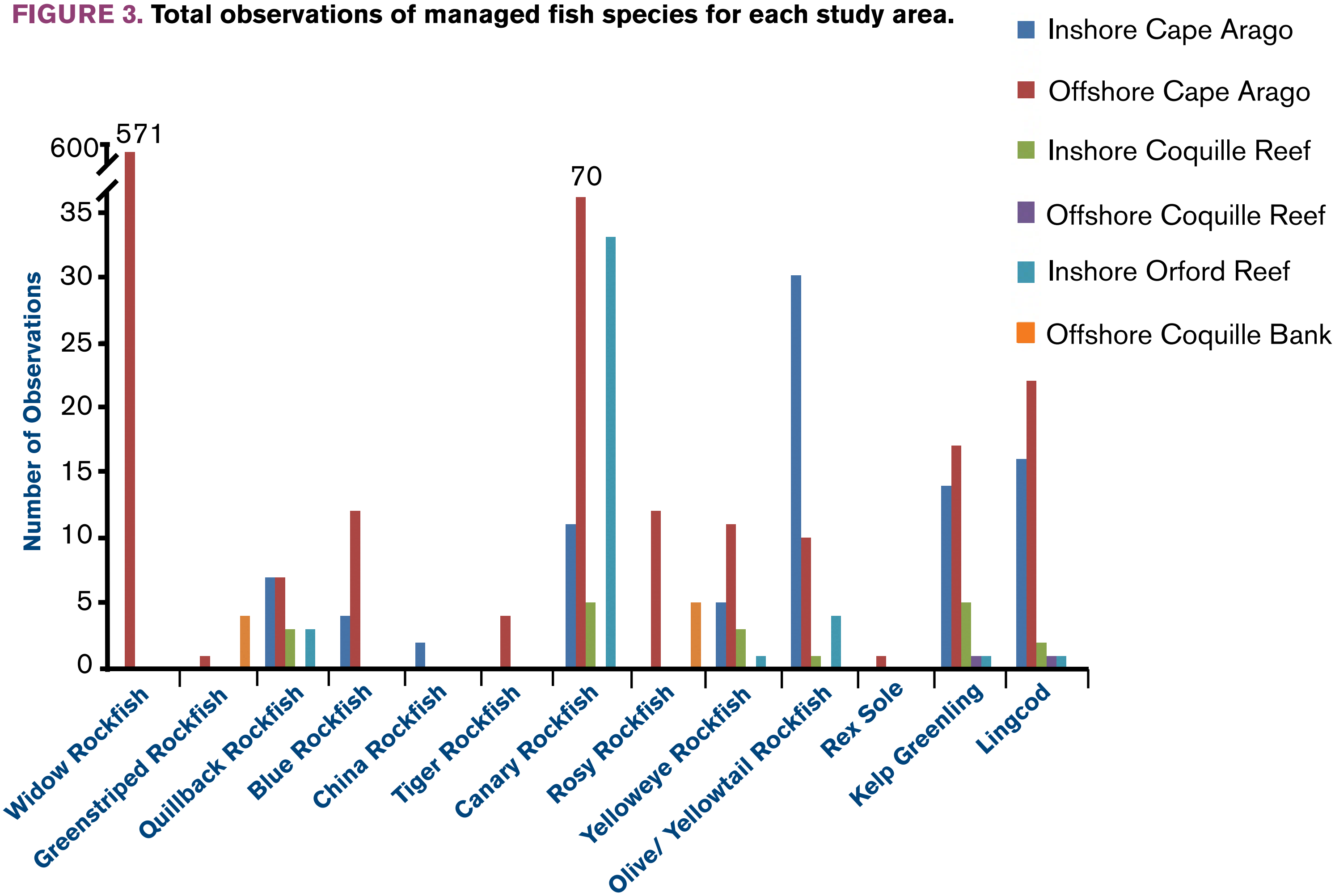
A. Continuous Analysis:

Fish Identification and Quantification

We identified a total of 13 FMP species at the different study sites (Figure 3). We observed twelve managed fish species at the offshore Cape Arago area, the highest number of species of all study sites. Here we also had the most fish observations of all study sites, with a total of 738 observations of managed fish species. At inshore Cape Arago we had the second highest number of fish observations at 89, followed by inshore Orford Reef with 43 observations, inshore Coquille Reef with 19 observations, offshore Coquille Bank with nine observations, and offshore Coquille Reef with two observations. When we normalize the number of managed fish observations by dive time we found the offshore Cape Arago area had the highest rate of managed fish observations at 2.76 fish observations/ minute of bottom time, followed by the inshore Cape Arago site at 0.88/minute, the inshore Orford Reef site at 0.54/minute, the inshore Coquille Reef site at 0.39/minute, the offshore Coquille Bank site at 0.05/minute, and finally the offshore Coquille Reef site at 0.02/minute.

At both offshore Coquille Reef and offshore Coquille Bank, we observed only two managed fish species, while at inshore Coquille Reef and inshore Orford Reef we observed six managed fish species. At inshore Cape Arago we observed eight managed fish species. Widow rockfish (*Sebastes entomelas*) and tiger rockfish (*S. nigorinctus*) were observed only at the offshore Cape Arago site. The species compositions of the inshore Coquille Reef and inshore Orford Reef sites were the same, but the number of observations differed, especially for canary rockfish (*S. pinniger*), which were observed at greater numbers at the inshore Orford Reef site.

FIGURE 3. Total observations of managed fish species for each study area.



B. Interval Analysis

Habitat Classification: Physical Substrate and Relief We grouped all substrates for reporting as hard, mixed or soft. Soft substrate was the most prevalent substrate type observed overall (Figure 4). The offshore Cape Arago, inshore Cape Arago, offshore Coquille Reef, and offshore Coquille Bank study sites are predominately composed of soft substrate, while the inshore Cape Arago site is dominated by hard substrate. The inshore Orford Reef study site has an even distribution of all substrate types.

The substrate compositions are slightly different for the identified secondary substrate (Figure 5). The offshore Cape Arago, inshore Cape Arago, offshore Coquille Reef, and offshore Coquille Bank study sites are still dominated by soft sediment, but offshore Coquille Reef and offshore Coquille Bank have a larger amount of hard substrate. The results of the secondary substrate analysis show the inshore Cape Arago study site to be dominated by hard substrate. The inshore Orford Reef study site has all three substrate types based on the secondary substrate analysis, but we observed slightly more hard substrate than soft or mixed.

Offshore Cape Arago: basket star and gorgonian coral

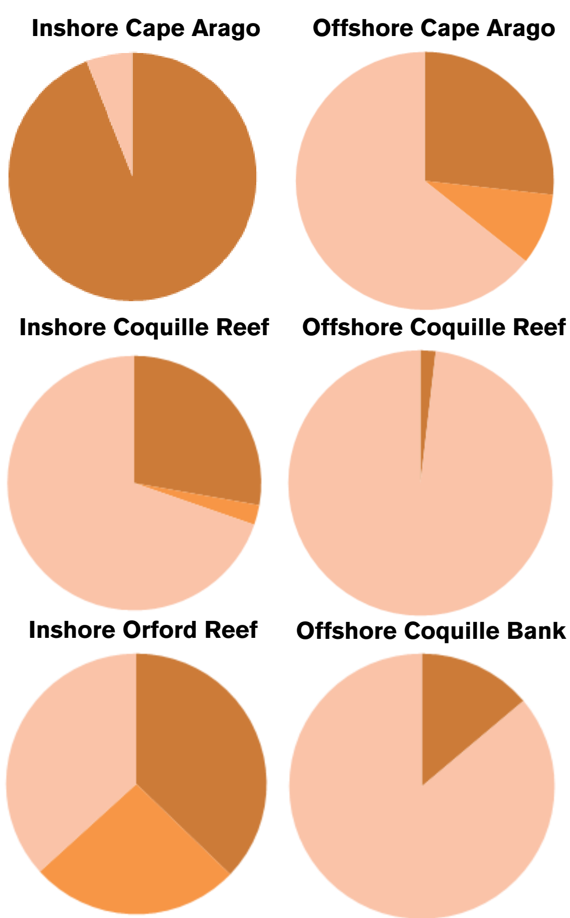
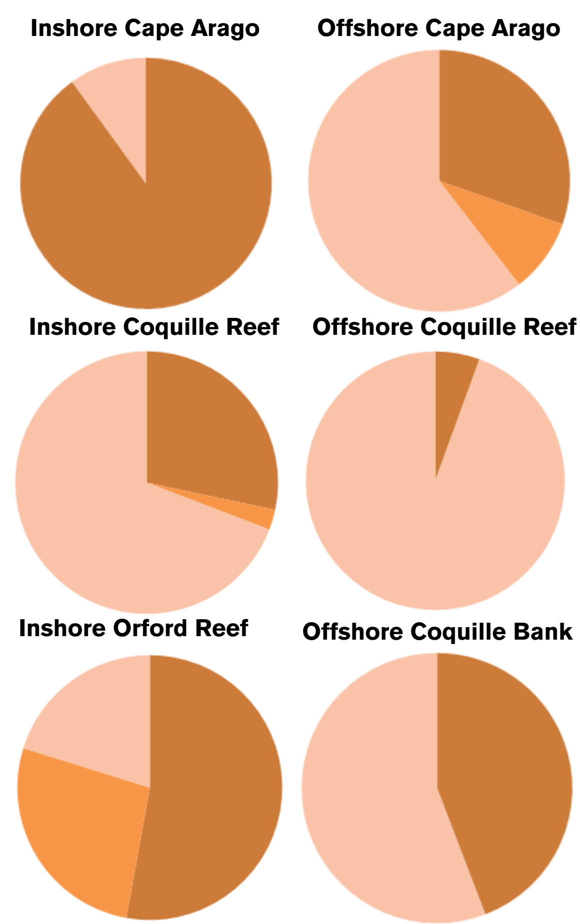


FIGURE 4. (left) Comparison of primary substrate (> 50% of the frame) among the six study areas.

Hard
Medium
Soft

FIGURE 5. (right) Comparison of secondary substrate (at least 20% of the remaining frame) among the six study areas.



All study sites are dominated by low relief habitat (Figure 6). The inshore Cape Arago and offshore Cape Arago study sites are the only sites where we documented high relief; however it was a very small percentage of the overall composition. Moderate relief made up approximately 25% of the inshore Cape Arago, offshore Cape Arago, inshore Coquille Reef, and inshore Orford Reef study sites.

Habitat Classification: Structure-forming Macro-invertebrates

We observed biogenic structure at all study sites. Low biogenic structure (less than 10 cm tall) was observed most frequently for all study sites except for offshore Coquille Reef, where bare substrate comprised approximately 40% of all observations (Figure 7). High biogenic structure was most abundant at the inshore Orford Reef study site, comprising approximately 40% of all observations.

Sponge and Coral Observations

We observed three coral orders in this study; Gorgonacea, Scleractinia, and Stylasterina (Figure 8). Alcyonacea, Antipatharia, and Pennatulacea were not observed at any of the study sites. We observed corals at all study areas and at 15 of 17 dives. We observed all three coral orders at the inshore Cape Arago, offshore Cape Arago, inshore Coquille Reef, and inshore Orford Reef study sites. At the offshore Coquille Reef and offshore Coquille Bank study sites only *Gorgonacea* corals were observed. Of all the study sites combined, the observed coral composition did not exceed approximately 30% of all observations (30% of all frames analyzed). For the offshore Cape Arago site, however, 36% of the frames we analyzed had coral.

We observed all sponge morphologies in this study (Figure 9). Sponges were also observed at all study areas and at 16 of 17 dives. Overall we observed more sponges than corals. Branching sponge was the most commonly observed morphology, followed by foliose and mound. Over 50% of the frames we analyzed for the offshore Cape Arago site had branching sponges. Barrel, shelf, and vase sponges were the least observed morphologies. At the offshore Cape Arago study site we had the highest number of sponge observations, followed by inshore Coquille Reef and inshore Cape Arago.

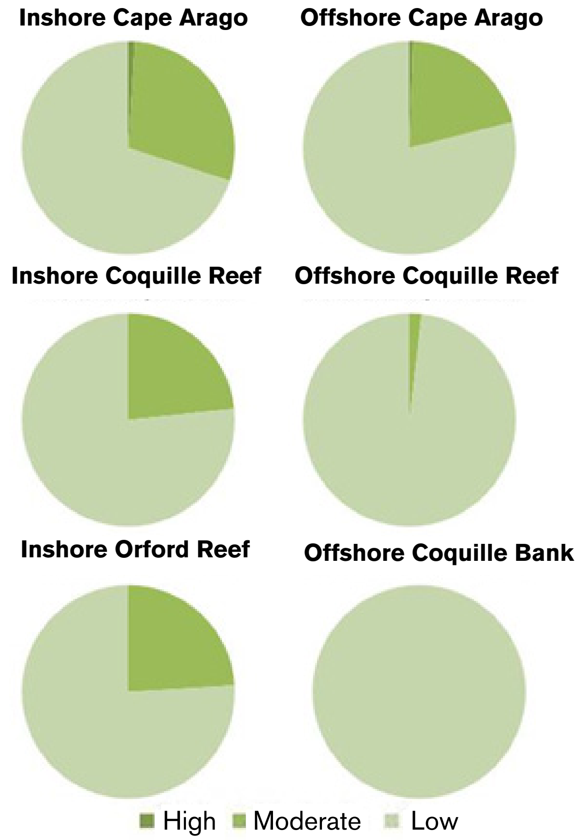


FIGURE 6. Comparison of relief among the six study areas.

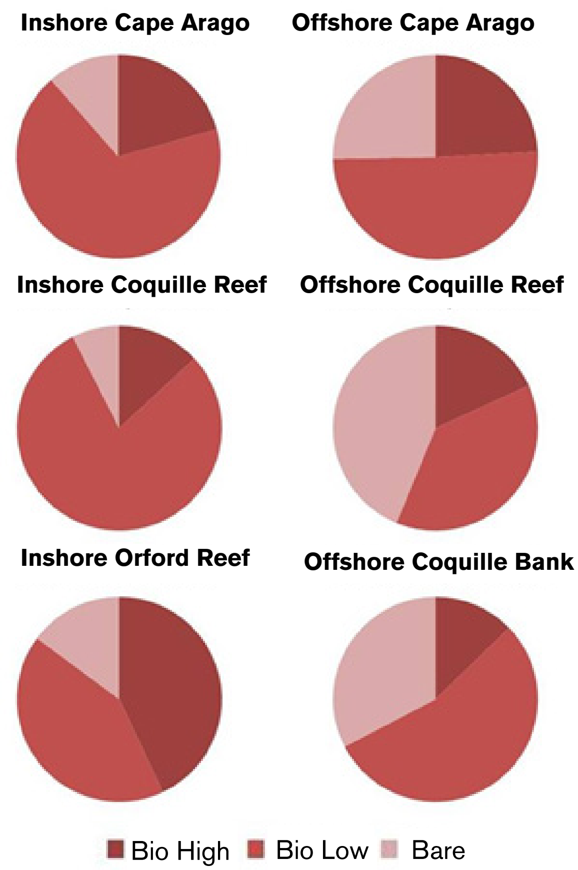


FIGURE 7. Comparison of structure forming macro invertebrates observed for each study area (Bio High = high biological structure, Bio Low = low biological structure).

FIGURE 8. Proportion of 30-second interval video frames with each coral type present. (%) indicates percentage of 30-second interval frames with one or more coral types within each study area: inshore Cape Arago (ICA), offshore Cape Arago (OCA), inshore Coquille Reef (ICR), offshore Coquille Reef (OCR), inshore Orford Reef (IOR) and offshore Coquille Bank (OCB).

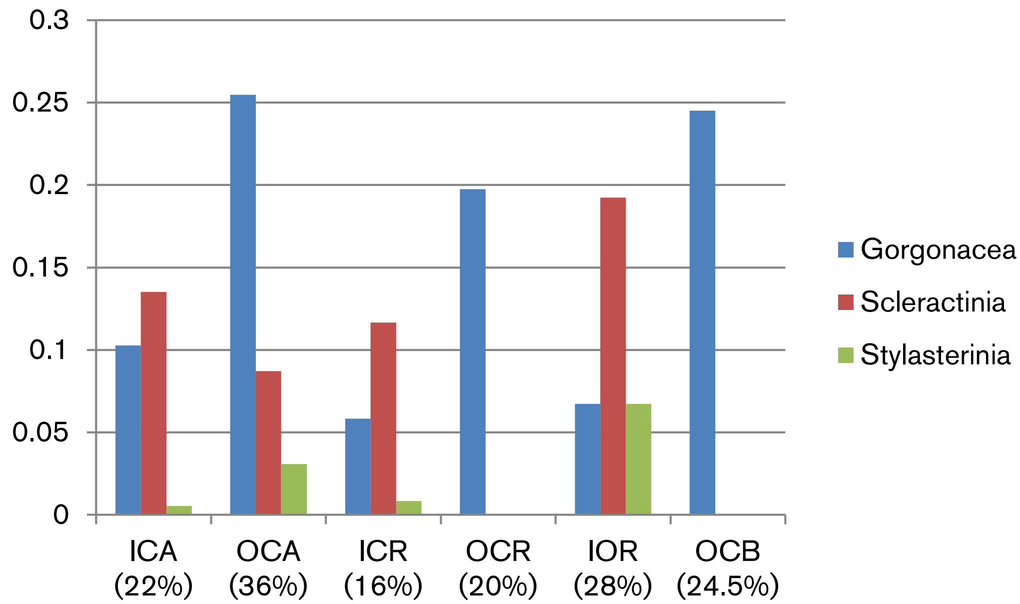
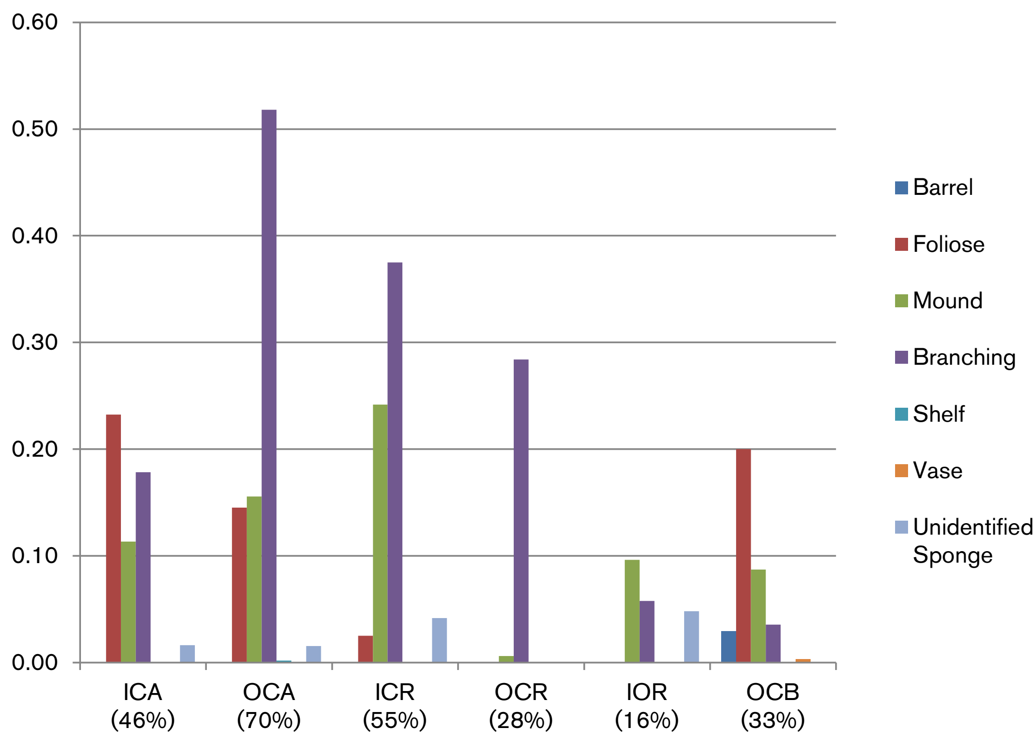
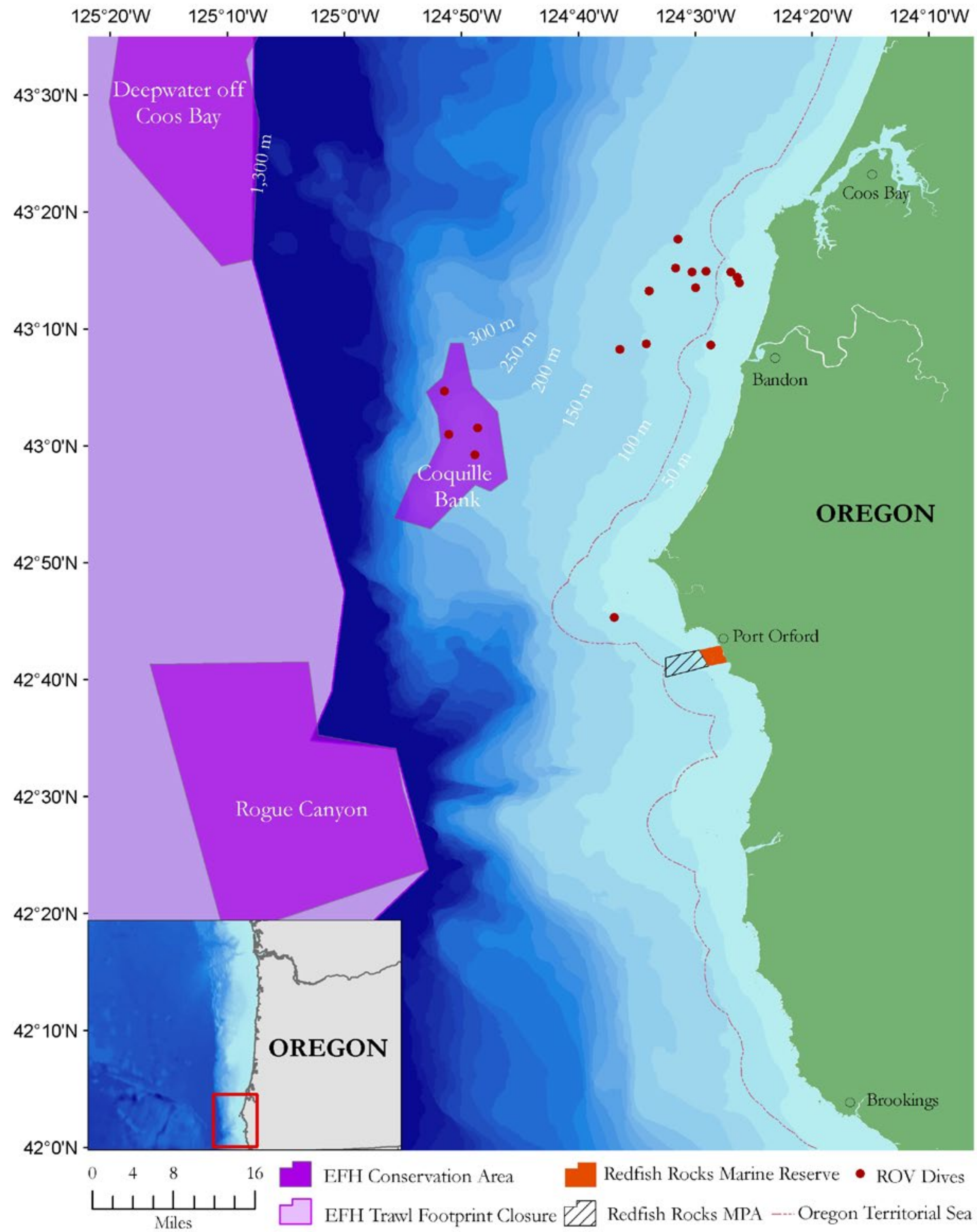


FIGURE 9. Proportion of 30-second interval video frames with each sponge morphology present. (%) indicates percentage of 30-second interval frames with one or more sponge types within each study area.



While this analysis did not examine fish behavior relative to various habitat components, we assessed whether each groundfish species occurred on the same dive as each coral and sponge category (Table 6). This provides "Level 1" presence/ absence information as described in the NOAA EFH regulatory guidance (50 CFR 600.815). We identified a total of 12 groundfish species present in habitats containing corals and sponges. Only rex sole was observed in a habitat area that did not contain coral.

FIGURE 10. ROV dives and state and federal marine protected areas off southern Oregon. EFH areas are closed to bottom trawling. The state Redfish Rocks area includes a no-take marine reserve and an MPA where fishing only for salmon and crab is allowed.



DISCUSSION

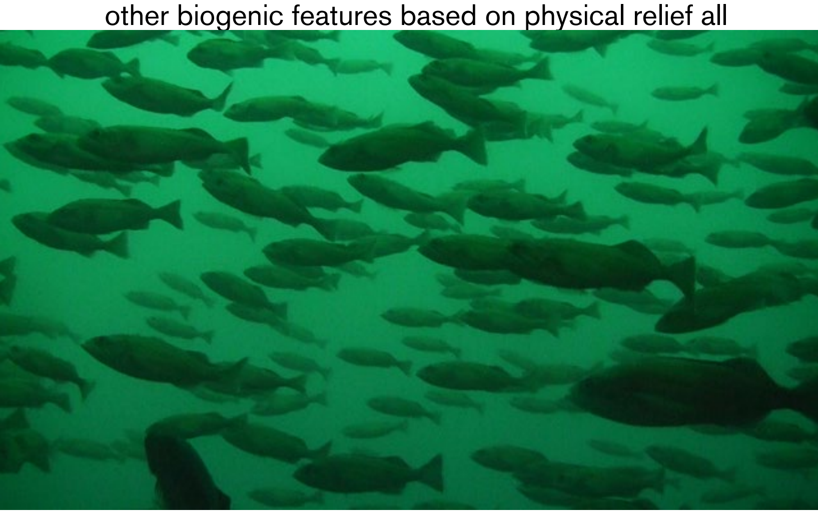
In this analysis we documented a diverse underwater ecosystem in the Pacific Ocean waters off Southern Oregon. With the ROV we surveyed and recorded a variety of physical and biogenic habitats and many different fish species across a wide range of depths. We also documented depleted fish species and sensitive habitat features that are vulnerable to impacts.

This analysis distills hours of video into site specific data designed to help improve understanding of the associations of managed fish species, physical and biological habitats, and coral and sponge distribution, across a range of different substrate types, depths and relief. The continuous analysis methodology used to analyze the ROV video allowed for detailed documentation of fish species in the areas surveyed and the interval analysis allowed for site characterization of the physical and biological seafloor habitats. Combining these methods provides a robust way to characterize the physical and biological habitat associations of fish species. This information increases our understanding of the biological communities in areas recently mapped with high resolution multibeam sonar and in areas for which there are little or no habitat data available.

The ROV allowed us to make *in situ* observations of complex habitats without disturbing the sites with extractive survey techniques such as trawls or dredges. Meanwhile without physical samples, identification of invertebrate species to the species level is not feasible, particularly the sponges. Grouping corals to taxonomic order, identifying sponges based on morphology, and other biogenic features based on physical relief all allow for a characterization of these sites indicative of habitat type, structural complexity and sensitivity consistent with analyses conducted by NOAA (NOAA 2011, Shester et al. 2012).

Of our data collected, the offshore Cape Arago area had the highest fish diversity and the highest percentage of coral and sponge observations of all areas observed. Our observations also suggest this area is primarily low physical relief. Thus, this diverse and relatively biologically rich habitat is likely susceptible to impacts from commercial bottom trawl gear. Our results suggest that closing this area to bottom trawling is warranted given the presence of sensitive habitat features and managed fish species.

Our data show the inshore reefs at Cape Arago, Coquille, and Orford all have similar compositions of corals and sponges. The inshore Cape Arago area had substantially more hard rock substrate in the areas we surveyed compared to the Coquille and Orford sites that have hard, soft and mixed substrates. We observed canary and yelloweye rockfish at all three inshore sites, as well as the offshore Cape Arago site, suggesting these areas with complex physical and biological features are important habitats for these overfished rockfish species. This finding largely confirms existing knowledge about the distribution of canary and yelloweye rockfish in the Oregon nearshore ecosystem except that essential fish habitat suitability maps did not previously identify the inshore Cape Arago site as habitat suitable for these overfished species (PFMC 2005).



Offshore Cape Arago: widow rockfish

Offshore Cape Arago: a red sea cucumber

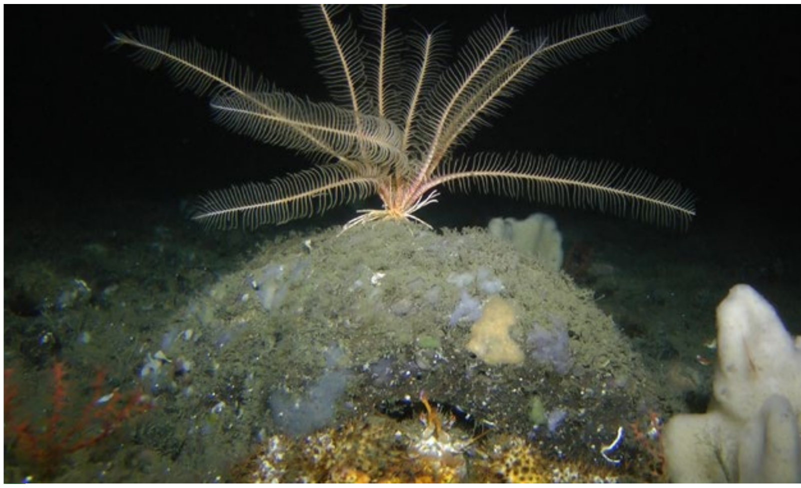
The offshore Coquille Reef study area, characterized by low physical relief and soft sediments had the fewest observations of macroinvertebrate structure and managed fish species. There was a noticeable contrast in this area between the two dive sites, where at dive number six we documented gorgonian corals, branching sponges and other high relief macroinvertebrates, and at dive number seven we documented far fewer biological features and no observed managed fish species. The only indication we had of high relief at dive number seven prior to deploying the ROV was the Zimmerman (2003) data suggesting a trawl hang in the area. The Zimmerman (2003) data may coarsely indicate areas of physical relief and structure, yet the OSU seafloor habitat data (OSU 2008) appears to be a more precise indication of seafloor habitat types in areas where those data are available. This could be further clarified with additional analysis of the data we collected, additional research dives, and multibeam seafloor habitat surveys.

The offshore Coquille Bank area is the only area studied that is currently protected from bottom trawling as part of the groundfish essential fish habitat conservation areas. We documented gorgonian corals, various sponge types, and managed fish species there and this area should remain protected. The other areas surveyed in state and in federal waters are not in any protected area status and these areas also have gorgonian corals, sponges and managed fish species. Closing these areas to bottom trawling would help ensure lasting protection for the habitats there.

There are important caveats to consider in interpreting quantitative data collected with the roving diver technique used in this study. Given the methodology used we cannot quantify the exact area surveyed and species counts cannot be extrapolated into quantitative estimates of abundance. This makes it difficult to draw comparisons of relative abundance or density of organisms across dive sites. The comparisons of relative abundance between survey areas should be viewed as initial estimates. Further, the 17 dives and 13.5 hours of video are a relatively small sample size compared to the large areas of reef habitat in the region. Additional dives and transects would be complementary to this study and further elucidate these findings.

A combination of roving diver technique and transect techniques could be used in future expeditions to allow for statistical comparisons between dive sites and for the identification of commercially and ecologically important species. This would allow for statistical analyses between dive sites while still allowing for detailed investigations of specific species, habitats and Important Ecological Areas.

Inshore Cape Arago: canary rockfish, sponge



Coquille Bank: the tip of a crab is visible underneath a rock decorated with a crinoid

CONCLUSION

This habitat assessment represents the first characterization of the nearshore rocky reefs in the Cape Arago inshore area, the offshore Cape Arago area and the nearshore Coquille reef area using an ROV. This is also the first reported seafloor habitat data collected inside the Coquille Bank essential fish habitat conservation area that was designated by the National Marine Fisheries Service in 2006 (NMFS 2006). In this study we documented commercially important groundfish species using biogenic habitat in both hard and soft substrates.

Our findings suggest that each of the areas surveyed are Important Ecological Areas as evidenced by the observations of managed fish species, sensitive seafloor habitat features such as corals and sponges, and complex physical and biological features. What is more, these findings significantly add to the direct observations of corals and sponge locations in the Pacific Ocean off southern Oregon.

In this habitat assessment we document Important Ecological Areas that are sensitive and vulnerable to disturbance and these areas warrant consideration for conservation as marine protected areas. The habitat and associated fish species information will be used in the Pacific Fishery Management Council's review of groundfish essential fish habitat identification and conservation. These findings will also be useful to current and future efforts to identify and protect Important Ecological Areas off the Oregon coast. Areas inside state waters should be considered for protection during marine spatial planning processes considering how to appropriately site renewable energy development, and in future Oregon marine reserve and protected area processes.

Simpson Reef at Cape Arago: an Important Ecological Area in southern Oregon.
Photo: Ben Nieves

LITERATURE CITED

Auster, P.J., J. Lindholm, and P.C. Valentine. 2003. Variation in habitat use by juvenile Acadian redfish, Sebastes fasciatus. Environmental Biology of Fishes 68: 381-389.

Auster, P.J., and R.W. Langton. 1999. The effects of fishing on fish habitat. In Fish Habitat: Essential Fish Habitat and Rehabilitation, Benaka, L. (ed.). American Fisheries Society, Bethesda, MD.

Ayers, J., A. Blacow, B. Enticknap, C. Krenz, S. Murray, S. Roberts, G. Shester, J. Short, and J. Warrenchuk. 2010. Important Ecological Areas in the Ocean: A comprehensive ecosystem protection approach to the spatial management of marine resources. Oceana. Available From: http://oceana.org/sites/default/files/reports/oceana_iea_discussion_paper.pdf

Council on Environmental Quality (CEQ), The White House. 2010. Final Recommendations of the Interagency Ocean Policy Task Force. Executive office of the President of the United States. July 19, 2010.

Goldfinger, C., 2010, Oregon State Waters Multibeam Mapping Project: A Progress Report. Corvallis, Oregon, Active Tectonics and Seafloor Mapping Laboratory pub. 2010-1, 26 p

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea Jr., and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Oceanologica Acta 22(6):663-678.

Hannah, R.W., S.A. Jones, W. Miller, and J.S. Knight. 2009. Effects of trawling for ocean shrimp (Pandalus jordani) on macroinvertebrate abundance and diversity at four sites near Nehalem Bank, Oregon. Fishery Bulletin 108(1) 30-38.

Hixon, M.A., and B.N. Tissot. 2007. Comparison of trawled vs untrawled mud seafloor assemblages of fishes and macroinvertebrates at Coquille Bank, Oregon. Journal of Experimental Marine Biology and Ecology. 344: 23-34.

Merems, A. 2003. 2002 Nearshore rocky reef assessment, ROV Survey. Newport, OR: Oregon Department of Fish and Wildlife. 24 pp.

National Marine Fisheries Service (NMFS). 2006. Final Rule Implementing Essential Fish Habitat Amendment 19 to the Groundfish Fishery Management Plan. 71 Fed.Reg. 27408 (May 11, 2006).

National Oceanographic and Atmospheric Administration (NOAA). 2011. Database for Coral Observations. Available from: http://www.ncdc.noaa.gov/paleo/corals.html

National Research Council (NRC). 2002. Effects of Trawling and Dredging on Seafloor Habitat. Washington, D.C, National Academy of Sciences, National Research Council.

Oceana. 2010. Protecting the Oregon Coast: Identifying and Protecting Important Ecological Areas. Available from: http://oceana.org/sites/default/files/reports/Oceana_IEAs_v6.pdf

Oregon Department of Fish and Wildlife (ODFW). 2012. Marine Reserve and Marine Protected Area Rules. OAR 635-012.

Oregon State University Active Tectonics and Seafloor Mapping Lab (OSU ATSML). 2011. Bathymetry, Backscatter, and Habitat Classification Maps. Oregon State University. Available from: http://activetectonics.coas.oregonstate.edu/state_waters_download.htm

Oregon State University (OSU). 2008. Version 3, Surficial Geologic Habitat, Washington and Oregon continental margins. Active Tectonics and Seafloor Mapping Lab. College of Oceanic and Atmospheric Sciences, Oregon State University.

Pacific Coast Ocean Observing System (PaCOOS) [date unknown]. Available from: http://pacoos.coas.oregonstate.edu/MarineHabitatViewer/viewer.aspx

Pacific Fishery Management Council (PFMC). 2012. Pacific Coast Groundfish 5-year Review of Essential Fish Habitat. Report to the Pacific Fishery Management Council. Phase I: New Information. Agenda Item H.6.b. EHRC Report 1. September 2012.

Pacific Fishery Management Council (PFMC). 2005. Pacific Coast Groundfish Fishery Management Plan. Appendix B Part 4. Habitat Suitability Probability Maps for Individual Groundfish Species and Life History Stages. Pacific Coast Groundfish EFH FEIS. December 2005.

Puig, P., M. Canals, J.B. Company, J. Martin, D. Amblas, G. Lastras, A. Planques, and A.M. Calafat. 2012. Ploughing the deep sea floor. Nature. Doi:10.1038/nature11410

Shester, G., and J. Warrenchuk. 2007. U.S. Pacific Coast experiences in achieving deep-sea coral conservation and marine habitat protection. Bulletin of Marine Science 81(1): 169-184.

Shester, G., N. Donlou, and M. Gorny. 2012. Important Ecological Areas Seafloor Habitat Expedition, Monterey Bay, California. Oceana. Available from: http://oceana.org/en/news-media/publications/reports/important-ecological-areas-in-monterey-bay

Thurman, H. V. and E. Burton. 2001. Introductory oceanography, Ninth Edition. Prentice Hall. Upper Saddle River. 554 p.

Tissot, B.N., M.M. Yoklavich, M.S. Love, K. York, and M. Amend. 2006. Structure-forming invertebrates as components of benthic habitat on deep banks off southern California with special reference to deep sea corals. Fishery Bulletin 104: 167–181.

Tissot B.N., M.A. Hixon, and D.L. Stein. 2007. Habitat-based submersible assessment of macro-invertebrate and groundfish assemblages at Heceta Bank, Oregon, from 1988 to 1990. Journal of Experimental Marine Biology and Ecology 352: 50-64.

Tissot, B.N. 2008. Video analysis, experimental design, and database management of submersible-based habitat studies. Marine Habitat Mapping Technology of Alaska: 97-105.

Schmitt, E.F., R.D. Sluka, K.M. Sullivan-Sealey. 2002. Evaluating the use of roving diver and transect surveys to assess the coral reef fish assemblage off southeastern Hispaniola. Coral Reefs 21: 216-223.

Weeks, H. and A. Merems. 2004. 2003 Nearshore Rocky Reef Habitat and Fish Survey, and Multi-Year Summary. Final Report for 2003-04 Grant. Cooperative Agreement No. 001-3176C-Fish. Oregon Department of Fish and Wildlife. 13 pp.

Zimmerman, M. 2003. Calculation of untrawlable areas within the boundaries of a bottom trawl survey. Can. J. Fish. Aquat. Sci. 60: 657-669.

ADDITIONAL INFORMATION:

A sample of the ROV video taken at the inshore Cape Arago area is available at: http://oceana.org/en/our-work/oceana-on-the-water/pacific-hotspots/video

Additional photos from this research expedition are available at: http://oceana.org/en/our-work/oceana-on-the-water/pacific-hotspots/photos

APPENDIX

FIGURE 11. Master table of all dives including managed fishes, corals, sponges, biogenic structure, substrate and relief.

Managed Fish (total observed)	Dive 1	Dive 2	Dive 3	Dive 4	Dive 5	Dive 6	Dive 7	Dive 8	Dive 9	Dive 10	Dive 11	Dive 12	Dive 13	Dive 14	Dive 15	Dive 16	Dive 17
Greenstriped Rockfish	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0
Widow Rockfish	0	0	571	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quillback Rockfish	4	1	4	3	3	0	0	0	0	0	0	0	2	1	2	0	0
Blue Rockfish	3	0	11	0	0	0	0	0	0	0	0	0	0	1	1	0	0
China Rockfish	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Tiger Rockfish	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canary Rockfish	2	2	7	33	5	0	0	5	0	0	0	0	0	9	56	0	0
Rosy Rockfish	0	0	5	0	0	0	0	0	2	3	0	0	0	0	7	0	0
Olive/ Yellowtail Rockfish	28	0	8	4	1	0	0	0	0	0	0	0	0	2	2	0	0
Yelloweye Rockfish	0	0	10	1	3	0	0	0	0	0	0	0	0	5	1	0	0
Rex Sole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kelp Greenling	4	3	5	1	5	1	0	0	0	0	0	0	1	9	9	0	0
Lingcod	5	1	12	1	2	1	0	0	0	0	0	0	4	7	9	0	0
Corals (proportion of frames)																	
Gorgonacea	0.00	0.16	0.14	0.07	0.06	0.33	0.00	0.45	0.60	0.06	0.12	0.09	0.10	0.15	0.37	0.40	0.00
Scleractinia	0.05	0.22	0.04	0.19	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.18	0.00	0.00
Stylasterinia	0.00	0.02	0.12	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
No Corals	0.95	0.65	0.71	0.72	0.84	0.67	1.00	0.55	0.40	0.94	0.88	0.91	0.82	0.66	0.45	0.60	1.00
Sponges (proportion of frames)																	
Barrel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00
Foliose	0.08	0.06	0.53	0.00	0.03	0.00	0.00	0.06	0.48	0.10	0.09	0.04	0.04	0.46	0.02	0.02	0.00
Mound	0.03	0.52	0.17	0.10	0.24	0.01	0.00	0.02	0.15	0.10	0.04	0.04	0.24	0.05	0.03	0.00	0.00
Branching	0.00	0.34	0.41	0.06	0.38	0.48	0.00	0.79	0.08	0.02	0.00	0.01	0.15	0.29	0.77	0.69	0.00
Shelf	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vase	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Unidentified Sponges	0.05	0.02	0.02	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.05
No Sponges	0.84	0.30	0.20	0.84	0.45	0.52	1.00	0.18	0.31	0.79	0.84	0.86	0.58	0.36	0.22	0.27	0.95
Biogenic Structure (proportion of frames)																	
High	0.58	0.51	0.30	0.49	0.14	0.30	0.05	0.29	0.56	0.00	0.00	0.00	0.13	0.20	0.54	0.42	0.27
Low	0.42	0.80	0.93	0.48	0.86	0.70	0.00	0.93	0.91	0.74	0.61	0.59	0.97	0.91	0.94	0.95	0.12
Primary Substrate (proportion of frames)																	
Hard	1.00	0.35	0.53	0.37	0.28	0.03	0.00	0.07	0.14	0.25	0.04	0.09	0.99	0.88	0.34	0.02	0.00
Mixed	0.00	0.30	0.11	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soft	0.00	0.35	0.36	0.37	0.70	0.97	1.00	0.93	0.86	0.75	0.96	0.91	0.01	0.12	0.66	0.98	1.00
Secondary Substrate (proportion of frames)																	
Hard	0.97	0.42	0.59	0.53	0.28	0.09	0.00	0.07	0.66	0.64	0.05	0.23	0.96	0.83	0.33	0.02	0.00
Mixed	0.00	0.31	0.11	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soft	0.03	0.27	0.30	0.20	0.69	0.91	1.00	0.93	0.34	0.36	0.95	0.77	0.04	0.18	0.67	0.98	1.00
Relief (proportion of frames)																	
High	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Moderate	0.32	0.24	0.47	0.24	0.23	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.36	0.23	0.23	0.00	0.00
Low	0.68	0.76	0.51	0.76	0.77	0.97	1.00	0.99	1.00	1.00	1.00	1.00	0.61	0.78	0.77	1.00	1.00
# of Frames Analyzed (interval analysis)																	
	38	124	129	103	120	96	66	112	95	84	57	74	67	80	105	55	60
Bottom Time (minutes)																	
	21	65	77	80	62	57	34	63	53	44	28	40	36	44	54	30	32
Depth (meters)																	
Range	40	72	55	63-69	39	96-98	118	80-82	126-128	205-210	127-129	226-228	28-34	38-41	60	80-81	99-100

Inshore Coquille Reef: kelp greenling

"We can only sense that in the deep and turbulent recesses of the sea are hidden mysteries far greater than any we have solved."

Rachel Carson, The Sea Around Us (1951)

Offshore Cape Arago: basket star and anemone

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Oceana is the largest international advocacy group working solely to protect the world's oceans. Oceana wins policy victories for the oceans using science-based campaigns. Since 2001, we have protected over 1.2 million square miles of ocean and innumerable sea turtles, sharks, dolphins and other sea creatures. More than 550,000 supporters have already joined Oceana. Global in scope, Oceana has offices in North, South and Central America and Europe. To learn more, please visit www.oceana.org.