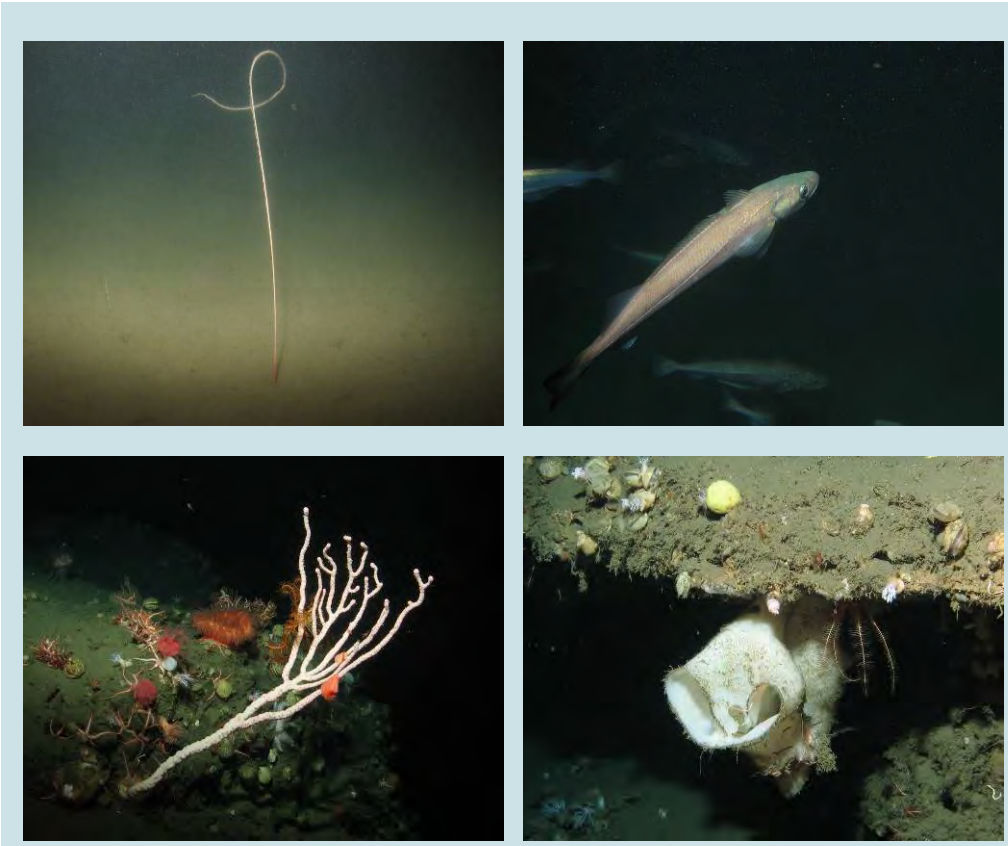
Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

CORDELL BANK NATIONAL MARINE SANCTUARY

Characterization of Cordell Bank, and Continental Shelf and Slope: 2018 ROV Surveys



NOAA ship *Bell M. Shimada*, August 2018

National Oceanic and
Atmospheric Administration

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Cover Photo
From top left to bottom right: *Halipteris californica* sea pen on the CBNMS continental shelf; Pacific hake *Merluccius productus*; Peppermint bubble gum coral, *Paragorgia yutlinux*, on the CBNMS slope; white Picasso sponge, *Staurocalyptus* spp. on the CBNMS slope.
Photo credit: CBNMS/NOAA

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Acknowledgments

We thank the science team from NOAA's Cordell Bank and Greater Farallones national marine sanctuaries and NOAA's National Centers for Coastal Ocean Science. We also thank the crew of the NOAA Ship Bell M. Shimada *and Marine Applied Research and Exploration (MARE) for providing their ROV and personnel. Scientists from U.S. Geological Survey, California Academy of Sciences, NOAA's Office of Coast Survey, and Greater Farallones Association participated in the mission. Funding and contributions were provided by NOAA's Deep Sea Coral Research and Technology Program, NOAA Office of National Marine Sanctuaries, NOAA National Ocean Service, NOAA Office of Marine and Aviation Operations, and MARE.*

Introduction and Cruise Objectives

NOAA's Cordell Bank National Marine Sanctuary (CBNMS), Greater Farallones National Marine Sanctuary (GFNMS), and National Center for Coastal Ocean Science (NCCOS) explored and characterized the benthic habitats in three national marine sanctuaries using a remotely operated vehicle (ROV) on the NOAA Ship *Bell M. Shimada* in August 2018. The team used Marine Applied Research and Exploration's (MARE) ROV *Beagle* to visually and systematically survey deep-water benthic habitats in CBNMS, GFNMS, and Monterey Bay National Marine Sanctuary (MBNMS) over various substrate types with the goal of characterizing deep-sea habitats and communities (corals, sponges, groundfishes, etc.) to inform sanctuary management of living resources. To assess baseline conditions, the team surveyed in two types of protected habitat zones, Essential Fish Habitat (EFH) and Rockfish Conservation Areas (RCA), that were proposed by the Pacific Fisheries Management Council (PFMC) to be re-opened to commercial bottom trawling. The final rule for the modifications to EFH and RCA (Amendment 28) became effective on January 1, 2020. Collections of biological specimens were identified by taxonomists at the California Academy of Sciences (CAS). The team also collected multibeam and backscatter data (led by NOAA's Office of Coast Survey) to map the seafloor and inform ROV dive planning.

ROV survey days were divided between CBNMS and GFNMS. Both sanctuaries had similar study objectives collecting mapping data, characterizing physical habitat and biological communities, visiting areas that have never been explored before, and assessing conditions in EFH and RCA areas before these areas re-opened to commercial bottom trawling. The specific science and management objectives in CBNMS were:

1) Survey areas in the RCA and EFH areas that were proposed by PFMC to be opened to commercial bottom trawling, at 80-200 meters. This was the first time assessing these areas since they were closed in 2005.

2) Explore and characterize new areas on the continental slope from 200-600 meters. Prior to these surveys, there was limited knowledge about the habitats and biological communities in this depth range for CBNMS.

3) Revisit sites on Cordell Bank for specimen collection and monitoring. One ROV dive on the bank was dedicated to collecting biological specimens to identify and better understand the organisms in the sanctuary. One ROV dive included resampling a historically surveyed area on Cordell Bank at 70-120 meters to monitor long-term changes to fish and invertebrate communities over time.

ROV dive sites and video analysis

Seven ROV dives were conducted in CBNMS from August 5- 9, 2018 (Figure 1 and Table 1) using the ROV *Beagle*. Digital video recorded on five of the seven dive sites was subset into quantitative transects that met specific criteria: the seafloor was in focus with clear visibility and the ROV moved at a consistent height and speed over bottom. The other two dives were on Cordell Bank (dives 13 and 14) and surveyed along a line (number 127) previously surveyed by a ROV in 2017, with the goal of collecting qualitative video, still images, and targeting specific specimens to be collected for identification.

While on transect, the ROV pilot strived to maintain a consistent height and speed from the bottom; targeting about 1 meter off the bottom and at a speed of 0.5 to 1 knot. During the dive, the ROV position was tracked using an ORE Trackpoint III ultra-short baseline acoustic positioning system which provided bearing and range from the NOAA Ship *Bell M. Shimada* to the ROV. The quantitative transects were used for classifying substrate (habitat type), species identification, and counts of corals, sponges, and fishes. Substrate type was classified using a two-code classification scheme based on particle size and vertical relief as described in Stein et al (1992). Distinct changes in substratum types greater than or equal to 10 seconds in duration along the transect were recorded, thus establishing “habitat patches” that were then summarized into three classes: hard rock (e.g., rock ridge, boulder, cobble), mixed (hard substrata combined with mud or sand), and soft (mud or sand) sediment. Individual corals, sponges, and fishes were identified to the lowest taxonomic level and recorded by time to be linked to geographic position. Some sponges were classified by general morphology (e.g., flat, foliose, barrel, and vase) when taxonomic identification was difficult. The maximum size of corals and sponges (to the nearest 5 cm) was determined using the set of paired scaling lasers spaced 10 cm apart and color of individuals was recorded. Condition of each coral and sponge was determined to be healthy (< 10% of organism is dead), unhealthy (10–50% is dead), or dead (> 50% of organism dead). Densities of corals, sponges, and fish were estimated by dividing the total number of each taxon by the area of each transect. Marine debris was also identified and georeferenced. Environmental data was collected by a Conductivity Temperature and Depth (CTD) sensor and Dissolved Oxygen (DO2) sensor on the ROV during each dive but was not analyzed for this report.

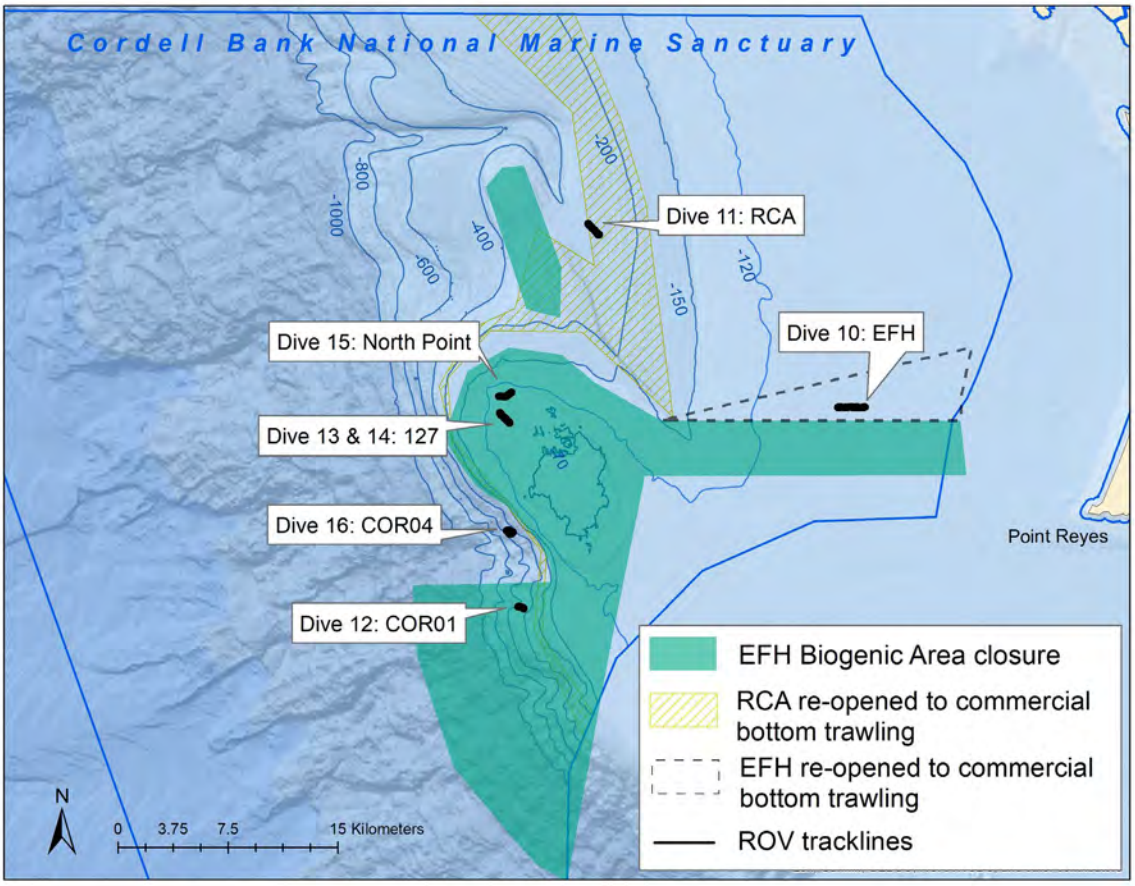

Figure 1. ROV Dive numbers and names at the survey sites in Cordell Bank National Marine Sanctuary.

Table 1. Dive details for the seven CBNMS ROV dives displayed in Figure 1.

Date	Dive Number	Name/Location	Num. quantitative transects	Maximum depth (m)	Minimum depth (m)
8/5/2018	10	EFH reopen to trawling	5	111	97
8/5/2018	11	RCA reopen to trawling	4	288	267
8/6/2018	12	COR01 Slope	3	543	453
8/8/2018	13	Line 127 Cordell Bank	none (collection dive)	106	91
8/8/2018	14	Line 127 Cordell Bank	none (collection dive)	97	79
8/8/2018	15	North Point Cordell Bank	5	84	55
8/9/2018	16	COR04 Slope	5	626	415

Chapter 1

ASSESSING CONDITIONS IN EFH AND RCA AREAS TO BE REOPENED TO COMMERCIAL BOTTOM TRAWLING

Essential fish habitat (EFH) for Pacific Coast groundfish was defined in 2006 as part of Amendment 19 to the Pacific Coast Groundfish Fishery Management Plan (FMP). In 2014, The Pacific Fisheries Management Council (PFMC) completed a review of EFH and determined that new information from the multi-year public process justified developing modifications to groundfish EFH. The PFMC began developing EFH alternatives and, separately, considered changes to the trawl rockfish conservation area (RCA). These efforts were merged into a single action under Amendment 28 to the groundfish FMP. The final rule went into effect on January 1, 2020 (C.F.R. 50 part 660) and includes:

1) New configuration of areas closed to bottom trawling to protect essential fish habitat (EFH);
2) Reopen the groundfish trawl RCA off Oregon and California to bottom trawling; and
3) Prohibit use of all groundfish bottom contact gear in waters off California deeper than 3,500 meters.

At the time of these surveys, the Cordell Bank Biogenic EFH was 149 square miles of protected benthic habitat. Amendment 28 opened 20 square miles of primarily sandy-mud habitat on the continental shelf to commercial bottom trawl fishing, while closing 19 square miles of shelf and slope habitat composed of hard and mixed substrate. The groundfish trawl RCA in CBNMS accounted for 60 square miles before being reopened.

The ROV dives conducted in August 2018 in the EFH and RCA reopen areas in CBNMS provided the most recent assessment and characterization for a portion of these areas before the final ruling on Amendment 28 went into effect opening these areas to commercial bottom trawling. Particular interest was given to enumerating corals and

sponges in these areas as they are long lived, slow growing species that are vulnerable to impacts from bottom trawling. Fish species were also enumerated.

Data Summary for Dive 10: EFH reopen to commercial bottom trawling

A total area of 1,792 m^2 was surveyed on five 15 minute transects on the continental shelf within the boundaries of an EFH trawl closure area that was reopened to commercial bottom trawling after the ROV survey was conducted (Figure 2, Appendix B). The seafloor habitat was 100% mud bottom and therefore the only corals observed were sea pens, *Halipteris californica*, at a density of one sea pen per square meter (Table 2). The sea pens were often very tall reaching a maximum height of 120 cm (Appendix A). Sea pen condition was recorded and 167 individuals (or 8.7% of total sea pens) were not upright and in dead or dying condition due to unknown reasons. One collection of *H. californica* was made to confirm species identification.

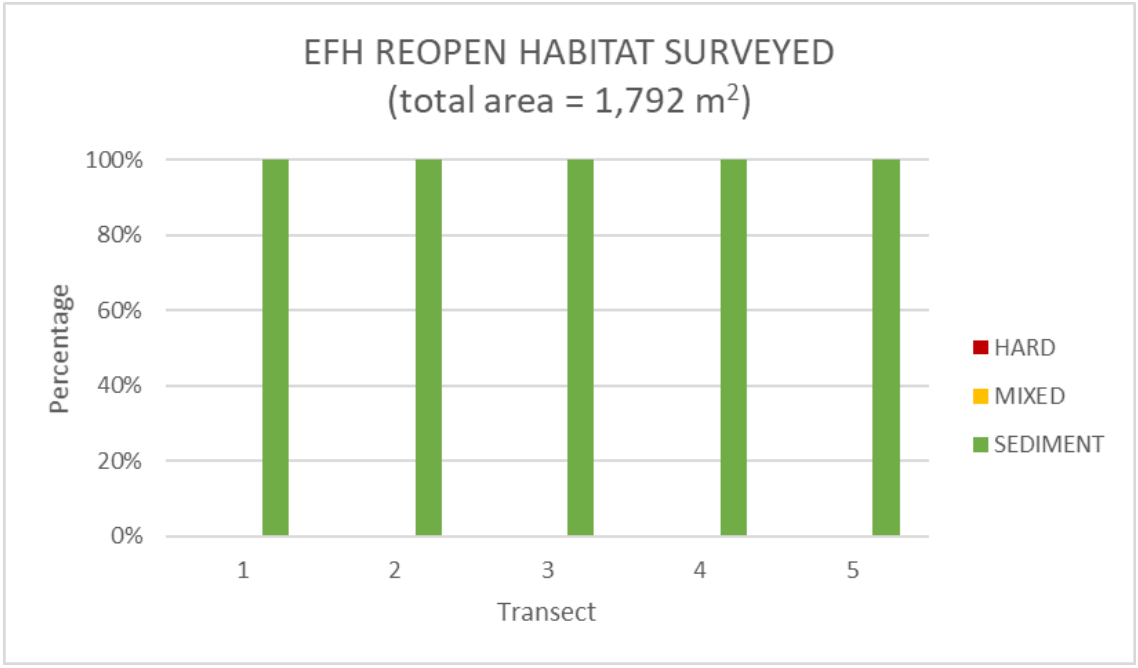

Figure 2. Percent of total habitat area surveyed per transect on dive 10. All transects were 100% soft sediment.

Table 2. Coral taxa observed on dive 10 reported as total number, percent of total corals, density per square meter, and height ranges and depth ranges.

Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Height Range (cm)	Depth Range (m)
CORALS						
Halipteris californica	Sea Pens	1929	100%	1	5-120	105-111

Fish taxa observed on transect were more diverse than invertebrates and were primarily dominated by flatfish species, as expected on soft substrate at this depth (Table 3). It was often difficult to distinguish the species of flatfish when individuals were buried in the mud or water column; visibility was low to determine if the individual was left eyed or right eyed, a distinguishing feature for flatfish species. At these depths of 105-111 meters on soft sediment, left eyed individuals would most likely be sanddabs. The other flatfish species listed in table 3 are right eyed.

Table 3. Fish taxa observed on dive 10 reported as total number, percent of total fish, density per square meter, and depth ranges.

Group	Family	Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Depth Range (m)
Flatfish	Pleuronectidae	*Citharichthys* spp.	Unidentified sanddab	121	20%	0.07	105-111
		Eopsetta jordani	Petrale sole	1	0.2%	0.001	110
		Glytocephalus zachirus	Rex sole	41	7%	0.02	106-110
		Lyopsetta exilis	slender sole	3	0.5%	0.002	108-110
		Microstomus pacificus	Dover sole	16	3%	0.009	106-110
		Parophrys vetulus	English sole	1	0.2%	0.001	109
		Pleuronectiformes	Unidentified flatfishes	402	67%	0.2	105-111
Rockfish	Scorpaenidae	*Sebastes saxicola*	Stripetail rockfish	2	0.3%	0.001	108-110
		Sebastes spp.	Unidentified rockfishes	3	0.5%	0.002	108-109
Other	Agonidae	Agonidae	Unidentifed poacher	2	0.3%	0.001	107-109
	Cottidae	Cottidae	Unidentified sculpin	1	0.2%	0.001	110
	Merlucciidae	*Merluccius productus*	Pacific hake	1	0.2%	0.001	107
	Gobiidae	*Rhinogobiops nicholsii*	Blackeye goby	1	0.2%	0.001	110
	Hexagrammidae	*Ophiodon elongatus*	Lingcod	3	0.5%	0.002	107-109
		Zaniolepis latipinnis	Longspine combfish	3	0.5%	0.002	108-110

Dive 10 Collections

# Sample ID	CAS IZ#	Genus/FAMILY/ HIGHER TAXON	Species	Time (UTC)	Latitude	Longitude	Depth (m)	Temp (c)	O2 Conc.
SH-18-19-015	228193	*Halipteris*	*californica*	13:30:23	38.0593	-123.1958	105	8.5	2.5

Data Summary for Dive 11: RCA reopen to commercial bottom trawling

A total area of 1,401 m^2 was surveyed on four 15 minute transects on the continental slope within the boundaries of the RCA closure area that was reopened to commercial bottom trawling after the ROV survey was conducted (Figure 3, Appendix B). The seafloor habitat was 100% mud bottom and a very limited number of sea pens, *Halipteris californica*, (n=18) were observed on transect (Table 4). Compared to the sizes of *H. californica* documented on the shelf on dive 10 in the EFH reopen area, these *H. californica* had a small range in height of 5-15 cm. Only one of the total 18 individuals was documented not upright in a dead or dying condition. No collections were made on this dive.

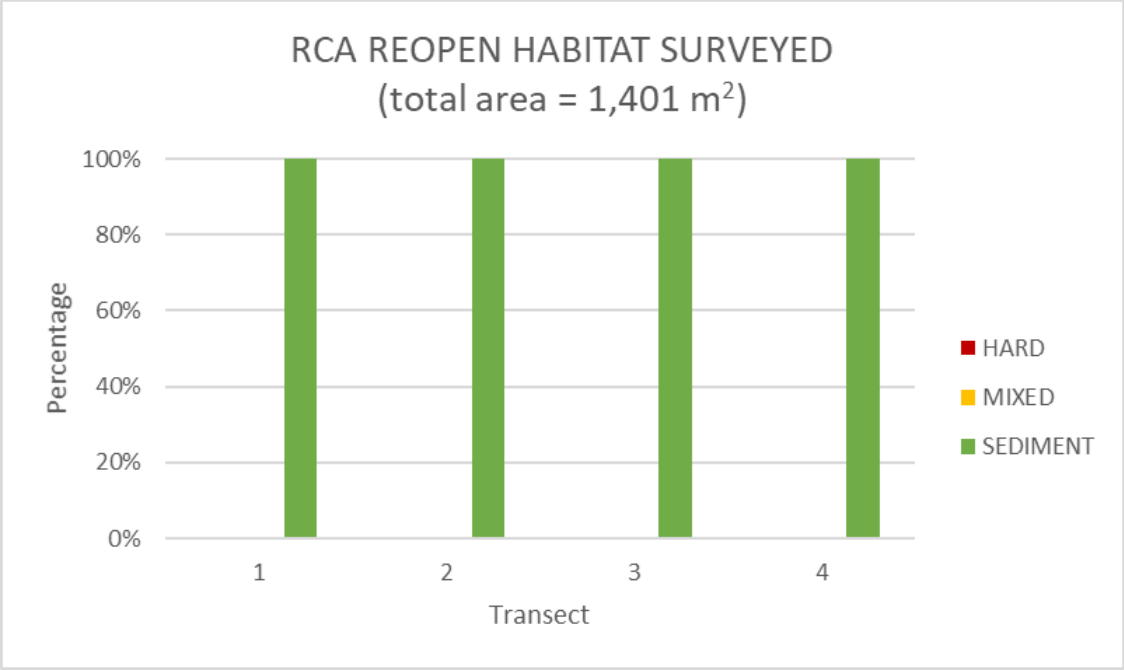

Figure 3. Percent of total habitat area surveyed per transect on dive 11. All transects were 100% soft sediment.

Table 4. Coral taxa observed on dive 11 reported as total number, percent of total corals, density per square meter, and height ranges and depth ranges.

Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Height Range (cm)	Depth Range (m)
CORALS						
Halipteris californica	Sea Pens	18	100%	0.01	5-15	272-280

Fish taxa observed on transect were more diverse than invertebrates with the greatest densities observed within the flatfish group; particularly Dover sole (*Microstomus pacificus*), Rex sole (*Glytocephalus zachirus*) and Slender sole (*Lyopsetta exilis*). High densities of Pacific hake (*Merluccius productus*) and Splitnose rockfish (*Sebastes diploproa*) were also observed (Table 5).

Table 5. Fish taxa observed on dive 11 reported as total number, percent of total fish, density per square meter, and depth ranges.

Group	Family	Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Depth Range (m)
Flatfish	Pleuronectidae	*Atheresthes stomias*	Arrowtooth flounder	1	0.2%	0.001	279
		Glytocephalus zachirus	Rex sole	56	13%	0.04	270-287
		Lyopsetta exilis	Slender sole	48	11%	0.03	270-287
		Microstomus pacificus	Dover sole	73	17%	0.05	270-287
		Unknown Pleuronectidae	Unidentified flatfishes	32	7%	0.02	270-287
Rockfish	Scorpaenidae	*Sebastes diploproa*	Splitnose rockfish	70	16%	0.05	270-287
		Sebastes saxicola	Stripetail rockfish	4	0.9%	0.003	277-286
		Sebastes spp.	Unidentified rockfishes	3	0.7%	0.002	270-280
		Sebastolobus altivelis	Longspine thornyhead	1	0.2%	0.001	286
		Sebastolobus spp.	Thornyheads	2	0.5%	0.001	280-285
Eelpout	Zoarcidae	*Lyconema barbatum*	Bearded eelpout	13	3%	0.009	269-287
		Lycodes cortezianus	Bigfin eelpout	2	0.5%	0.001	269-284
		Zoarcidae	Unidentified eelpout	8	2%	0.006	270-281
Other	Agonidae	Agonidae	Unidentifed poacher	34	8%	0.02	270-286
	Cottidae	Cottidae	Unidentified sculpin	1	0.2%	0.001	281
	Myxinidae	Eptatretus stoutii	Pacific hagfish	15	3%	0.01	272-287
	Merlucciidae	Merluccius productus	Pacific hake	71	16%	0.05	270-286
	Hexagrammidae	Ophiodon elongatus	Lingcod	1	0.2%	0.001	283
	Rajidae	Raja rhina	Longnose skate	1	0.2%	0.001	279

Chapter 2

CHARACTERIZING NEW DEPTH ZONES ON THE CBNMS SLOPE

Dive locations on the CBNMS slope in a depth range of 400-600 meters were selected from substrate maps interpreted from multibeam and backscatter data in areas that were predicted to have hard and mixed substrate types with high to moderate slopes, the preferred habitat for deep-sea corals and sponges. Knowledge about the types of habitats and animals living at 400-600 meters on the CBNMS slope was a data gap for the sanctuary as these bottom depths had not been previously sampled by a ROV. The depth ranges of dives COR01 (453-543 m) and COR04 (415-626 m) were important to build on the depth distribution data known from previously collected benthic datasets of deep sea coral and sponges (DSCS) and fishes from deeper and shallower areas on the CBNMS slope. Specifically, the other datasets include a ROV survey in 2010 that surveyed 167-497 meters, an autonomous underwater vehicle (AUV) survey in 2011 that surveyed 188-388 meters, and a ROV survey in 2017 that surveyed 866-1,116 meters.

Data Summary for Dive 12: COR01

A total area of 621 m^2 was surveyed on three 15 minute transects on the continental slope from 453-543 meters at dive site COR01 (Figure 4, Appendix B). Mixed substrate types on each transect accounted for greater than 60% of the total area. The mixed substrates included mud and high relief rock, mud and flat rock, and mud with rock covered in a mud veneer. The other substrate type observed was soft mud sediment. There were no areas on the three transects of all hard rock.

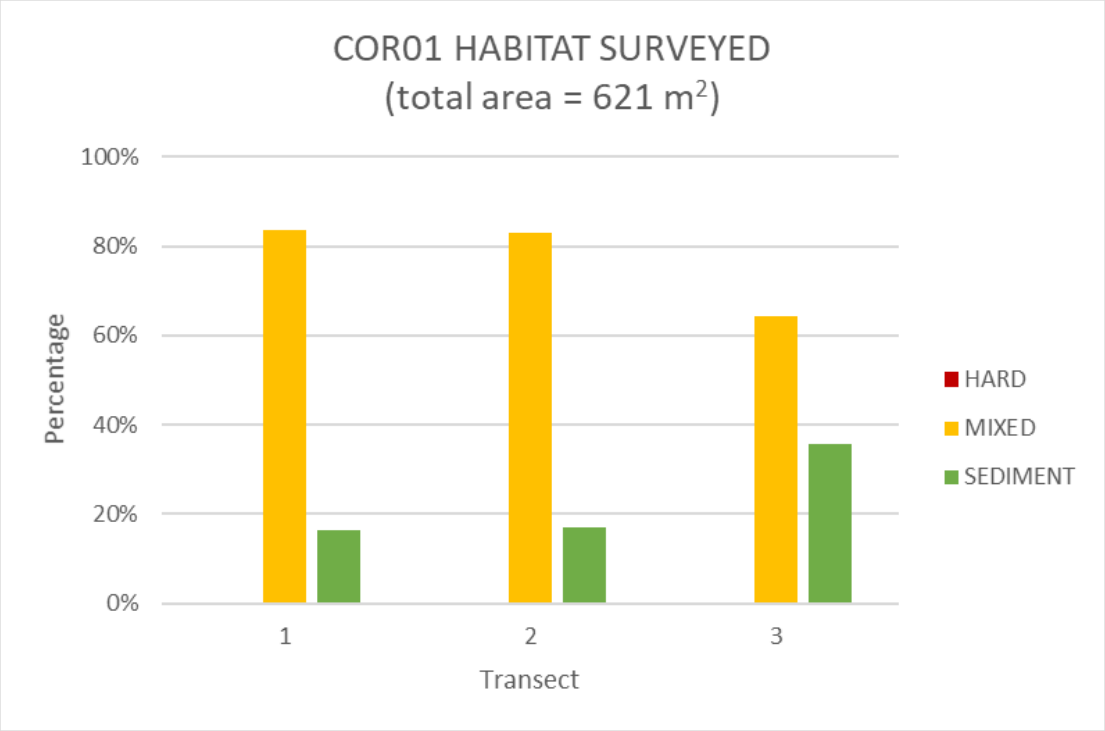

Figure 4. Percent of total habitat area surveyed per transect on dive 12 summarized into three habitat categories: hard, mixed, and soft. There was no consolidated hard rock observed.

The mixed mud and rock habitats (with the rock often being mud draped) resulted in coral and sponge species common for these type of substrates. The dominant corals were mushroom corals, *Heteropolypus ritteri*, accounting for nearly 95% of the total corals and sponges observed and an estimated density of one individual per square meter. Red fan gorgonians, *Swiftia* spp. (possibly species *S. pacifica*) were seen, but in low numbers accounting for only 2% of total corals and sponges. At least 10 taxa of sponges were documented and all accounted for 3% of total corals and sponges (Table 6). A new

observation for CBNMS was the club sponge, *Rhizaxinella gadus* (Appendix A). No collections of corals or sponges were made on this dive.

Table 6. Coral and sponge taxa observed on dive 12 reported as total number, percent of total corals and sponges, density per square meter, and height ranges and depth ranges.

Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Height Range (cm)	Depth Range (m)
CORALS						
Halipteris californica	Sea pen	2	0.2%	0.003	20-30	493-522
Heteropolypus ritteri	Mushroom coral	862	95%	1.4	5-15	479-540
Swiftia pacifica	Gorgonian	18	2%	0.03	5-20	479-541
SPONGES						
Farrea occa	Lace foliose sponge	2	0.2%	0.003	15-15	480-534
Polymastia spp. #1	White nipple foliose sponge	2	0.2%	0.003	10-10	496
Rhabdocalyptus dawsoni	Brown barrel sponge	6	0.7%	0.01	15-50	479-525
Rhizaxinella gadus	Club sponge	1	0.1%	0.002	25	523
Staurocalyptus spp.	White lacey vase sponge	2	0.2%	0.003	15-20	500-524
Morphological unkwn spp.	Barrel sponges unknown species	3	0.3%	0.005	5-15	511-534
	Branching sponges unknown species	6	0.7%	0.01	5-10	480-524
	Foliose sponges unknown species	3	0.3%	0.005	5	506-508
	Mound sponges unknown species	1	0.1%	0.002	5	486
	Shelf sponges unknown species	1	0.1%	0.002	15	504

Fish species in the rockfish group (Scorpaenidae) accounted for the highest counts of all fish taxa, particularly Thornyhead rockfish (*Sebastolobus* spp.), Shortspine thornyhead (*Sebastolobus alascanus*), and Longspine thornyhead (*Sebastolobus altivelis*) were 52% of total fish observed. The other rockfish species seen was Aurora rockfish (*Sebastes aurora*) as this area is this fish's preferred depth and habitat type. Flatfish species observed were Dover sole (*Microstomus pacificus*) and Deepsea sole (*Embassichthys bathybius*). Other types of fish documented included skates, poachers, sablefish, grenadiers, eelpouts and a notable count (n=6) of cat sharks (Table 7).

Table 7. Fish taxa observed on dive 12 reported as total number, percent of total fish, density per square meter, and depth ranges.

Group	Family	Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Depth Range (m)
Flatfish	Pleuronectidae	*Embassichthys bathybius*	Deepsea sole	3	2%	0.005	507-535
		Microstomus pacificus	Dover sole	19	15%	0.03	494-538
Rockfish	Scorpaenidae	*Sebastes aurora*	Aurora rockfish	19	15%	0.03	479-523
		Sebastes spp.	Unidentified rockfishes	2	2%	0.003	521-524
		Sebastolobus alascanus	Shortspine thornyhead	4	3%	0.006	502-540
		Sebastolobus altivelis	Longspine thornyhead	11	8%	0.02	480-539
		Sebastolobus spp.	Thornyheads	52	40%	0.08	480-539
Skate	Arhynchobatidae	*Bathyraja interrupta*	Sandpaper skate	1	0.8%	0.002	527
	Rajidae	*Raja rhina*	Longnose skate	2	2%	0.003	483-500
Other	Agonidae	Agonidae	Unidentifed poacher	4	3%	0.006	499-531
	Anoplopomatidae	*Anoplopoma fimbria*	Sablefish	1	0.8%	0.002	479
	Macrouridae	Macrouridae	Unidentified grenadier	1	0.8%	0.002	529
	Scyliorhinidae	Scyliorhinidae	Unidentified cat shark	6	5%	0.01	487-530
	Zoarcidae	*Lycodes cortezianus*	Bigfin eelpout	5	4%	0.008	480-538

Data Summary for Dive 16: COR04

A total area of 1,228 m^2 was surveyed on five 15 minute transects on the continental slope from 415-626 meters at dive site COR04 (Figure 5, Appendix B). The deepest transect (number 1) was the only transect of the five transects on this dive with hard rock-ridge substrate which was 8% of the transect's total area, with the remaining 92% being mixed substrates (mud and high relief rock and mud with rock covered in a mud veneer). Transects 2 and 4 had an almost equal proportion of the total area sampled being soft sediment and mixed substrates. Transect 3 was 100% mixed substrates (mud and high relief rock and mud with rock covered in a mud veneer) and transect 4 was 100% soft mud sediment.

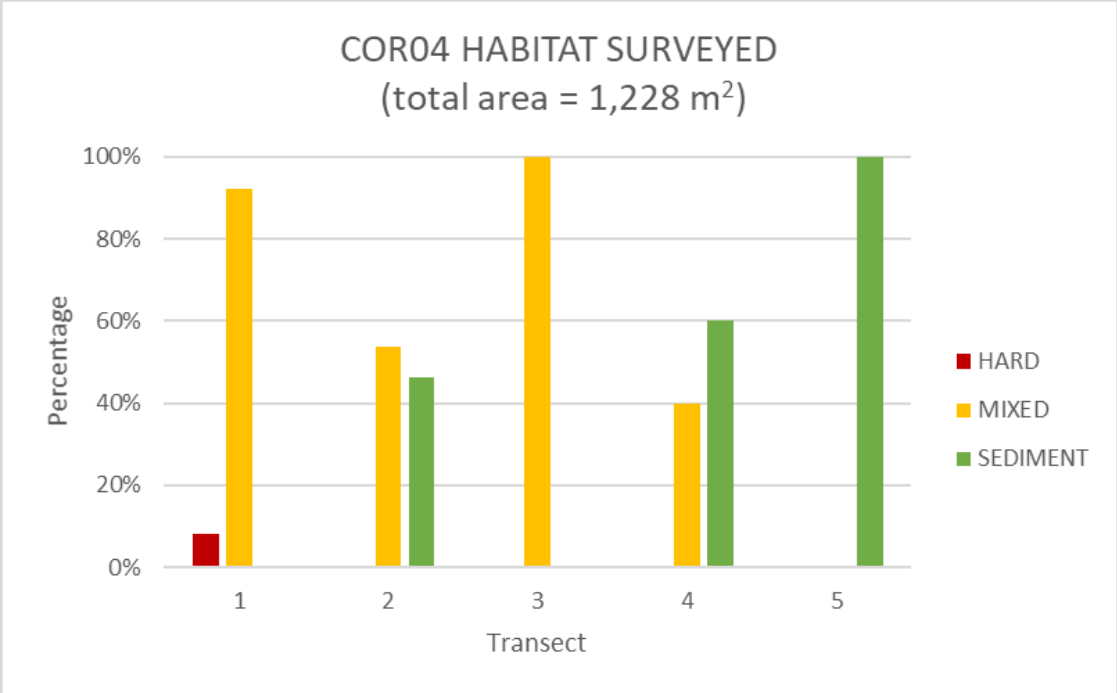

Figure 5. Percent of total habitat area surveyed per transect on dive 16 summarized into three habitat categories: hard, mixed, and soft.

Similar to dive COR01, mushroom corals *Heteropolypus ritteri* accounted for the greatest density of all corals and sponges on dive COR04. This dive also surveyed deeper depths than dive COR01, which revealed a higher abundance of red fan shaped *Swiftia* spp. (possibly *S. pacifica*) accounting for 34% of total corals and sponges and the presence of peppermint bubble gum corals (*Paragorgia yutlinux*) at the deepest depths of this dive at 579-623 meters (Table 8, Appendix A). Two specimens of *Swiftia* (sp. 1 and sp. 2) and one specimen of *P. yutlinux* were collected.

Brittle stars were often seen associated on *Swiftia* spp. (n=218 or 34% of all *Swiftia* individuals) and the majority of those individuals (n=153) were recorded to be in a healthy condition. There were a high number (n=158 or 24% of total individuals) of *Swiftia* spp. in a "dying" condition classified as 10-50% of the individual is dead and 7% of all *Swiftia* spp. individuals had greater than 50% of dead material (Appendix A). Furthermore, of those 7%, 22 total individuals were recorded being completely dead. There were no direct signs of physical disturbances to the seafloor or the over colonization of epiphytes on the unhealthy or dying corals. There could be underlying physical oceanographic conditions influencing the gorgonian's health so the fact that 31% of all *Swiftia* spp. observed on this dive are not completely healthy is the type of indicator that needs to be further monitored.

The sponge taxa seen on dive COR04 were similar to those observed on dive COR01. At least seven taxa of sponges were documented; accounting for 2.5% of total corals and sponges (Table 8).

Table 8. Coral and sponge taxa observed on dive 16 reported as total number, percent of total corals and sponges, density per square meter, and height ranges and depth ranges.

Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Height Range (cm)	Depth Range (m)
CORALS						
Halipteris californica	Sea pen	3	0.2%	0.002	20-35	559-586
Heteropolypus ritteri	Mushroom coral	1112	59%	0.9	5-15	557-623
Paragorgia yutlinux	Peppermint bubblegum coral	14	0.8%	0.01	15-40	579-623
Swiftia spp.	Gorgonian	645	34%	0.5	5-20	576-623
Virgularia spp.	Sea pen	53	3%	0.04	15-20	581-590
SPONGES						
Farrea occa	lace foliose sponge	4	0.2%	0.003	5	586-621
Poecillastra spp.	fringed shelf sponge	2	0.1%	0.002	5-25	582-601
Rhabdocalyptus dawsoni	brown barrel sponge	9	0.5%	0.007	10-30	579-621
Rhizaxinella gadus	club sponge	4	0.2%	0.003	5	586-621
Staurocalyptus spp.	white lacey vase sponge	5	0.3%	0.004	15-20	581-590
Morphological unkwn spp.	barrel sponges unknown species	3	0.2%	0.002	10-25	582-587
	puffball mound sponges unknown species	21	1%	0.02	5	610-621

Fish species in the rockfish group (Scorpaenidae) accounted for the highest counts of all fish taxa, particularly Thornyhead rockfish (*Sebastolobus* spp.), Shortspine thornyhead (*Sebastolobus alascanus*), and Longspine thornyhead (*Sebastolobus altivelis*) were 66% of total fish observed. Other rockfish species seen included Aurora (*Sebastes aurora*), Blackgill (*Sebastes melanostomus*), and Splitnose (*Sebastes diploproa*). Dover sole (*Microstomus pacificus*) was the second most abundant fish species, accounting for 16% of all fish observed. Other types of fish seen in lower abundances were similar to those seen on dive COR01, including eelpouts, grenadiers, skates, hake, hagfish, cat sharks, and a notable total percentage (4%) of Sablefish (*Anoplopoma fimbria*) (Table 9).

Table 9. Fish taxa observed on dive 16 reported as total number, percent of total fish, density per square meter, and depth ranges.

Group	Family	Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Depth Range (m)
Flatfish	Pleuronectidae	*Embassichthys bathybius*	Deepsea sole	3	0.8%	0.002	588-622
		Glytocephalus zachirus	Rex sole	3	0.8%	0.002	477-486
		Microstomus pacificus	Dover sole	57	16%	0.05	468-621
Rockfish	Scorpaenidae	*Sebastes aurora*	Aurora rockfish	2	0.6%	0.002	580-584
		Sebastes diploproa	Splitnose rockfish	3	0.8%	0.002	470-471
		Sebastes melanostomus	Blackgill rockfish	1	0.3%	0.001	472
		Sebastes spp.	Unidentified rockfishes	1	0.3%	0.001	588
		Sebastolobus alascanus	Shortspine thornyhead	35	10%	0.03	474-623
		Sebastolobus altivelis	Longspine thornyhead	46	13%	0.04	560-623
		Sebastolobus spp.	Thornyheads	167	46%	0.2	477-623
Eelpout	Zoarcidae	*Lycodes cortezianus*	Bigfin eelpout	6	2%	0.005	468-573
		Lycodes diapterus	Black eelpout	3	0.8%	0.002	471-492
		Zoarcidae	Unidentified eelpout	5	1%	0.004	479-589
Other	Anoplopomatidae	*Anoplopoma fimbria*	Sablefish	14	4%	0.01	469-622
	Myxinidae	*Eptatretus stoutii*	Pacific hagfish	7	2%	0.006	580-622
	Macrouridae	*Nezumia stelgidolepis*	California grenadier	3	0.8%	0.002	588-600
		Unknown Macrouridae	Unidentified grenadier	1	0.3%	0.001	601
	Scyliorhinidae	Scyliorhinidae	Unidentified cat shark	1	0.3%	0.001	491
	Merlucciidae	*Merluccius productus*	Pacific hake	3	0.8%	0.002	590-620
	Rajidae	*Raja rhina*	Longnose skate	1	0.3%	0.001	585

Dive 16 Collections:

# Sample ID	CAS IZ#	Genus/FAMILY/ HIGHER TAXON	Species	Time (UTC)	Latitude	Longitude	Depth (m)	Temp (c)	O2 Conc.
SH-18-19-028	228206	*Swiftia*	sp. 1	9:20:41	37.9828	-123.4752	621	5.5	0.43
SH-18-19-029	228207	*Swiftia*	sp. 2	9:25:25	37.9828	-123.4752	617	5.6	0.47
SH-18-19-030	228208	*Paragorgia*	*yutlinux*	9:31:05	37.9828	-123.4751	617	5.6	0.49

Chapter 3

LONG TERM MONITORING AND SAMPLING ON CORDELL BANK

Cordell Bank has been historically surveyed using various technologies and approaches ranging from scuba in the late 1970s, human occupied submersibles in the 2000s, and remotely operated vehicles in the 2010s. In 2016, CBNMS staff developed a comprehensive benthic monitoring plan to conduct consistent and comparable surveys that would enable scientists and managers to monitor and detect changes in benthic communities over time (Lipski and Graiff, 2017). The monitoring plan's survey design includes stratified random transects as well as "fixed sites" that had been historically sampled and will be repeatedly sampled into the future for comparison among years.

In 2017, CBNMS conducted a ROV survey on Cordell Bank focused on the depth strata of 70-120 meters. During this cruise there were numerous observations of small yellow gorgonians of unknown species, but attempts to collect a sample of an individual were not successful at the time of the cruise (Graiff et al., 2019). Therefore, two dives (numbers 13 and 14) conducted in 2018 were dedicated to sampling line number 127 and targeting collections of gorgonian corals. The "fixed site" named North Point was surveyed on dive 15 to build on invertebrate and fish datasets previously collected at this site to monitor patterns or changes in the benthic communities over time.

Data Summary for Dives 13 and 14: Line 127

Two samples of the unknown yellow gorgonian were made and were determined to be a new species, later described and named *Chromoplexaura cordellbankensis* (Williams and Breedy, 2019, Appendix A). Three samples of the red branched gorgonian were made to confirm the species identification as *Chromoplexaura marki.* Other taxa of unknown species targeted for collection included an encrusting tunicate and a gray "plate" shaped sponge; both were commonly seen on ROV video collected in 2014 and 2017. Another finding from the 2018 collections were cup corals, *Coenocyathus bowersi*, determined to be the most northern observation and specimen collection for this species (Gary Williams, CAS, pers. comm., 2020, Appendix A). Tables 10a and 10b list collection details for the specimens collected on line 127 and the collection locations of those species are shown on the map in figure 6.

Table 10a. Collections made on dive 13

# Sample ID	CAS IZ#	Genus/FAMILY/ HIGHER TAXON	Species	Time (UTC)	Latitude	Longitude	Depth (m)	Temp (c)	O2 Conc.
SH-18-19-016	228194	*Chromoplexaura*	*cordellbankensis*	10:31:55	38.0544	-123.4802	102	9.8	5.9
SH-18-19-017	228195	*Chromoplexaura*	*cordellbankensis*	11:03:33	38.0542	-123.4800	101	9.6	5.9
SH-18-19-018	228196	*Chromoplexaura*	*marki*	11:13:30	38.0540	-123.4797	100	9.8	6
SH-18-19-019	228197	*Chromoplexaura*	*marki*	11:36:21	38.0538	-123.4796	97	9.7	5.9
SH-18-19-020	228199	*Swiftia*	sp. 1	11:53:43	38.0537	-123.4795	98	10	5.9
SH-18-19-021	228201	Didemnidae		11:59:59	38.0536	-123.4794	95	9.6	5.9

Table 10b. Collections made of dive 14

# Sample ID	CAS IZ#	Genus/FAMILY/ HIGHER TAXON	Species	Time (UTC)	Latitude	Longitude	Depth (m)	Temp (c)	O2 Conc.
SH-18-19-022	228202	Plexaurid axis with anemones		13:31:00	38.0533	-123.4790	97	9.8	5.9
SH-18-19-023	228203	*Chromoplexaura*	*marki*	13:52:44	38.0524	-123.4778	90	9.6	5.9
SH-18-19-024	228204	*Coenocyathus*	*bowersi*	14:05:24	38.0522	-123.4775	86	9.7	5.9
SH-18-19-025	228205	Hexactinellida		14:56:56	38.0500	-123.4748	82	10	6

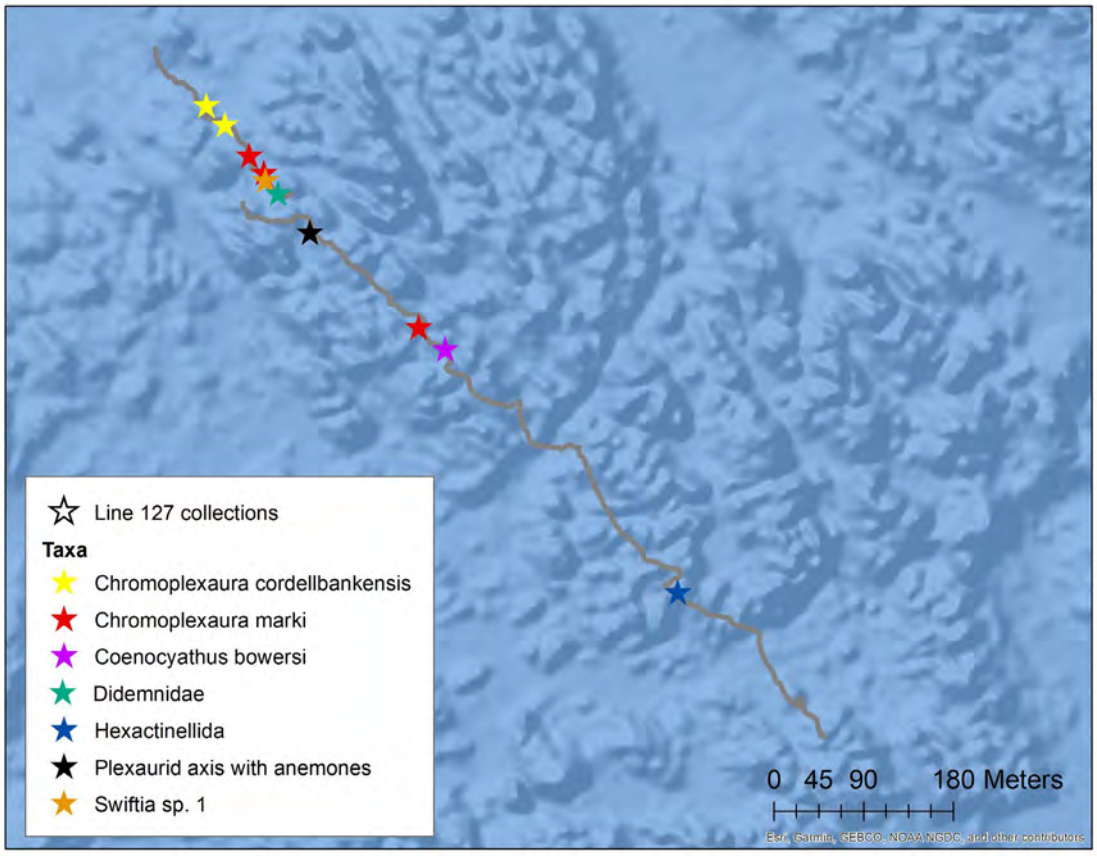

Figure 6. Collection locations of the taxa sampled and identified from dives 13 and 14 on Cordell Bank line 127.

Data Summary for Dive 15: North Point

A total area of 1,088 m^2 was surveyed on five 10 minute transects at the fixed site North Point (Figure 7, Appendix B). This site has been historically surveyed three times by the Delta submersible in the 2000s and by a ROV in 2017. Transects are 10 minutes long to be consistent with methods from the 2017 survey. Fixed sites, like North Point, control for other habitat variables to better understand biological patterns or changes in the invertebrate and fish communities. For example, conducting quantitative transects in the same area over the long term (decades), enables monitoring large changes in issues like coral and sponge health, counts of young-of year (YOY) rockfish, and detecting invasive species.

The primary substrate sampled at North Point was high relief hard rock and boulders accounting for 60-100% of the total area for each of the five transects (Figure 7). The mixed habitats included rock ridge or boulders with sand. The soft sediment habitats seen on transect 2 were small areas of flat sand between areas of rock that are characteristic of this depth and location of Cordell Bank.

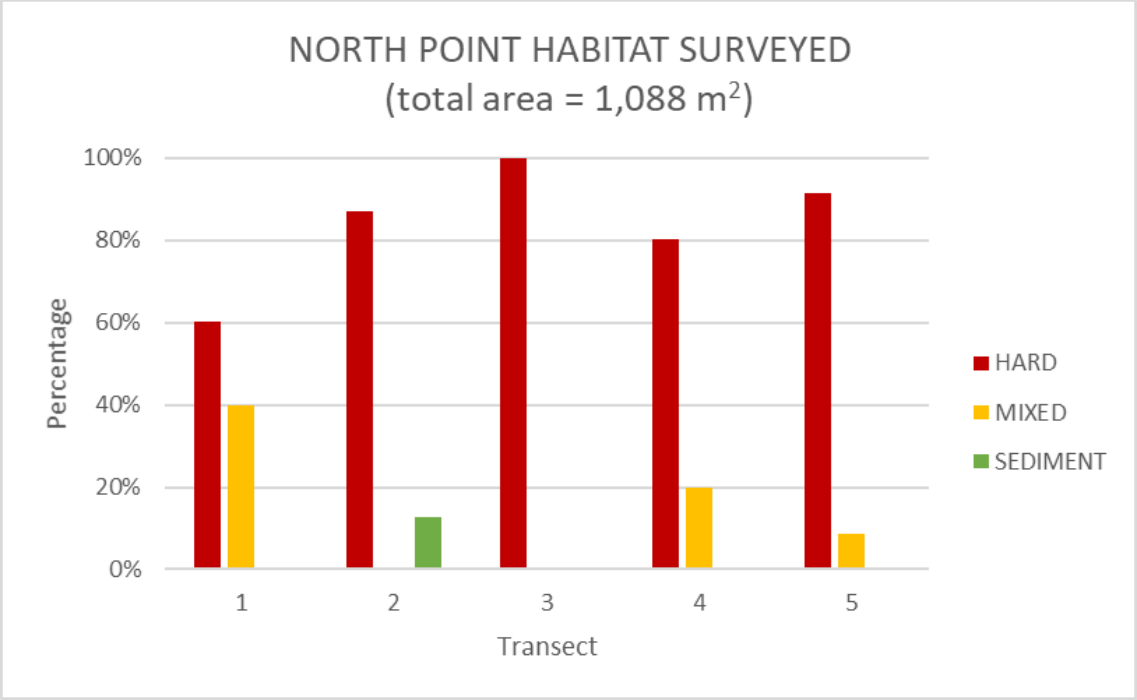

Figure 7. Percent of total habitat area surveyed per transect on dive 15 summarized into three habitat categories: hard, mixed, and soft.

The dominant coral and sponge at North Point is the hydrocoral *Stylaster californicus* and "Cordell sponge" *Xestospongia edapha*, each species had a density of three individuals per square meter (Appendix A). Gorgonian corals, *Chromoplexaura marki* and *Swifita* spp., accounted for less than 1% of the total corals and sponges (Table 11). The gorgonians were documented to be in healthy condition with only five of the total 39 gorgonians having associated ovulid snails (possibly *Simnia* sp.). Data from the 2017 ROV survey on Cordell Bank found ovulid snails on 10% of total gorgonians, in highest abundance on healthy corals and lower abundance on dead or dying corals (Graiff et al., 2019). Ovulid snails are known to be predators on gorgonian corals (Williams, pers. comm.,) so resampling North Point on future surveys will allow us to monitor changes in gorgonian health and abundance.

We were also interested in monitoring a species of gray encrusting tunicate that has been observed on Cordell Bank as early as 2002 and in relatively higher abundances in 2014 and 2017 (Graiff and Lipski, 2016 and Graiff et al., 2019). A sample was collected on dive 13 along line 127 and identified to be a tunicate in the family Didemnidae (Appendix A). At this time it seems that this tunicate is common for the area (it has also been observed in GFNMS and MBNMS) and there is no direct evidence it is an invasive species. At North Point Didemnidae had an overall low density of 0.03 individuals per square meter (Table 11). It does not appear to be outcompeting other benthic invertebrates on the bank although its structure resembles the colonial tunicate *Didemnum vexillum*, a species that has smothered areas of George's Bank in the Gulf of Maine and has been documented in the San Francisco Bay area.

Table 11. Coral and sponge taxa observed on dive 15 reported as total number, percent of total corals and sponges, density per square meter, and height ranges and depth ranges.

Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Height Range (cm)	Depth Range (m)
CORALS						
Chromoplexaura marki	Red branched gorgonian	30	0.4%	0.03	5-20	68-83
Swifita spp.	Red branched gorgonian with unknown polyps	9	0.1%	0.01	10-20	73-80
Stylaster californicus	California lace coral	3285	39%	3	5-20	56-84
SPONGES						
Mycale spp.	Upright flat sponge (yellow)	238	3%	0.2	5-20	58-83
Poecillastra spp.	Fringed shelf sponge	3	0.04%	0.003	5-15	71-83
Rhabdocalyptus dawsoni	Brown barrel sponge	1	0.01%	0.001	20	72
Stelletta clarella	Black edge sponge	26	0.3%	0.02	5-10	67-83
Xestospongia edapha	Cordell sponge	2891	35%	3	5-20	56-83
Morphological unkwn spp.	Barrel sponges unknown species	20	0.2%	0.02	10-40	59-83
	Foliose sponges unknown species	4	0.1%	0.004	5-10	58-59
	Leathery shelf sponge	358	4%	0.3	5-10	57-80
	Mound sponges unknown species	1395	17%	1.3	5-10	56-84
	Puffball mound sponge unknown species	9	0.1%	0.01	5-10	58-80
	Shelf sponges unknown species	11	0.1%	0.01	5-15	69-83
	Upright flat sponges unknown species	3	0.04%	0.003	5-15	72-79
OTHER						
Didemnidae	Gray tunicate	35	0.4%	0.03	5	68-77

Cordell Bank is known to be a rockfish "hotspot" due to the abundance of food resources in the region and protective habitat. Eleven species of rockfish were documented on North Point, the highest abundances of rockfish included Pygmy (*Sebastes wilsoni*) at 42% of total fish observed, Rosy (*Sebastes rosaceus*) at 19% of total fish observed, and Widow (*Sebastes entomelas*) at 11% of total fish observed (Table 12). The size class of Yelloweye rockfish (*Sebastes ruberrimus)* were noted because juveniles are easy to identify by their coloration and are of interest as an "overfished" species. Rockfish data results from the 2017 ROV survey found that 30% of Yelloweye rockfish observed on all transect lines were observed at North Point; 8 individuals were adults and 8 individuals were juveniles. Of the 19 Yelloweye individuals observed in 2018 on North Point, five were equal to or less than 10 cm in length (juveniles) and 14 individuals ranged in larger sizes of 30 to 50 cm (adults). Conducting long term counts of rockfish, particially those

of special interest due to questions about population and recruitment, are important for understanding the fisheries management needs for Cordell Bank.

Table 12. Fish taxa observed on dive 15 reported as total number, percent of total fish, density per square meter, and depth ranges.

Group	Family	Scientific Name	Common Name	Total Number	Percent of Total	Density per m^2	Depth Range (m)
Rockfish	Scorpaenidae	*Sebastes constellatus*	Starry rockfish	2	0.2%	0.002	71-76
		Sebastes entomelas	Widow rockfish	146	11%	0.1	59-83
		Sebastes flavidus	Yellowtail rockfish	40	3%	0.04	59-83.1
		Sebastes maliger	Quillback rockfish	4	0.3%	0.004	56-70
		Sebastes miniatus	Vermilion rockfish	1	0.1%	0.001	70
		Sebastes nebulosus	China rockfish	2	0.2%	0.002	59-66
		Sebastes paucispinis	Bocaccio	1	0.1%	0.001	72
		Sebastes pinniger	Canary rockfish	2	0.2%	0.002	73-83
		Sebastes rosaceus	Rosy rockfish	264	19%	0.2	56-83
		Sebastes ruberrimus	Yelloweye rockfish	19	1%	0.02	58-80
		Sebastes wilsoni	Pygmy rockfish	569	42%	0.5	58-83
		Sebastes spp. YOY	juvenile rockfish	248	18%	0.2	56-83
Greenlings	Hexagrammidae	*Hexagrammos decagrammus*	Kelp greenling	1	0.1%	0.001	59
		Ophiodon elongatus	Lingcod	5	0.4%	0.005	58-72
		Oxylebius pictus	Painted greenling	15	1%	0.01	56-73
Other	Cottidae	Cottidae	unidentified sculpin	3	0.2%	0.003	80-82
	Gobiidae	*Rhinogobiops nicholsii*	Blackeye goby	45	3%	0.04	58-82

References

C.F.R. 50 part 660. Magnuson-Stevens Act Provisions; Fisheries Off West Coast States; Pacific Coast Groundfish Fishery; Pacific Fishery Management Plan; Amendment 28, final rule. Vol. 84, No. 223, November 19, 2019.

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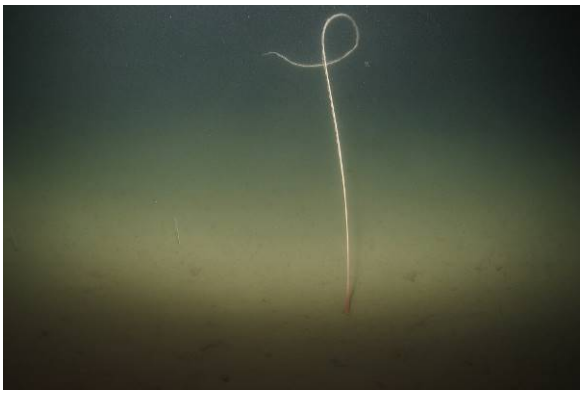
Williams, G.C., and O. Breedy. 2019. A new species of gorgonian octocoral from the mesophotic zone off the central coast of California, Eastern Pacific, with a key to related regional taxa (Anthozoa, Octocorallia, Alcyonacea). Proceedings of the California Academy of Sciences 65(6): 143-158.

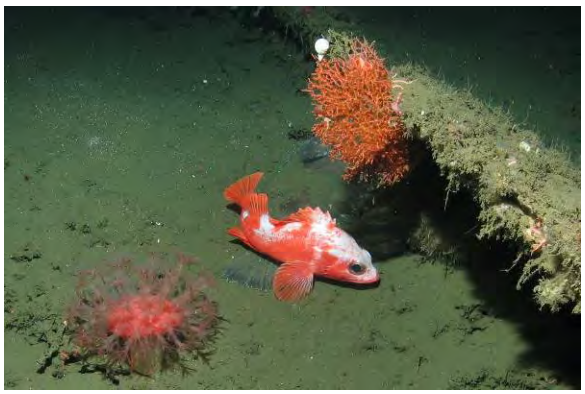
Appendix A: Image gallery



Halipteris californica sea pens on the CBNMS shelf were often very tall reaching a maximum height of 120 cm.

Halipteris californica sea pens on the shelf were observed not upright and in dead or dying condition due to unknown reasons (8.7% of total sea pens).

A new observation for CBNMS was the club sponge, *Rhizaxinella gadus,* seen on both dives on the CBNMS slope.

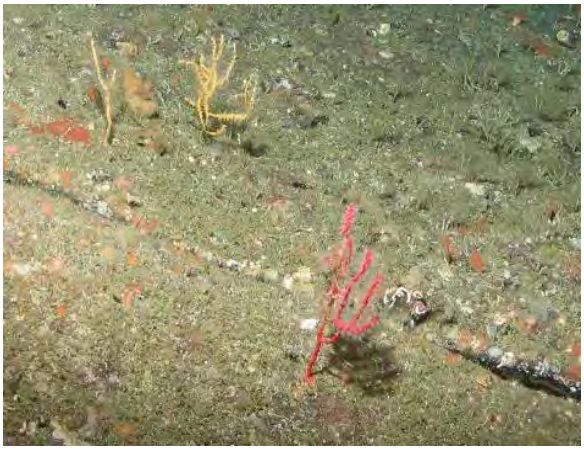


A representative species assemblage on the CBNMS slope: red gorgonian with fan morphology “Swiftia spp.,” mushroom coral (*Heteropolypus ritteri), and* Aurora rockfish (*Sebastes aurora*) resting on a Dover sole (*Microstomus pacificus*).

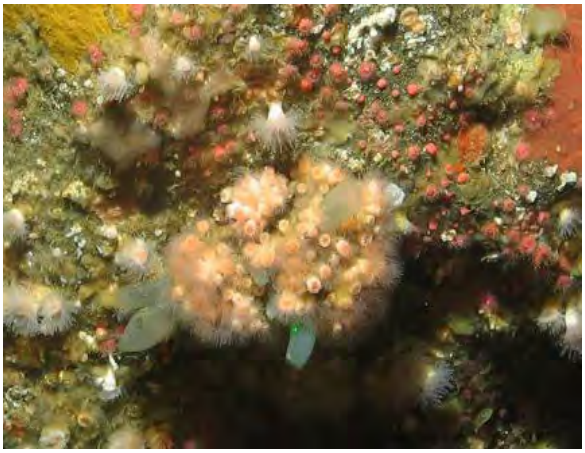
Example of *Swiftia* spp. individuals in an “unhealthy” condition with brown and dead branches.

Peppermint bubble gum corals (*Paragorgia yutlinux*) were observed deep on the CBNMS slope.

Appendix A: Image gallery



On Cordell Bank the yellow gorgonians are the new species *Chromoplexaura cordellbankensis* and red gorgonians are *Chromoplexaura marki.*

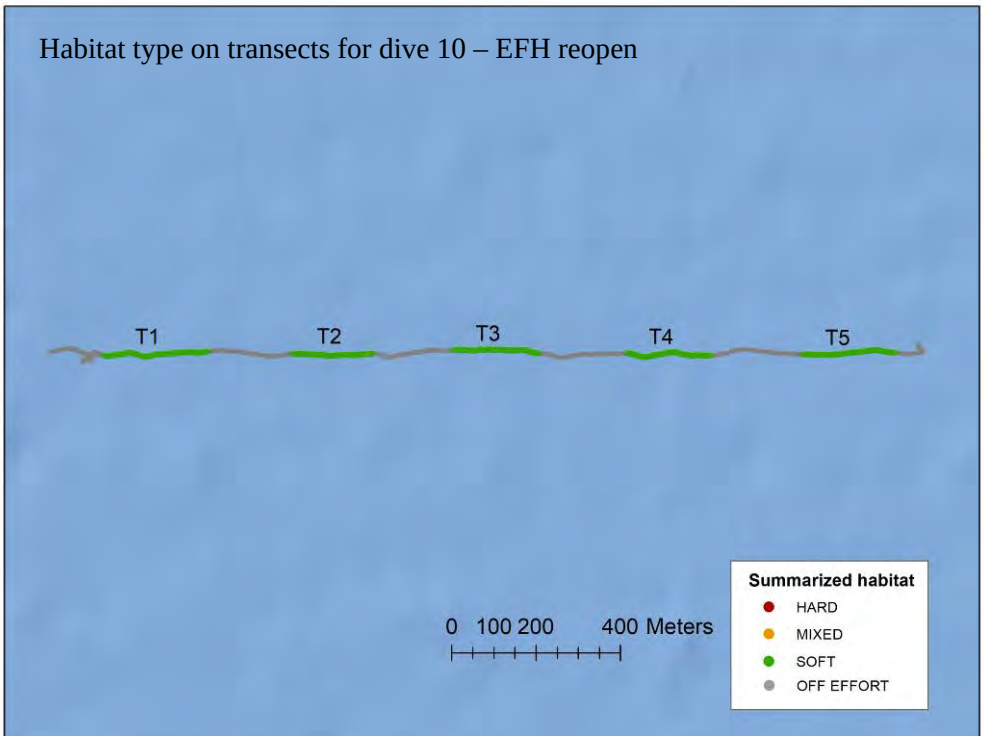


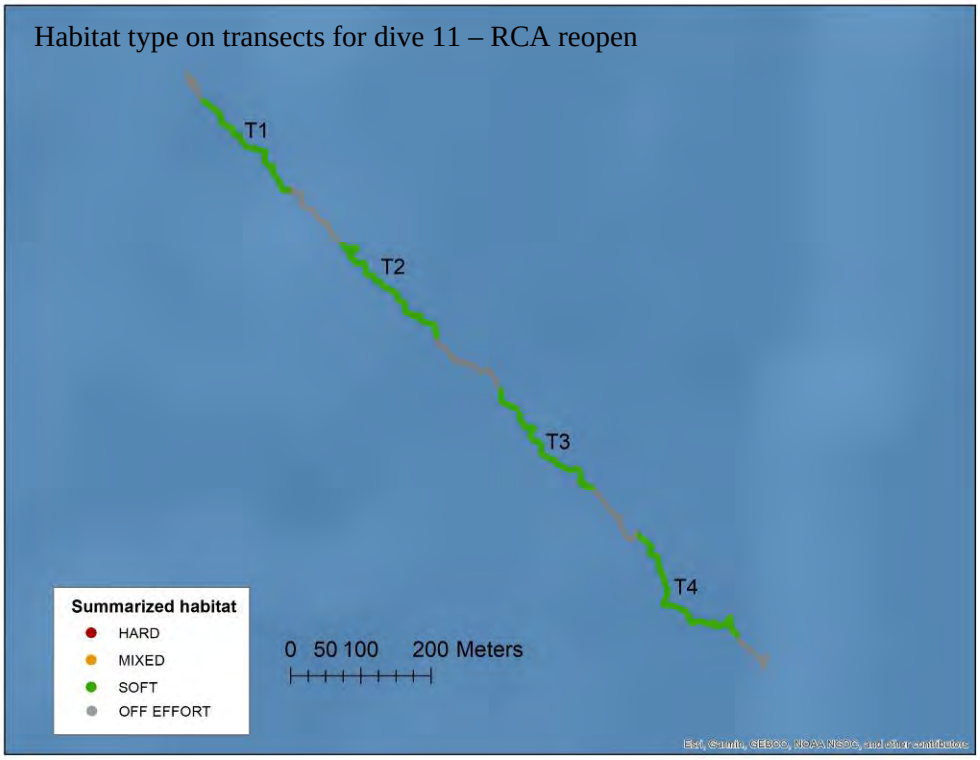
These cup corals, *Coenocyathus bowersi,* were collected and determined to be the most northern observation and specimen collection for this species.

The primary coral and sponge cover at North Point is the hydrocoral *Stylaster californicus* and “Cordell sponge” *Xestospongia edapha*, each species had a density of three individuals per square meter.

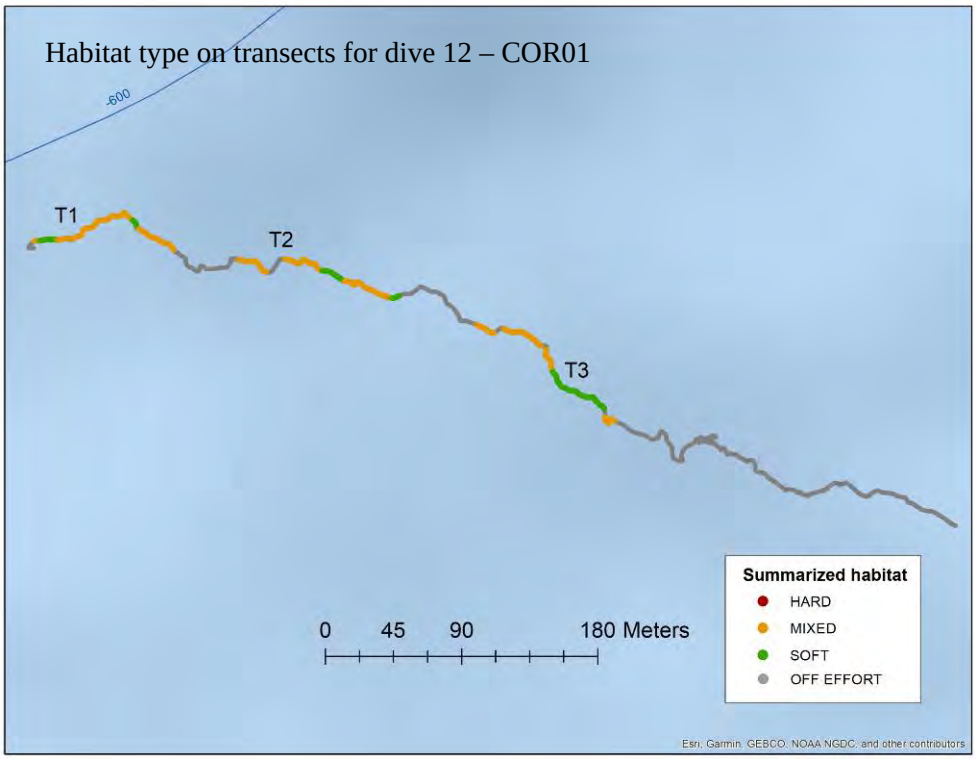
A sample of this gray encrusting tunicate was collected on dive 13 along line 127 and identified to be in the family Didemnidae.

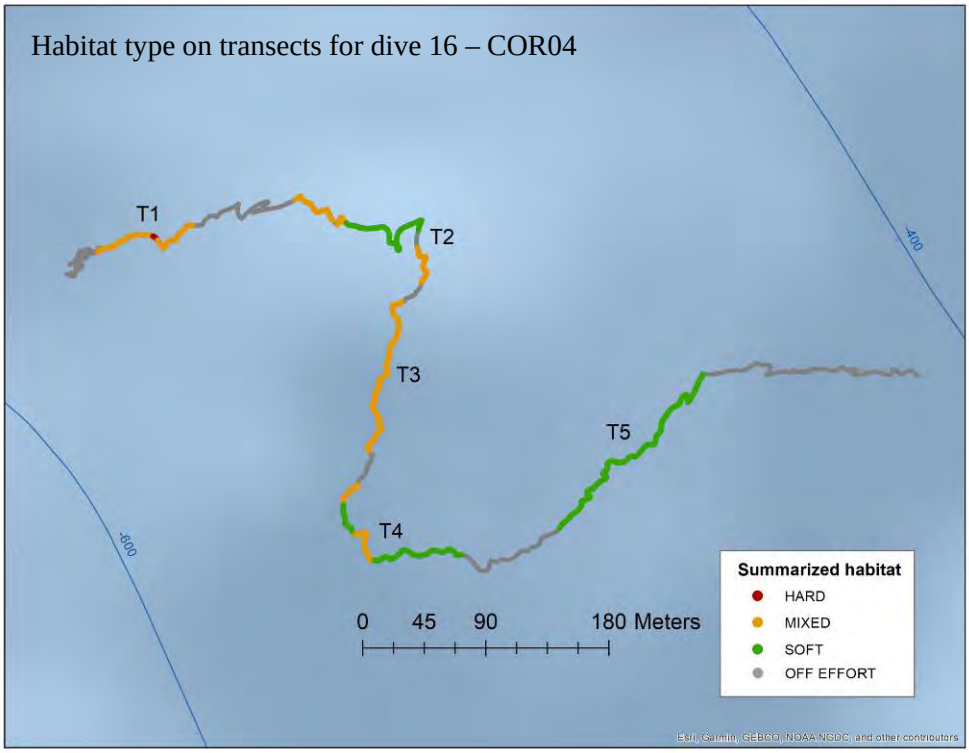
Appendix B: Habitat Transect Maps



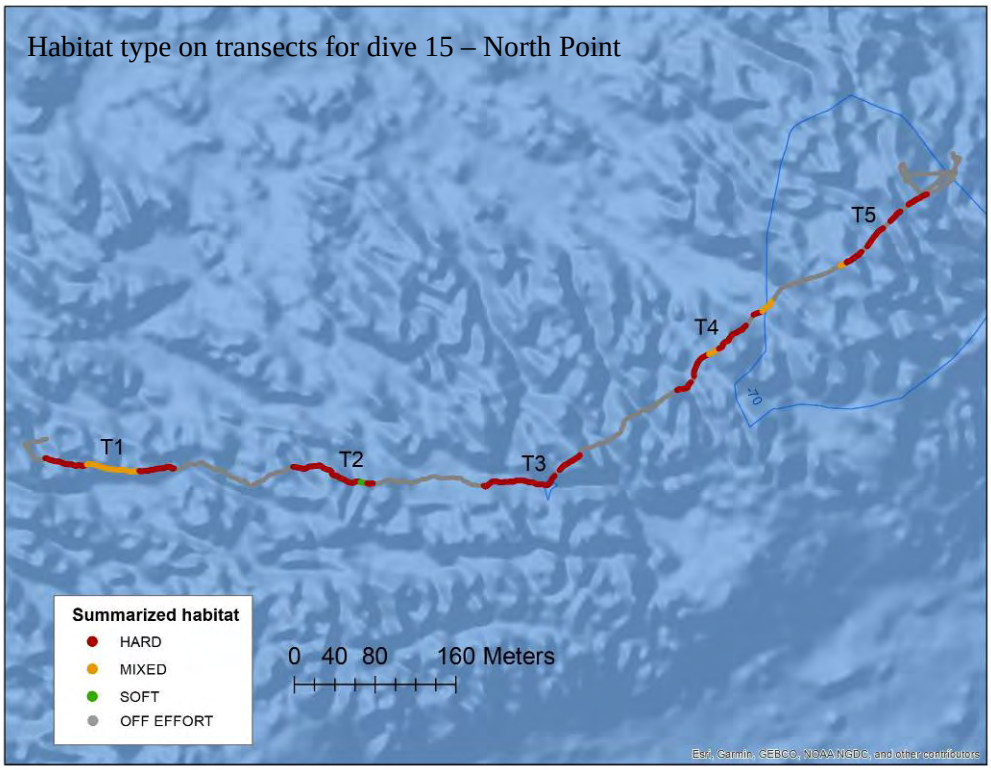


Appendix B: Habitat Transect Maps





Appendix B: Habitat Transect Maps

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