Distribution and Abundance of Selected Corals and Sponges in the Channel Islands National Marine Sanctuary as Determined from ROV Video Imagery

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Introduction

Deep sea coral and sponge communities are considered important benthic resources due to their vulnerability to alteration by bottom-contact fishing gear and their potential importance as habitat for demersal fish species. Efforts have been undertaken to specifically locate, map, and characterize deep-sea coral and sponge communities in numerous National Marine Sanctuaries (NOAA 2010, GFNMS 2010). The most recent of these efforts was at the Channel Islands NMS, in June of 2013.

The Institute for Applied Marine Ecology (IfAME) at CSU Monterey Bay was contracted to conduct a “first pass” through the video imagery to quantify the abundance/density of selected organisms.The following summarizes the results of analyses conducted on ROV imagery from the 2013 CINMS survey to quantify deep-sea coral and sponge communities, as well as investigate the role of habitat availability in organism distribution.

Methods

The *ROV Beagle* (below) was configured with five cameras: two video cameras (forward-oblique and down-looking), one forward-looking digital still camera, one forward looking HD video, and a rear-facing safety video camera. Additionally, paired sizing lasers (spaced at 10cm) were visible in the all but the rear-facing camera. The ROV is also equipped with two HMI and two Quartz halogen HMI lights, a strobe for the still camera, forward-facing sonar, and a CTD+DO_2.

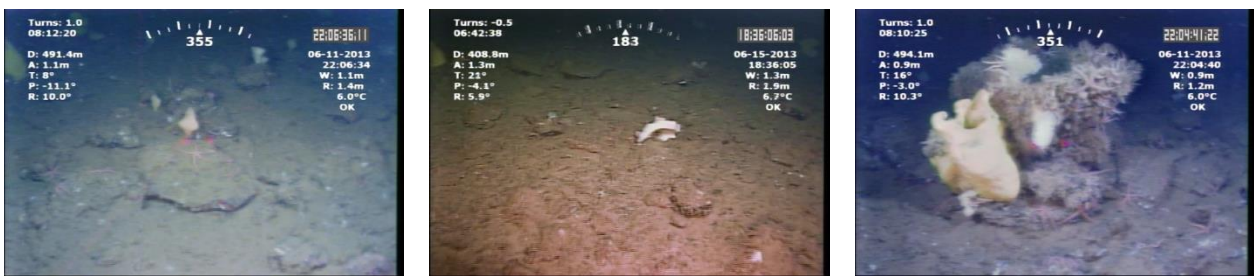
Figure 1. The ROV *Beagle* during deployment in southern California.

The vehicle was also equipped with an altimeter and was “flown” at an altitude of approximately 0.1-0.3 m above the seafloor at a speed of approximately 0.5-0.7 knots. Transects were positioned to optimize imagery collection in all three substrate types (unconsolidated, rocky, and mixed) within each site based on high-resolution topographic maps of the seafloor. The position of the ROV on the seafloor was derived by the Trackpoint III ® acoustic positioning system with the resulting coordinates logged into Hypack® navigational integration software, yielding subsea GPS position of the ROV on the seafloor. Completed transects for each site are shown below in the summaries for each site.

A total of 41.2 hours of ROV video imagery (including both forward- and down-looking) was collected from 9 transects in the vicinity of the CINMS.

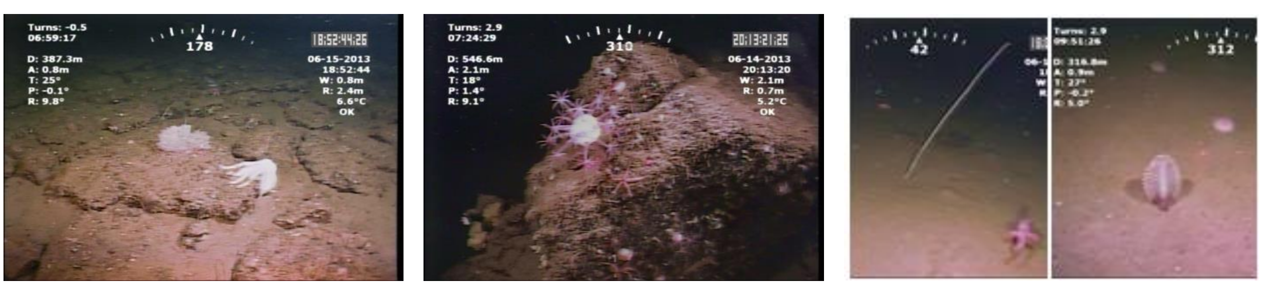
Data Extraction from Video Imagery

All organisms were separated into morphological categories based on genera and size. The sponge categories included 0-10 cm, 10-20 cm, and 20+ cm (Figure 2). Sizing was achieved using the paired 10 cm lasers projected into the video frame. Corals were categorized based solely on morphology -- Hard corals, Soft corals, and Whip/Pens (Figure 3).



Sponges 0-10 cm Sponges 10-20 cm Sponges 20+ cm

Figure 2. Video frames depicting sponges in each of the three size categories.

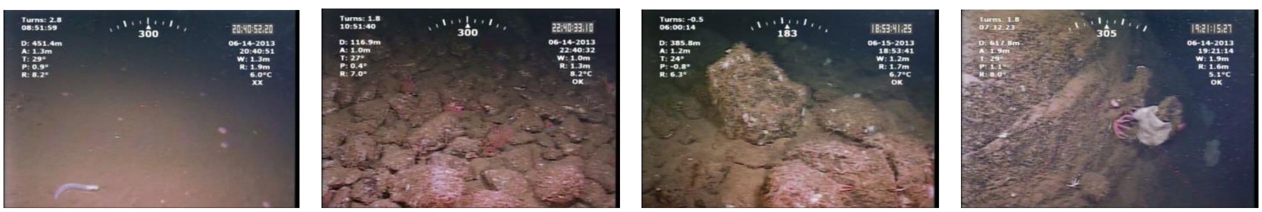


Hard Corals Soft Corals Pens and Whips

Figure 3. Video frames depicting morphological categories for corals.

Organism data were collected on a frame by frame basis. A frame was defined as a non-overlapping video quadrat. The number of frames per transect was calculated by multiplying the average number of frames per minute (9) by the number minutes. For the majority of data, the presence or absence of the organism within the frame was quantified. In addition, some organisms were able to be accurately surveyed on an individual basis: large sponges (20+ cm), Hard corals, Soft corals, and Whip/Pens - for these organisms the number of individuals within each frame was also counted.

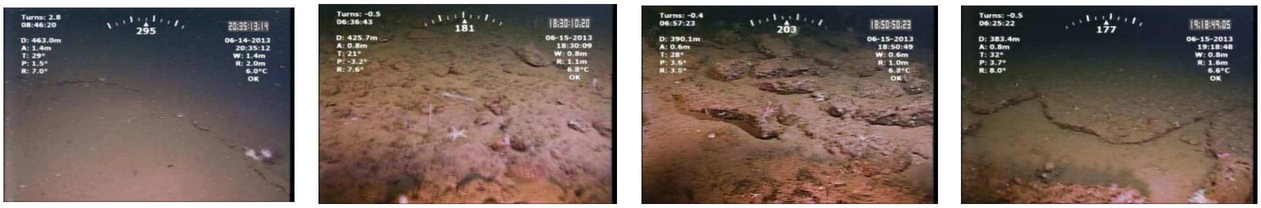
Habitat classification was done using four substrate categories: Soft, Cobble, Boulder, and Rocky Reef (Figure 4). Soft habitat was any soft sediment, such as mud or sand. Cobbles were defined as rocks smaller than 20 cm. Boulders were rocks larger than 20cm that appeared to have the ability to roll. Rocky Reef was rocky outcroppings or continuous hard substrate. Habitats were classified as a combination of Primary (50% of frame) and Secondary (30% of frame) habitats based on the percent cover in a 10-second video frame (See Tissot et al. 2007) (Table 1).



Soft Cobble Boulder Rocky Reef

Figure 4. Examples of the four habitat classes. The habitat listed above is the primary habitat in each frame.

In addition to the four habitat classes, a habitat modifier was also used: Veneer. The Veneer category was used as a modifier for any habitat classifications that had Soft as one of the habitat classes and had discernible hard substrate underneath the soft sediment (Figure 5, Table 1). This modifier was used in order to characterize the depositional attributes of a habitat, and because ground-truthing is not possible with video data. During data analysis, additional habitat classes were made by combining similar habitats that contained Veneer with one another (Table 1). For example, the “Veneer_softcobblecobblesoft” class was the result of adding the percentages of SoftCobble and CobbleSoft habitats that had Veneer for each transect (Table 1).



a) Soft with a Veneer

b) Cobble with Veneer

c) Boulder with Veneer

d) Rocky Reef with Veneer

Figure 5. Examples of the four habitat classes with Veneer. The habitat listed above is the primary habitat in each frame.

Table 1. Habitat classes using Primary habitat as the habitat that is 50% of the frame, and Secondary habitat as the habitat that is the next highest percent (~ 30%).

Possible Habitat Classes

Primary Habitat	**Secondary Habitat**	**Veneer**	**Class**
Soft	Soft	--	SoftSoft
Soft	Cobble	--	SoftCobble
Soft	Boulder	--	SoftBoulder
Soft	Rocky Reef	--	SoftRockyReef
Soft	Soft	Yes	SoftSoft_V
Soft	Cobble	Yes	SoftCobble_V
Soft	Boulder	Yes	SoftBoulder_V
Soft	Rocky Reef	Yes	SoftRockyReef_V
Cobble	Soft	--	CobbleSoft
Cobble	Soft	Yes	CobbleSoft_V
Cobble	Cobble	--	CobbleCobble
Cobble	Boulder	--	CobbleBoulder
Cobble	Rocky Reef	--	CobbleRockyReef
Boulder	Soft	--	BoulderSoft
Boulder	Soft	Yes	BoulderSoft_V
Boulder	Cobble	--	BoulderCobble
Boulder	Boulder	--	BoulderBoulder
Boulder	Rocky Reef	--	BoulderRockyReef
Rocky Reef	Soft	--	RockyReefSoft
Rocky Reef	Soft	Yes	RockyReefSoft_V
Rocky Reef	Cobble	--	RockyReefCobble
Rocky Reef	Boulder	--	RockyReefBoulder
Rocky Reef	Rocky Reef	--	RockyReefRockyReef

Generated Veneer Habitat Classes

Primary Habitat	Secondary Habitat	Veneer	Class
Any	Any	Yes	Veneer_Sum
Boulder/Cobble or Soft	Soft or Boulder/Cobble	Yes	V_BoulderCobble
Cobble or Soft	Soft or Cobble	Yes	V_softcobblecobblesoft
Boulder or Soft	Soft or Boulder	Yes	V_softboulderbouldersoft
Rocky Reef or Soft	Soft or Rocky Reef	Yes	V_softrockyreefrockyreefsoft

Regressions were run to analyze the relationships between Sponge and Coral density and the percent of habitat available on a transect using generalized linear models. Generalized linear models were used because they do not have the same restrictive assumptions of normality as other linear model applications. These regressions investigated the relationship between each morphological grouping (Sponge 0-10cm, Sponge 10-20cm, Sponge 20+cm, Hard Corals, Soft Corals, Pens/Whips) and the percent of available habitat on a transect

Preliminary Results

A total of 22255 m^2 of sea floor was sampled. This resulted in 11127 video frames. Sponges were observed in 2282 of these frames, while 1713 frames contained coral. Of the frames that contained sponges, 1205 contained sponges from 0-10 cm, 1168 sponges from 10-20 cm, and 537 contained sponges larger than 20 cm. From the 1713 frames containing corals, 491 contained hard corals, 69 soft corals, and 1251 contained pens/whips. Of the individually surveyed organisms (large sponges and all corals), there were 629 sponges (20+), 1134 hard corals, 95 soft corals, and 2306 pens/whips.

During data collection three uniquely large corals were encountered. These corals were much larger than the majority of corals observed so the depth and habitat of each coral was noted (Table 2).

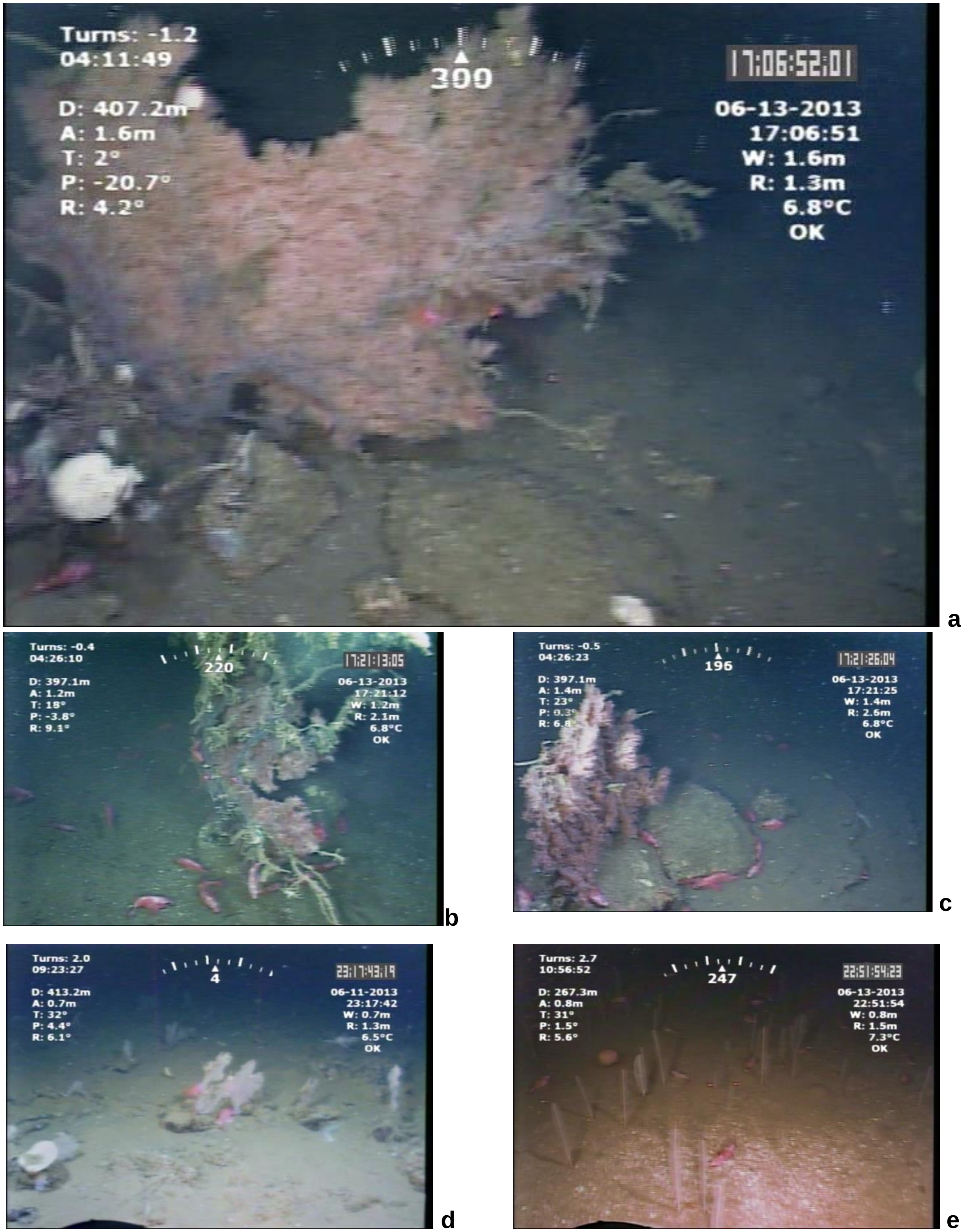


Figure 6. Photographs of notable organisms encountered during surveys. The large corals (a, b, and c) were all encountered on transect 5. The large grouping of hard corals (d) was on transect 14, and the “field” of pen/whips was from transect 4.

Table 2. Depth and Size of uniquely large corals encountered on Transect 5

Coral	Depth (m)	Est. Height (cm)	Est. Width (cm)	Primary	Secondary	Veneer?	Time
a	407.2	110	80	Boulder	Soft	Y	17:06:51
b	397.1	200	120	RockyReef	Soft	Y	17:21:14
c	397.1	120	100	RockyReef	Soft	Y	17:21:24

Across transects, the composition of sponges and corals varied (Figure 7, 8). Hard corals were more abundant than soft corals on all transects, though both were eclipsed by pens (Figure 8). Though pens dominated both hard and soft corals in general, in two of the transects (14 and 10) frames containing hard and soft corals were more abundant.

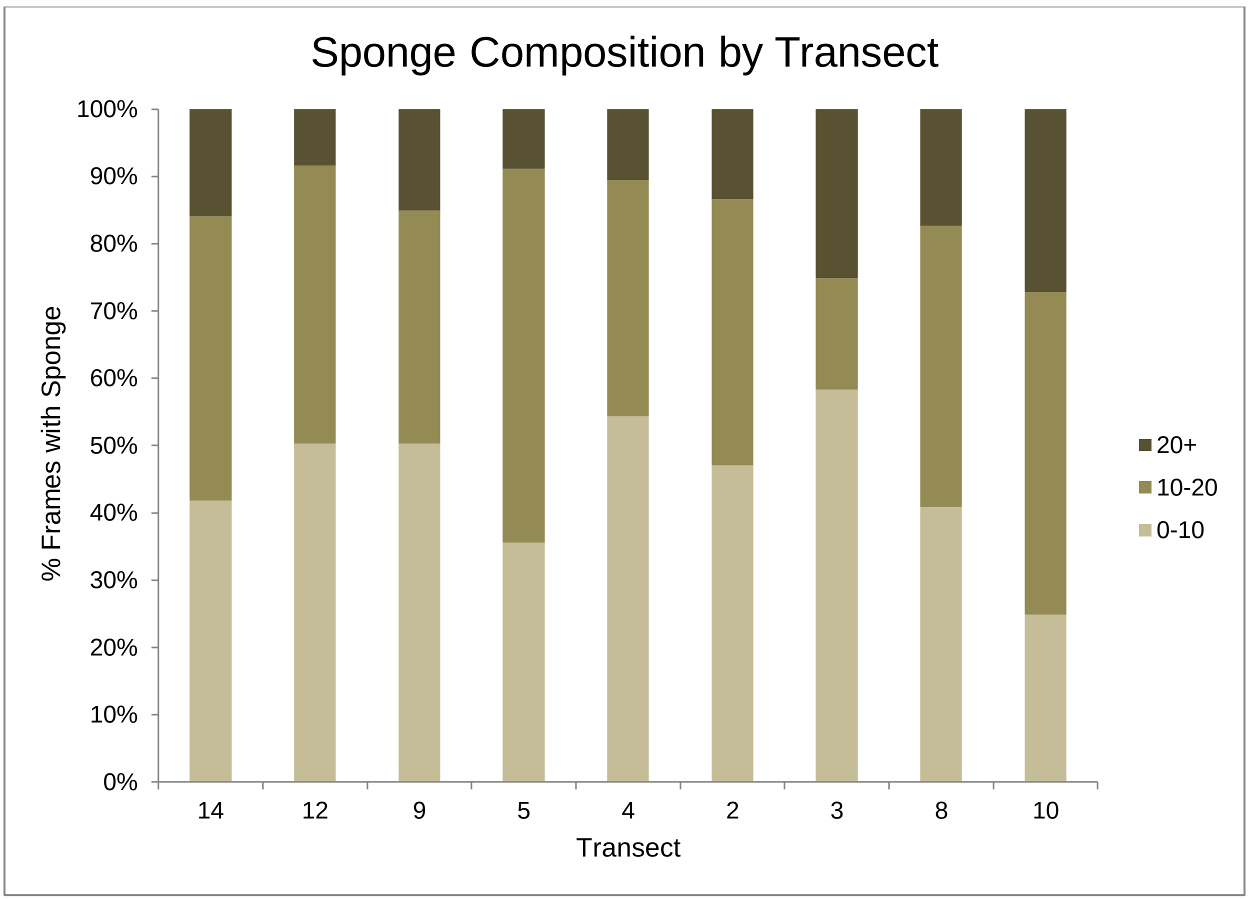


Figure 7. Sponge compositions by transect. Percentages represent the number of frames in the transect that contained sponges of each grouping compared to the total number of frames.

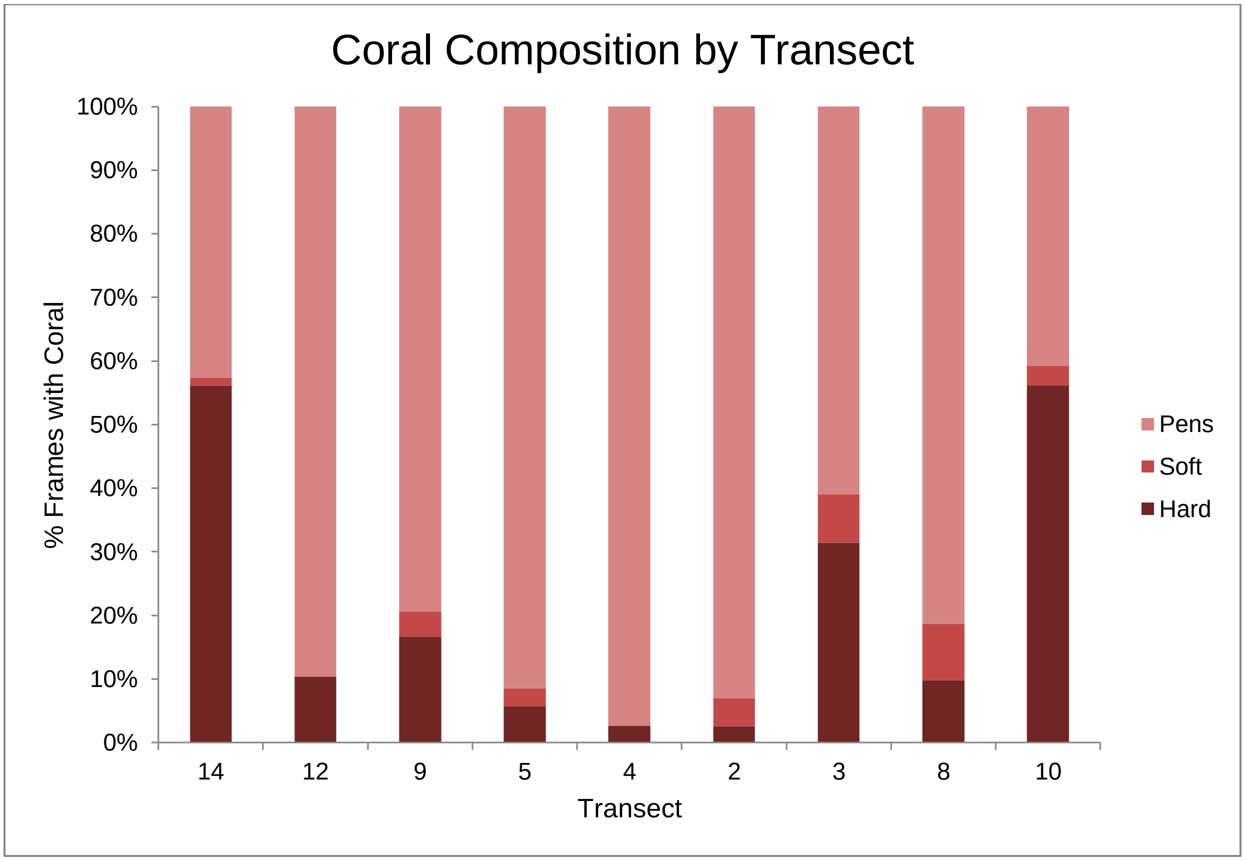
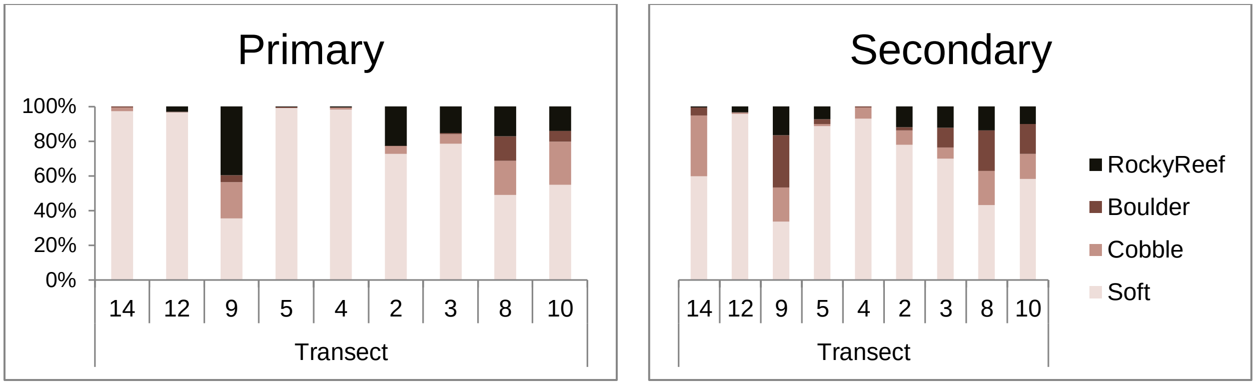


Figure 8. Coral compositions by transect. Percentages represent the number of frames in the transect that contained sponges of each grouping compared to the total number of frames.

The habitat analysis revealed that the majority of primary and secondary habitat sampled was “Soft” habitat (76%, 69% respectively). Rocky Reef was the second most abundant Primary habitat (12% of surveyed habitat) while Cobble was the second most abundant Secondary habitat (12%) (Table 3). Per transect, the composition of primary and secondary habitat varied (Figures 9).

Table 3. Percent of each habitat type across transects

	Primary Habitat	Secondary Habitat
Soft	76.31%	69.26%
Cobble	8.50%	12.35%
Boulder	2.93%	10.04%
Rocky Reef	12.26%	8.36%



Primary habitat composition by transect

Secondary habitat composition by transect

Figure 9. Composition of each transect by Primary and Secondary habitat

The more nuanced habitat classifications (Primary and Secondary habitats combined) showed a similar pattern to the separated Primary and Secondary habitats (Figure 9), with Transects 9, 8, and 10 having significantly more Rocky Reef (Figure 10). The distribution of Veneer habitat within transects also varied (Figure 11).

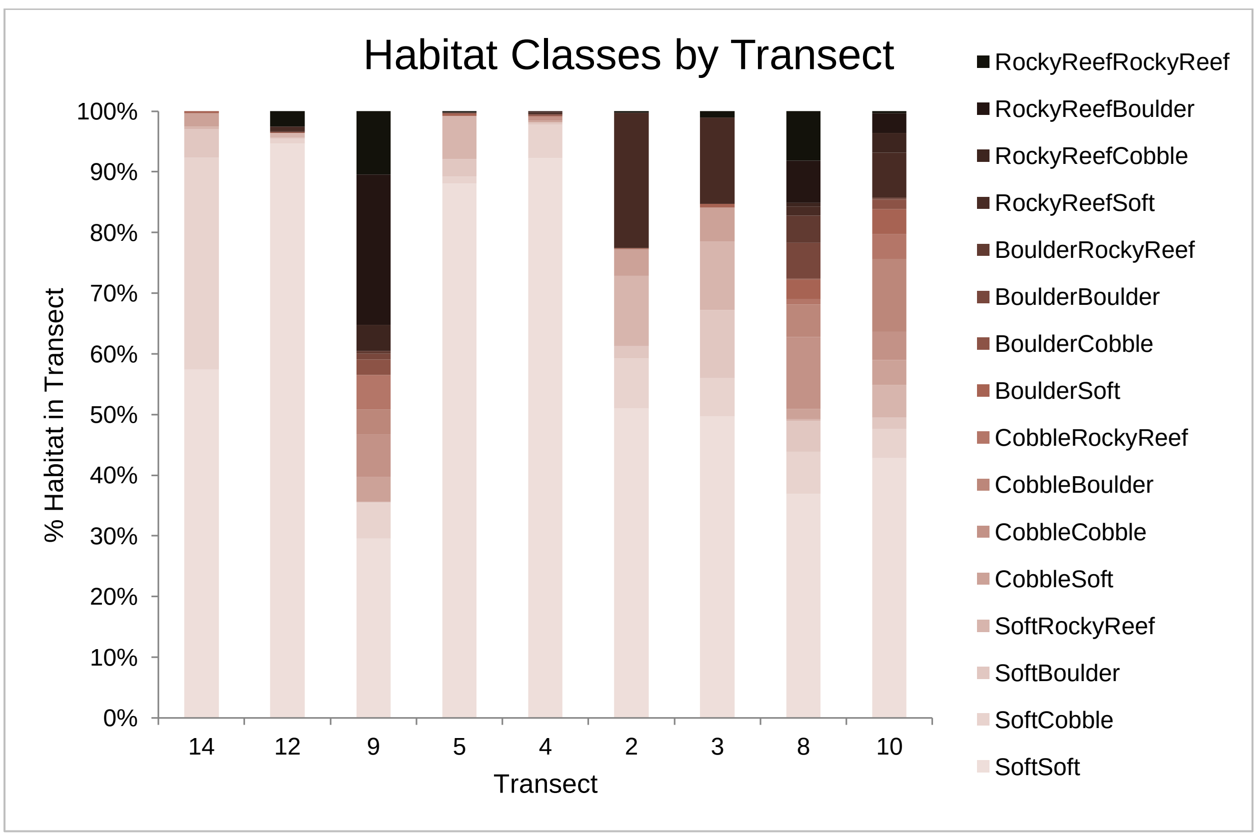


Figure 10. Composition of each transect by combined PrimarySecondary habitat class

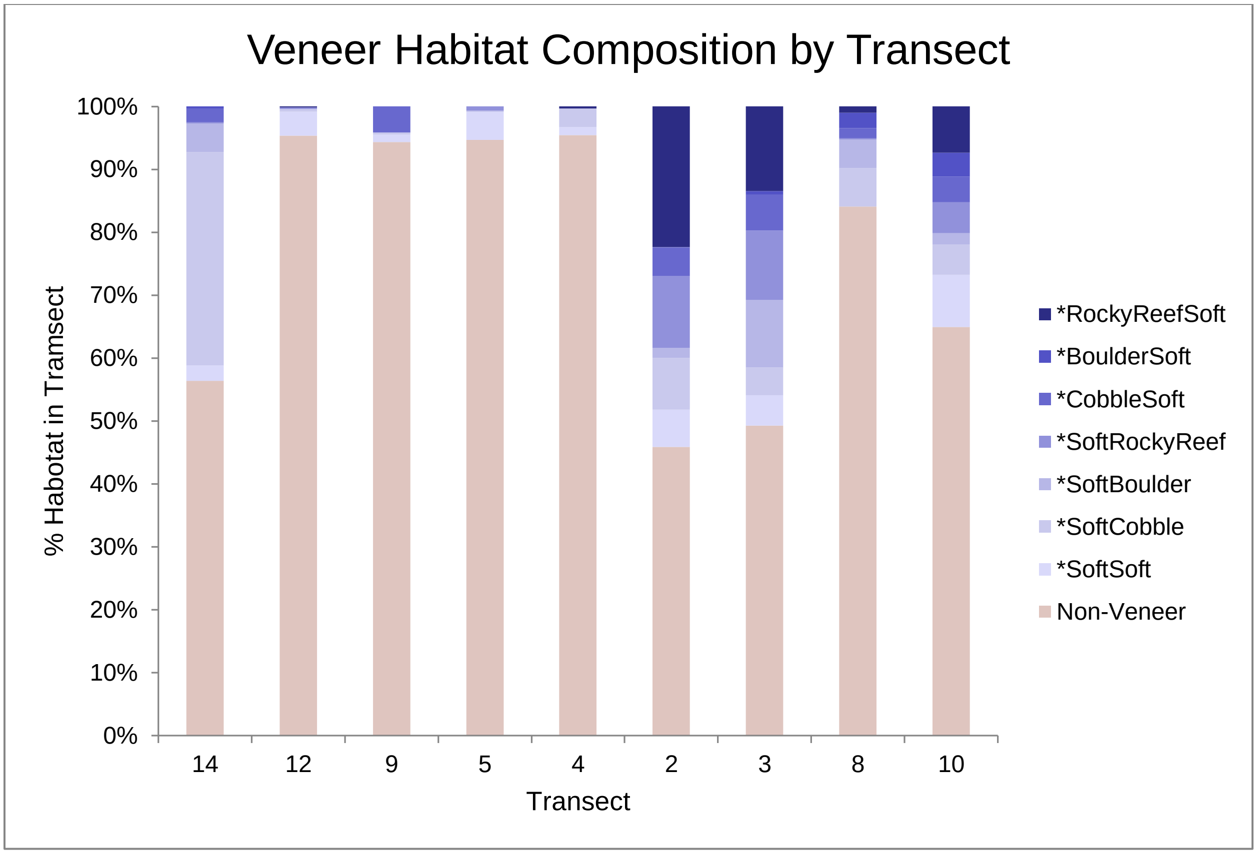


Figure 11. Composition of Veneer classes in each transect. Veneer denoted by an asterisk, *.

Results of the regression analysis showed a significant relationship between both Sponge and Coral density and percent of Cobble and Soft habitats, including those habitats with Veneers (Table 4, 5) (α = 0.05). For Soft Corals, the significant models strongly with Veneer and both Soft Corals and Pens/Whips had significant relationships with Rocky Reef habitats, unlike Hard Corals or Sponges (Table 5).

Table 4. Significant Sponge Models.

Model Name	Tests	*p-values*
SpAllvCs.glm	All Sponges vs. Cobble as a secondary habitat	0.00189
SpAllvSs.glm	All Sponges vs. Soft as a secondary habitat	0.01998
SpAllvSS.glm	All Sponges vs. SoftSoft habitat	0.03249
SpAllvVsccs.glm	All Sponges vs. Veneer habitats that have Cobbles	0.0386
Sp0.10vCs.glm	Sponges from 0-10 cm vs. Cobble as a secondary habitat	0.00389
Sp0.10vSs.glm	Sponges from 0-10 cm vs. Soft as a secondary habitat	0.02815
Sp10.20vCs.glm	Sponges from 10-20 cm vs. Cobble as a secondary habitat	0.00527
Sp10.20vVsccs.glm	Sponges from 10-20 cm vs. Veneer habitats that have Cobbles	0.0498
Sp20vCp.glm	Sponges larger than 20 cm vs. Cobble as a primary habitat	0.033
Sp20vCs.glm	Sponges larger than 20 cm vs. Cobble as a secondary habitat	0.0317
Sp20vSs.glm	Sponges larger than 20 cm vs. Soft as a secondary habitat	0.02607
Sp20vSS.glm	Sponges larger than 20 cm vs. SoftSoft habitat	0.009594
Sp20vCB.glm	Sponges lager than 20 cm vs. CobbleBoulder habitat	0.0427
Sp20vVbs.glm	Sponges larger than 20 cm vs. BoulderSoft habitat with Veneer	0.0427

Table 5. Significant Coral Models.

Model Name	Tests	*p-values*
CorAllvCs.glm	Any type of coral vs. Cobble as a secondary habitat	0.045
CorAllvVbc.glm	Any type of coral vs. Veneer habitats that have either Cobbles or Boulders	0.00719
CorAllvVsccs.glm	Any type of coral vs. Veneer habitats that have Cobbles	0.0151
CorAllvVsc.glm	Any type of coral vs. SoftCobble habitat with Veneer	0.0314
CorHardvCs.glm	Hard corals vs. Cobble as a secondary habitat	0.0436
CorHardvVbc.glm	Hard corals vs. Veneer habitats that have either Cobbles or Boulders	0.0107
CorHardvVsccs.glm	Hard corals vs. Veneer habitats that have Cobble	0.0157
CorHardvVsc.glm	Hard corals vs. SoftCobble habitat with Veneer	0.0275
CorSoftvRRs.glm	Soft corals vs. Rocky Reef as a secondary habitat	0.0131
CorSoftvVsum.glm	Soft corals vs. Any habitat with Veneer	0.0413
CorSoftvVsbbs.glm	Soft corals vs. Veneer habitats that have Boulders	0.0162
CorSoftvVsrrs.glm	Soft corals vs. Veneer habitats that have RockyReef	0.0213
CorSoftvVsb.glm	Soft corals vs. SoftBoulder habitat with Veneer	0.0179
CorSoftvVsr.glm	Soft corals vs. SoftRockyReef habitat with Veneer	0.013
CorSoftvVcs.glm	Soft corals vs. CobbleSoft habitat with Veneer	0.00527
CorSoftvVrs.glm	Soft corals vs. RockyReefSoft habitat with Veneer	0.0313
PenWhipvVsrrs.glm	Pen/Whips vs. Veneer habitats that have RockyReef	0.03983
PenWhipvVrs.glm	Pen/Whips vs. RockyReefSoft habitat with Veneer	0.02567

In all but two significant models there was a positive relationship between organism density and the amount of habitat. The two negative relationships were between Sponge Density and the percent of Soft secondary habitat and Sponge Density and the percent of SoftSoft habitat. Scatter plots for the significant models can be found in Appendix A.

Preliminary Summary

These preliminary results suggest a positive correlation between the number of sponges and cobble or boulder habitats. They also suggest that large sponges are associated with larger substrates – boulders rather than cobbles. Sponges also have a positive relationship with the amount of cobble habitat that contains a veneer of sediment. Sponges have a negative relationship with the amount of soft sediment.

The coral species investigated in this project separated into two distinct groups based on their morphologies: Hard corals and Soft corals/Pens/Whips. Hard corals were similar to sponges in that they had a positive association with boulders and cobbles, especially when a veneer was present. The Soft corals and Pens/Whips had a much stronger relationship with the veneer category than Hard corals or Sponges. Soft corals in particular were strongly associated with hard substrate (Cobble, Boulder, and Rocky Reef) that had a layer of veneer.

Despite initial expectations, Sponges and Hard Corals were not positively associated with Rocky Reef habitat. Cobbles and boulders were observed to contain the majority of sponges and corals but Rocky Reef habitats also had a high prevalence of both genera. The lack of a detectable pattern could be due to the method of habitat sampling. Rocky Reef was most often encountered in one of two scenarios: rocky outcroppings among soft sand, or the base substrate in a boulder/cobble field. In the first instance, the 10 second frame used for habitat sampling and the high amount of soft sediment surrounding the outcropping meant that the hard substrate was often less than 50%, or the next 30%, of the frame (i.e. not Primary or Secondary habitat). In the second most common occurrence of Rocky Reef habitat (the boulder/cobble fields), the Boulder or Cobble habitats were often the first 50% and second 30% of the frame – the Rocky Reef was perhaps only 5% visible beneath the layers of the other two. Where the Rocky Reef was more visible, it was often covered in a Veneer, resulting in the habitat classification of “Soft” with a Veneer (see *Data Extraction from Video Imagery* for clarification). Further analysis with the Veneer categories counting as “hard” substrates (Cobble, Boulder, and RockyReef) could detect the importance of Rocky Reef, but would lose the importance of the depositional characteristics of sponge and coral habitats.

The findings from these analyses suggest that the depositional attributes of a community, as well as the substrate type, determine the distribution and abundance of deep sea corals and sponges. Future investigations of these communities should focus on this depositional aspect of habitat, since these communities are of interest to the National Sanctuaries program. Understanding the depth and current characteristics of hard bottom areas would assist the program in locating and managing potential sponge and coral habitats.

Additionally, based on the regression analyses, the habitat requirements of soft corals and pen/whips differ from the requirements of hard corals, so future investigations should separate corals into two distinct categories – Hard and Soft/Pen/Whips. Future work into these communities could also focus on the growth rates of notable corals and sponges. The three uniquely large corals noted earlier, as well as a number of large vase sponges, were orders of magnitude greater than the majority of corals and sponges sampled. Although identification to species may not be possible with video analysis, investigations into the amount of time it takes for a sponge or coral to *generally* grow to those sizes could help to indicate the stability and longevity of these deep sea coral and sponge communities.

References

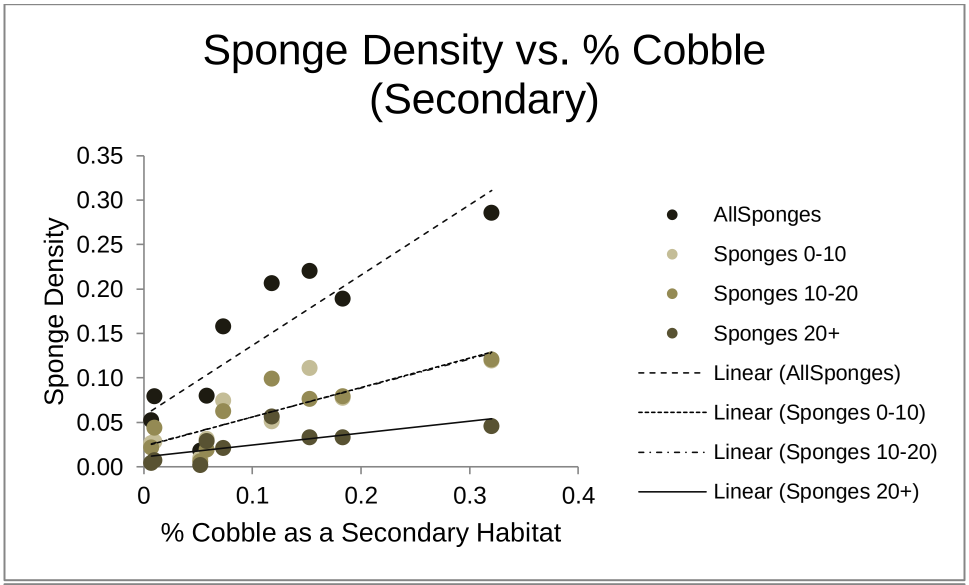
[GFNMS] Deep Sea Coral Communities. 2010. Gulf of the Farallones National Marine Sanctuary. Available from: http://sanctuaries.noaa.gov/science/assessment/pdfs/gfnms_deep_sea_corals.pdf

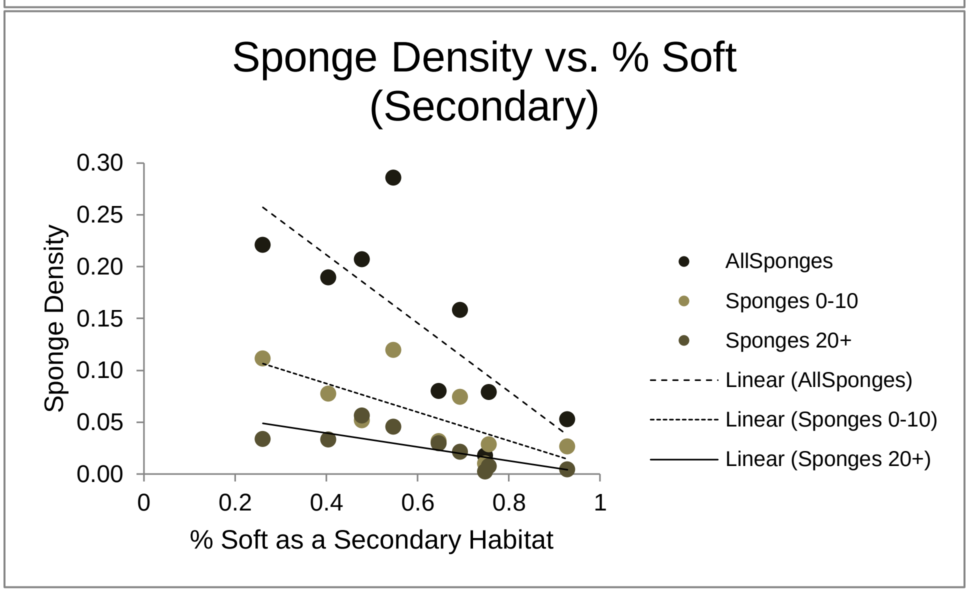
Tissot BN, Hixon MA, Stein DL. 2007. Habitat-based submersible assessment of macro-invertebrate and groundfish assemblages at Heceta Bank, Oregon, from 1988-1990. Journal of Experimental Marine Biology and Ecology 352:50-64.

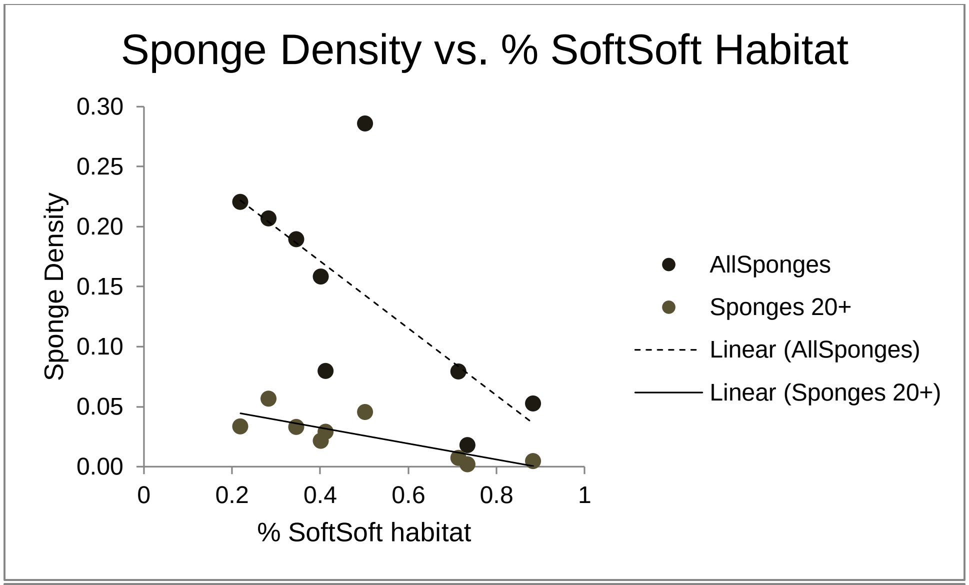
[NOAA] West Coast Deep Seal Coral Cruise. 2010. National Oceanic and Atmospheric Administration. National Marine Sanctuaries. Available from: http://sanctuaries.noaa.gov/missions/2010coral_west/

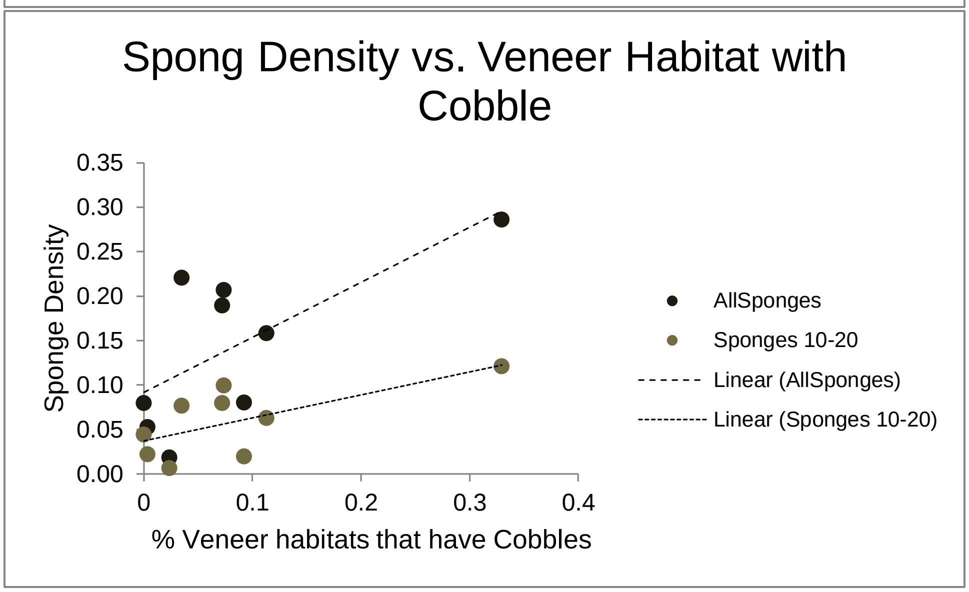
Appendix A – Plots of significant relationships between Sponges and Corals and the percent habitat of each transect

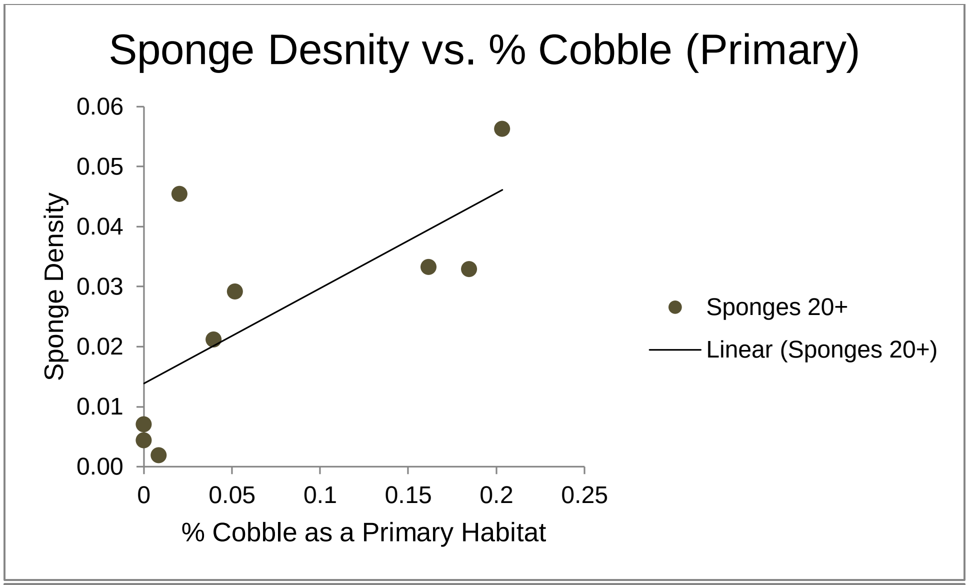
Sponge Models

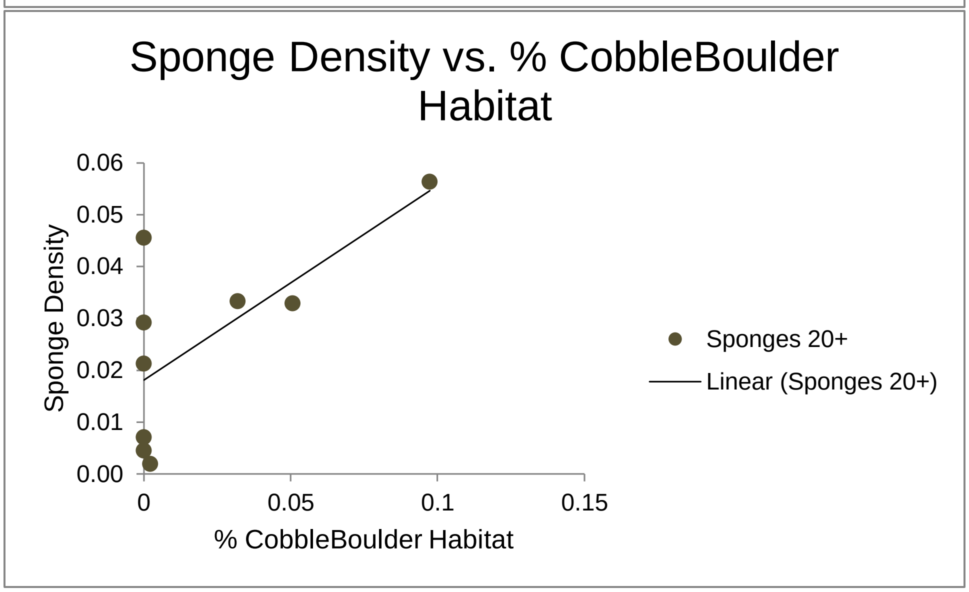


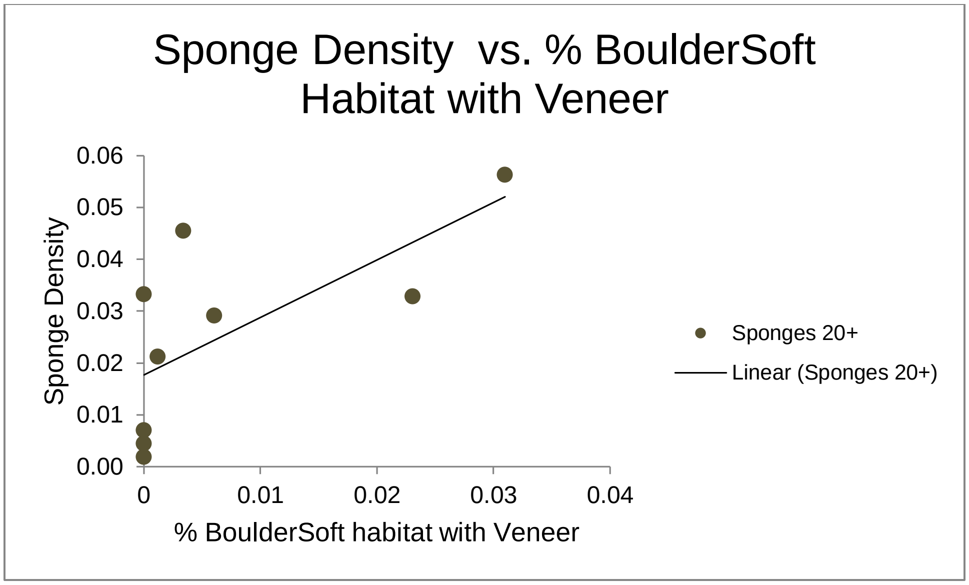



Sponge Density vs. % SoftSoft Habitat
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Sponge Density
0
0.2
0.4
0.6
0.8
1
% SoftSoft habitat
AllSponges
Sponges 20+
Linear (AllSponges)
Linear (Sponges 20+)

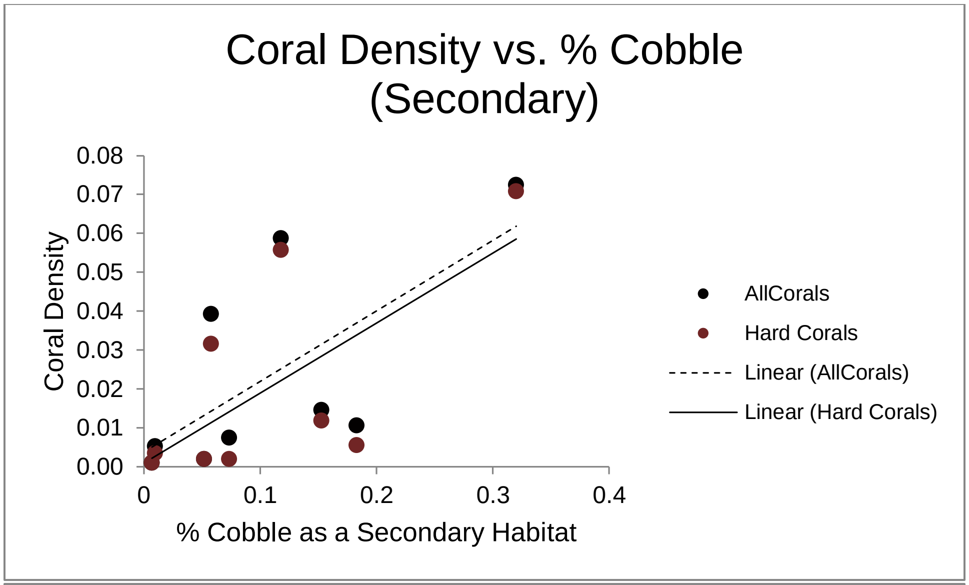

Spong Density vs. Veneer Habitat with Cobble
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Sponge Density
0
0.1
0.2
0.3
0.4
% Veneer habitats that have Cobbles
AllSponges
Sponges 10-20
Linear (AllSponges)
Linear (Sponges 10-20)

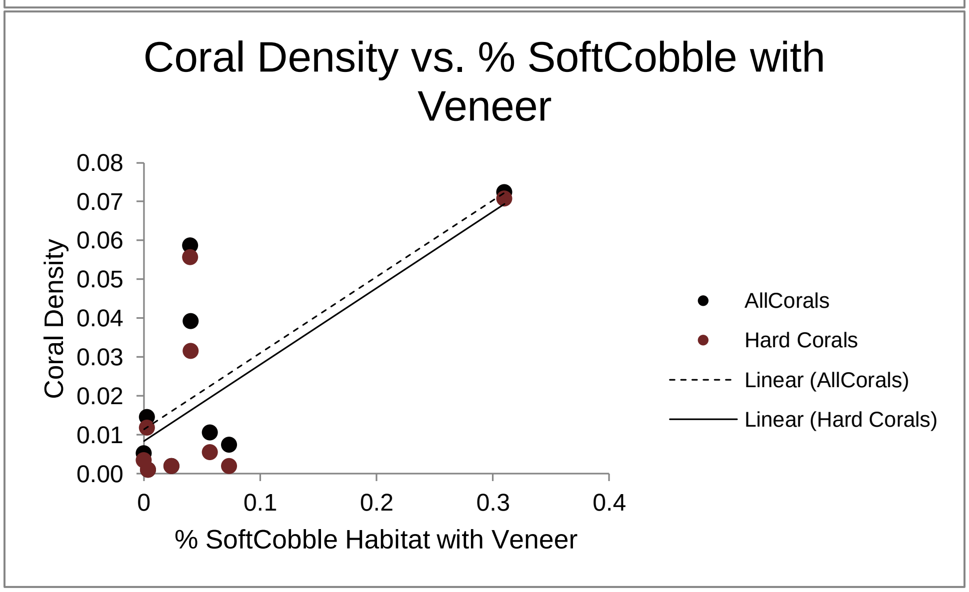

Sponge Desnity vs. % Cobble (Primary)
Sponge Density
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
0.05
0.1
0.15
0.2
0.25
% Cobble as a Primary Habitat
Sponges 20+
Linear (Sponges 20+)

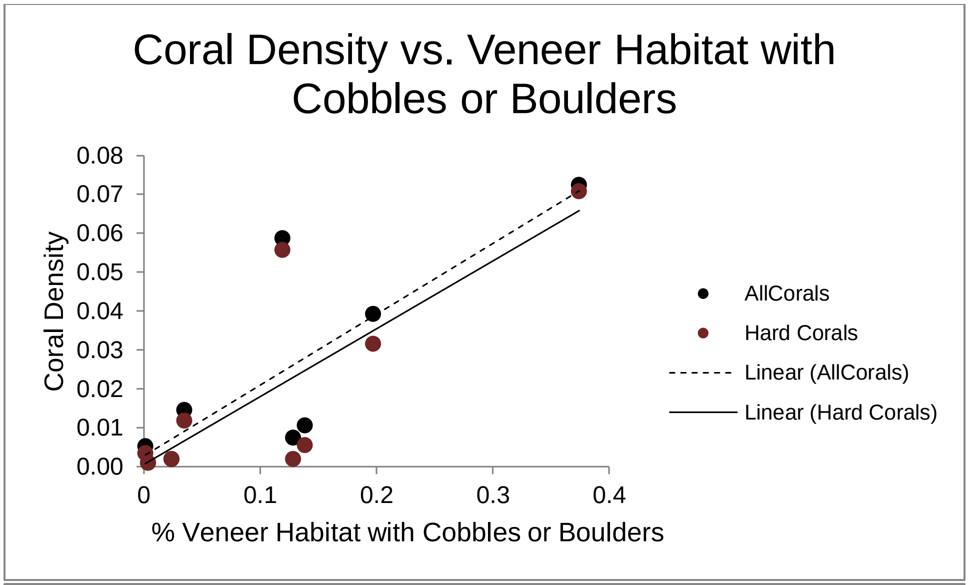

Sponge Density vs. % CobbleBoulder Habitat
Sponge Density
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
0.05
0.1
0.15
% CobbleBoulder Habitat
Sponges 20+
Linear (Sponges 20+)

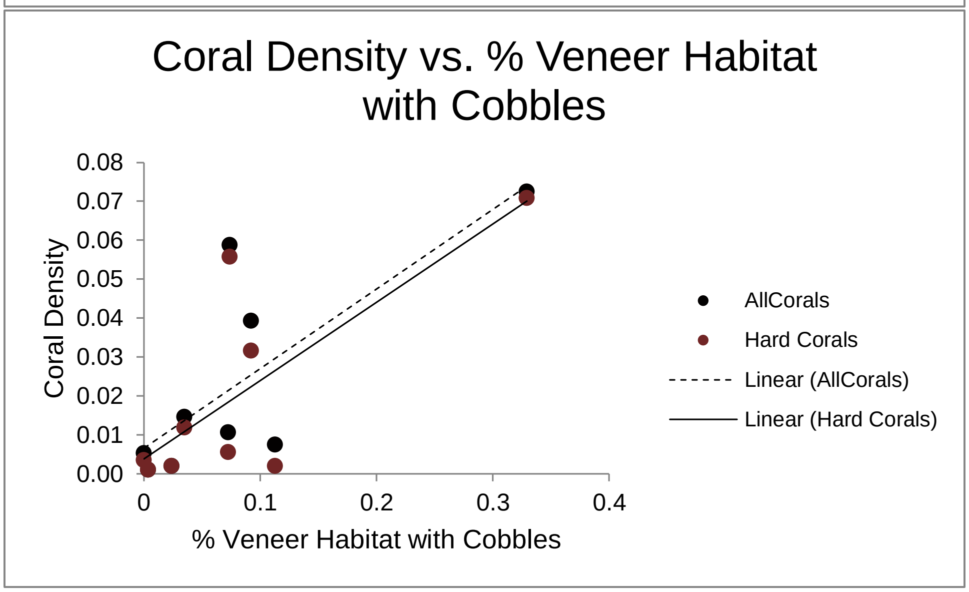

Sponge Density vs. % BoulderSoft Habitat with Veneer
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Sponge Density
0
0.01
0.02
0.03
0.04
% BoulderSoft habitat with Veneer
Sponges 20+
Linear (Sponges 20+)

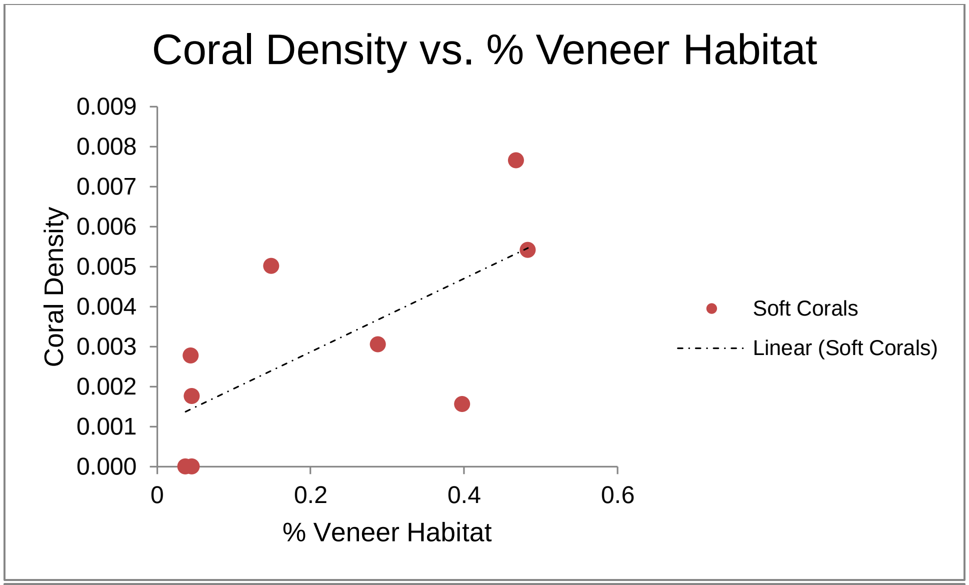
Coral Models

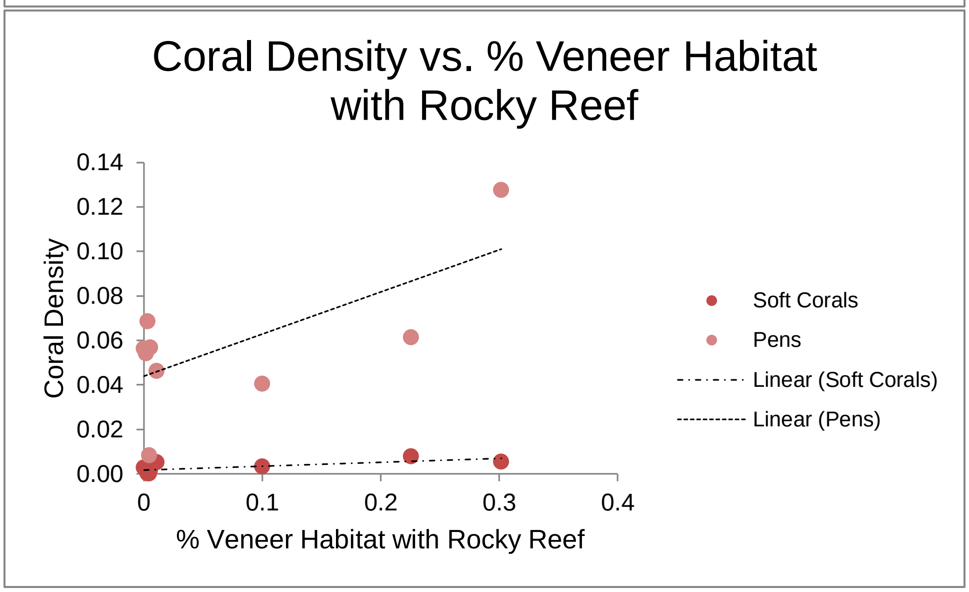


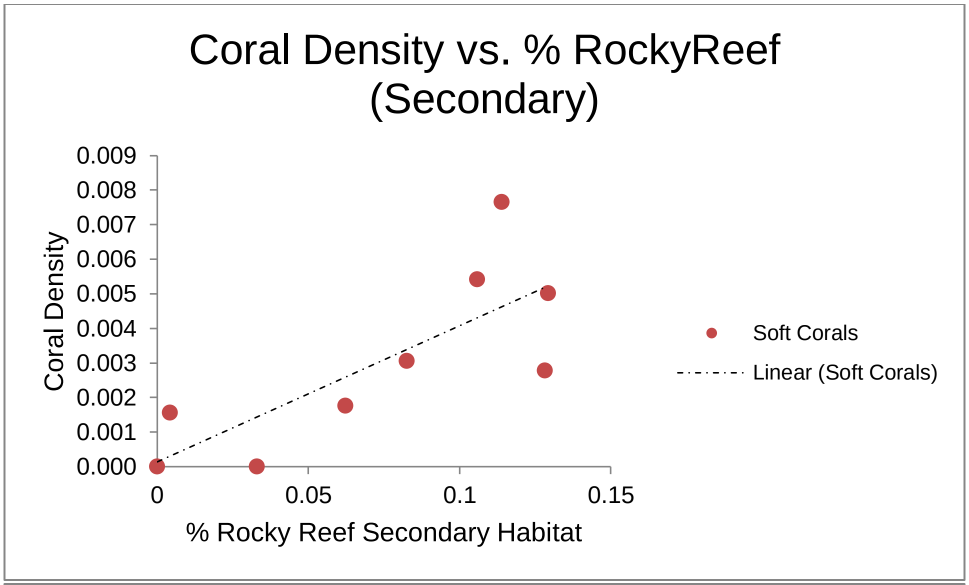


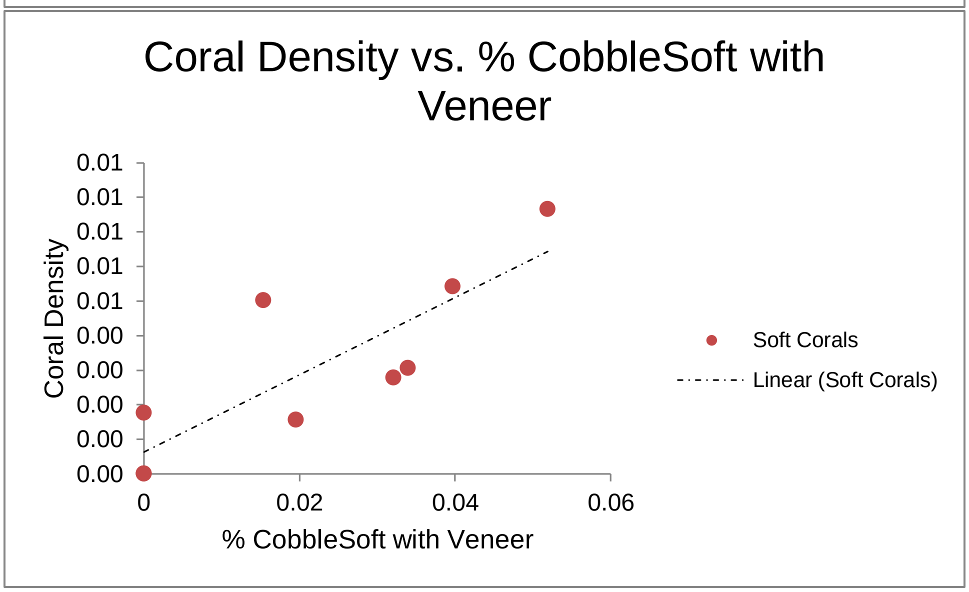

Coral Density vs. Veneer Habitat with Cobbles or Boulders
Coral Density
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
0.1
0.2
0.3
0.4
% Veneer Habitat with Cobbles or Boulders
AllCorals
Hard Corals
Linear (AllCorals)
Linear (Hard Corals)

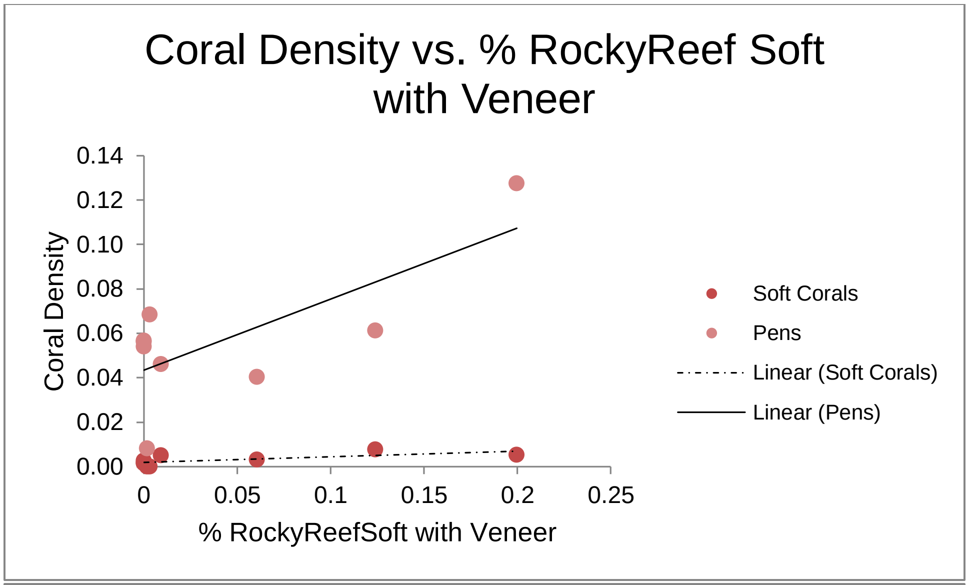

Coral Density vs. % Veneer Habitat with Cobbles
Coral Density
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
0.1
0.2
0.3
0.4
% Veneer Habitat with Cobbles
AllCorals
Hard Corals
Linear (AllCorals)
Linear (Hard Corals)


Coral Density vs. % Veneer Habitat
Coral Density
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
0.2
0.4
0.6
% Veneer Habitat
Soft Corals
Linear (Soft Corals)

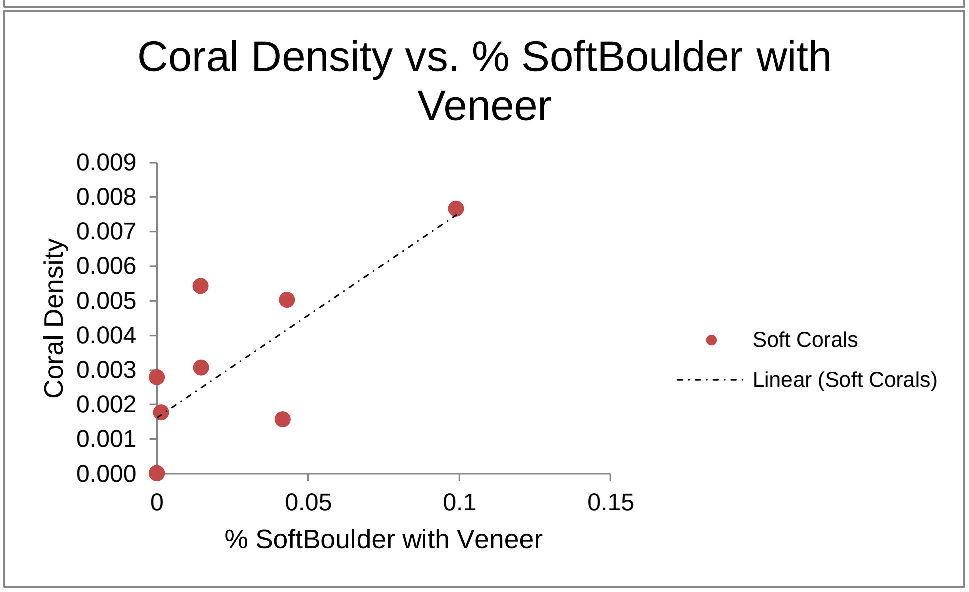

Coral Density vs. % Veneer Habitat with Rocky Reef
Coral Density
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
0.1
0.2
0.3
0.4
% Veneer Habitat with Rocky Reef
Soft Corals
Pens
Linear (Soft Corals)
Linear (Pens)


Coral Density vs. % RockyReef (Secondary)
Coral Density
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
0.05
0.1
0.15
% Rocky Reef Secondary Habitat
Soft Corals
Linear (Soft Corals)

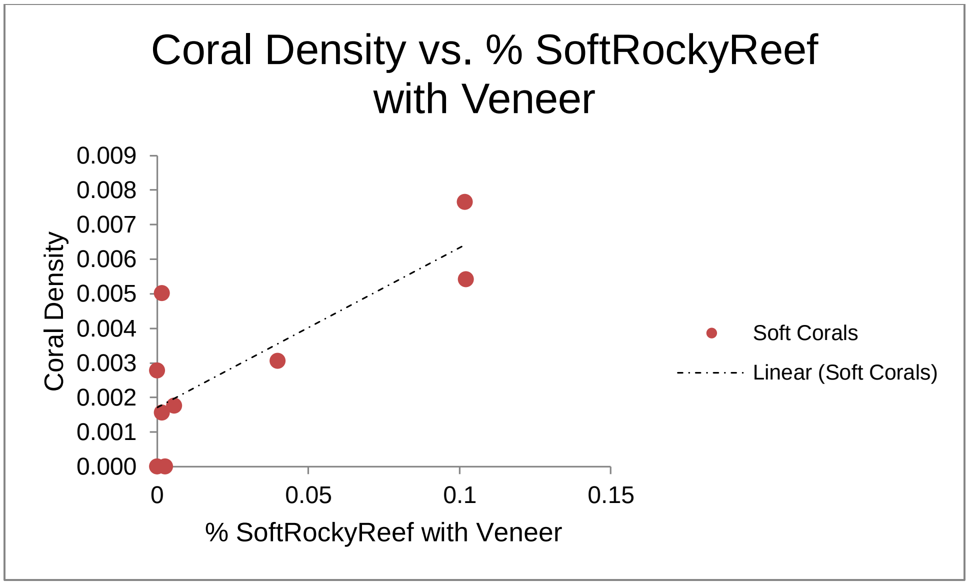

Coral Density vs. % CobbleSoft with Veneer
Coral Density
0.01
0.01
0.01
0.01
0.01
0.00
0.00
0.00
0.00
0.00
0
0.02
0.04
0.06
% CobbleSoft with Veneer
Soft Corals
Linear (Soft Corals)



Coral Density vs. % RockyReef Soft with Veneer
Coral Density
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
0.05
0.1
0.15
0.2
0.25
% RockyReefSoft with Veneer
Soft Corals
Pens
Linear (Soft Corals)
Linear (Pens)



Coral Density vs. % SoftBoulder with Veneer
Coral Density
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
0.05
0.1
0.15
% SoftBoulder with Veneer
Soft Corals
Linear (Soft Corals)



Coral Density vs. % SoftRockyReef with Veneer
Coral Density
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0
0.05
0.1
0.15
% SoftRockyReef with Veneer
Soft Corals
Linear (Soft Corals)