Goleta Bay Kelp Anchor Demonstration Project

Preliminary Site Surveys and Project Monitoring Reports to Date

Robert Kiel and Greg Christman

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Contents

Abstract

A unique phenomenon to the Santa Barbara Channel, sand-dwelling (*Macrocystis*) kelp beds were present along the mainland coast since before Europeans colonized the area. Their critical size and density likely contributed to their ability to thrive over the years as conditions within the beds were altered to favor the continued growth and survival of individual plants. The disappearance of these beds began with the 1982/'83 El Niño event. Warm water and storm conditions associated with this event resulted in the dislodgement of growth-centers (holdfast structures which utilize worm tubes to anchor on sand bottom). The resulting reduction in the overall (critical) size and density of the beds prevented remaining plants from surviving. By the mid-1980's the sand-dwelling kelp beds were gone. Since then, juvenile *Macrocystis* kelp plants can be observed growing on worm tubes, but the inherent buoyancy and drag of the growing fronds eventually results in dislodgement of the plants before adequate holdfast structures (growth-centers) can be established. The purpose of this demonstration project is to test a potential means of aiding in the restoration of a sand-dwelling kelp bed of historical proportions within Goleta Bay. The method being examined involves the setting of granite columns (2" x 2" x 30") into the seafloor. The stability of the columns in handling oceanic conditions, their ability to recruit *Macrocystis* kelp naturally and growth-center establishment are key issues being tested in this study.

Preliminary Surveys

April 2007 – Seafloor once occupied by historical sand-dwelling kelp bed, from south to north boundary:

https://www.youtube.com/watch?v=b35vQQfs9A0

Bob and Justin Kiel, and Greg Christman performed seafloor survey dives using dive sleds, while being towed by a boat (Jeff Phillips – owner and operator) from the south boundary to the north boundary of the area once occupied by the historical sand-dwelling kelp bed (~ 55' to 34' water depth). Divers used underwater communications system and were in communication with boat operator. Video camera was mounted to the front of one of the dive sleds. The abundance and concentration of eelgrass increased as depth decreased. Fish and invertebrate species and numbers were sparse. The video link is 11:59 in duration and shows one of four such surveys performed.

December 26, 2009 – Water jetting, column drop and installation tests:

https://www.youtube.com/watch?v=CNKWzkYbQws

Fred Hepp took Ed De La Torre, Greg Christman and Bob Kiel to Goleta Bay from Santa Barbara harbor in his boat (Plumeria). Greg and Bob performed dives to test water jetting at various locations/depths within the area once occupied by the historical sand-dwelling kelp bed. Sediment overburden was verified to be adequate for column installation. Tested various methods of using water jet to set test column. Also test-dropped column and confirmed it needed some type of drag device to control rate of descent and ensure it dropped straight down. Found torpedo ray on one of the dives. Video is 3:09 in duration.

October 15, 2011 – Proposed site-1 south end:

https://www.youtube.com/watch?v=Ti2NfwGKmVQ

Greg Christman and Bob Kiel launched (inflatable) 12' Achilles boat from beach late in the day and performed a survey dive of proposed site-1 south end. Water depth was 53' and light level was low. Installed wood stake and took core sample. Video shows core sample being taken as well as core laid out alongside a tape measure. Note shell layer beginning at ~ 15" sediment depth. This shell layer was observed in cores taken from other locations at water depths between 30-55 feet. Video is 2:37 in duration.

October 16, 2011 – Proposed site-3: https://www.youtube.com/watch?v=O3quKRsBCN4

Greg Christman and Bob Kiel performed survey dive of proposed site-3. Launched (inflatable) 12' Achilles boat from beach. Installed wood stake and took core sample at each end. South end water depth 36' and north end water depth 38'. Found several stones/rocks and two

Feather Duster worm tubes (*Eudastylia polymorpha*): indicative of shallow overburden or underlying rocks). The decision was made later to abandon site-3 as a test site for the columns. Video is 4:07 in duration.

October 17, 2011 – Proposed site-1 center plot, N-S center line:

https://www.youtube.com/watch?v=Upu-ynBEaBg

Greg Christman and Bob Kiel performed survey dive of proposed site-1 N-S center line. Launched (inflatable) 12' Achilles boat from Goleta pier. Installed wood stake and took core sample at each end. South end water depth 40' and north end water depth 34'. Found three juvenile kelp plants growing on *Diopatra ornata* worm tubes. Small clusters of eelgrass at shallower depths. Video link is 5:20 in duration.

October 18, 2011 – Proposed site-2:

https://www.youtube.com/watch?v=soiiY2t7uLw

Greg Christman and Bob Kiel performed survey dive of proposed site-2. Launched Achilles boat from Goleta pier. Noticed low sediment overburden and exposed silt stone at proposed north end (32' depth). Gas bubbles coming out of seafloor in area as well. Installed wood stake and took core sample at proposed south end (38' depth), which became the new north end. Ran 220' tape south from new north end. Installed stake and took core sample (40' depth). Video is 2:20 in duration.

October 21, 2011 – Proposed site-1 plot, north center to NW corner to SW corner:

https://www.youtube.com/watch?v=X-r7h5wTdkI

Greg Christman and Bob Kiel performed survey dive. Launched Achilles boat from beach. Set buoys from boat using GPS. Installed wood stake at center of north end of plot (41' depth), used compass and tape measure to NW corner (measured 104'), installed wood stake (41' depth), used compass and tape measure to SW corner (measured 195', saw one small dead *Macrocystis* kelp plant on worm tube). Video link is 2:27 in duration.

October 21, 2011 – Proposed site-1 plot, SE corner to NE corner to N side center:

https://www.youtube.com/watch?v=VuAJTtMzIQs

Greg Christman and Bob performed survey dive. Launched Achilles boat from beach. Set buoys from boat using GPS. Drop tested column using whirligig descender. Column dropped straight down at < 2' per second. Installed wood stake at SE corner (42' depth). Used compass and tape measure to NE corner (210', 40' depth). Installed wood stake. Used compass and tape measure to north side center (99', 39' depth). Found one small *Macrocystis* kelp plant growing on *Diopatra* worm tube. Video is 3:13 in duration.

Google Earth Link:

GE with 1972 and 1975 photos depth chart, and test sites.kmz

To download Google Earth (for free), go to:
http://www.google.com/earth/download/ge/agree.html

Test Site-1 Installation Report

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Kelp Anchor Demonstration Project

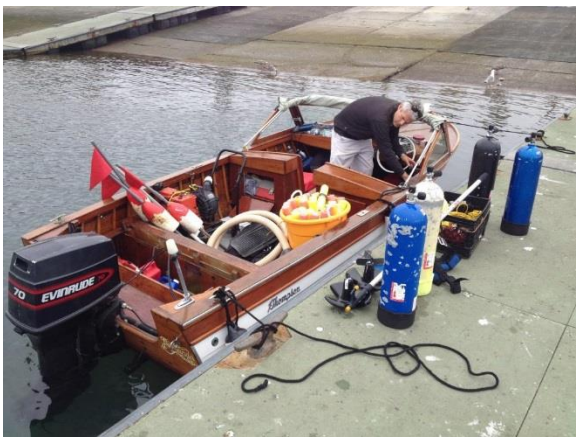
Monitoring Report

Report Date: December, 2015

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test Site-1 Center Grid.
Kelp Anchor Installation:	In early December, 2015, Greg Christman and Bob Kiel (visiting from Seattle) water jetted eleven columns into the seafloor along the center north-south line of the central plot (grid). The row of columns was set in place by clipping each column at 20-foot-centers to a line being payed-out from the boat. A small anchor was used to place the first column and end of rope. This method for lowering the anchors proved to be cumbersome and was difficult to control accuracy with respect to placement. We also consumed our limited supply of (SCUBA) air making dives to check and reset the line of columns. Time and weather constraints prevented the installation of additional columns. With El-Niño conditions developing, we felt the eleven columns would at least provide some indication of their stability with respect to projected winter storm activity.
Survey Performance Specifics:	
Date:	12-12-2015
Method:	Deploy columns from boat and water jet into seafloor using SCUBA.
Performed By:	Greg Christman and Bob Kiel.
Scope:	Managed to only deploy and set 11 columns into the seafloor.

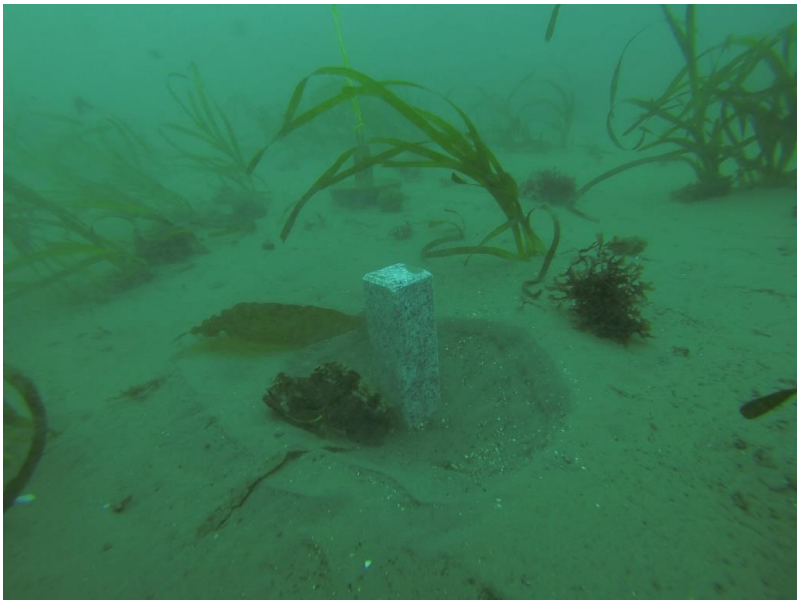
Survey Results/Observations:		
1	**Weather:**	Winds picked up to 15+ mph.
2	**Visibility:**	< 15 feet.
3	**Accounting for Installed Columns:**	11 total.
4	**Column Burial:**	All columns were protruding ~ 6-7 inches from the seafloor.
5	**Vertical or horizontal Movement of Installed Columns:**	NA

6	**Scour evident:**	NA
7	**Kelp Recruitment:**	NA
8	**Type of kelp recruited:**	NA
9	**Size and condition of Kelp:**	NA
10	**Size of "hold-fast" at columns (if present):**	NA
11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	NA



Greg Christman getting his boat (Amanda) ready to head out from Santa Barbara harbor. Gear on board includes, buoys, anchors, dive gear, granite columns, descenders, gas pump, hose and water jet wand (to name a few).

Granite columns ready to deploy with descenders attached using prussic loops.



Newly installed granite column, north end of center N-S line of central plot. Note “Sarcastic Fringehead” fish claimed column shortly after it was installed. This fish would attack us when we approached it!

Mid-April, 2016:

BEACON

Kelp Anchor Demonstration Project

Monitoring Report

Report Date: April, 2016

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test Site-1 Center Grid.
Kelp Anchor Installation:	Original 11 columns were surveyed by Greg, Hannah and Casey. All columns had only a "fuzzy" algae film on them. There wasn't any noticeable change with respect to amount of each column protruding from the seafloor.
Survey Performance Specifics:	
Survey Date:	4-16-2016
Survey Method:	Dive.
Survey Performed By:	Greg and Hannah Christman, and Casey Morse.
Survey Scope:	Check initial 11 columns and vicinity.

Survey Results/Observations:		
1	**Weather:**	Nice!
2	**Visibility:**	15'
3	**Accounting for Installed Columns:**	Saw all 11 columns.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	Algae fuzz on columns. Some spade-shaped blades, characteristic of juvenile *Macrocystis*.
8	**Type of kelp recruited:**	Unknown.
9	**Size and condition of Kelp:**	NA
10	**Size of "hold-fast" at columns (if present):**	NA

11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.

Typical column with algae fuzz growth. Note larger blade is possibly a juvenile *Macrocystis* plant.

Memorial Day Weekend and the first week of June, 2016:

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Kelp Anchor Demonstration Project

Monitoring Report

Report Date: June, 2016

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test Site-1 Center Grid.
Kelp Anchor Installation:	Greg and Bob managed to complete the installation of the 110 columns which make up the central (200' x 200') plot. Greg made a chart showing the GPS coordinates of each column (see Appendix-2). This chart was used at location to place each column. Buoyant descenders were used to create drag and control the decent of columns deployed from the boat. This method of deployment proved to be much easier and was performed as follows: 1. The GPS coordinates of the north and south ends of each line within the plot were set into the boats GPS. 2. A mushroom anchor with buoy was placed at each end of the row being set. 3. Columns were made ready to deploy by attaching a descender to each column using a prussic loop. 4. Greg drove the boat along the respective longitudinal heading, while Bob deployed each anchor from the boat at the appropriate latitude (using a Garmen hand-held GPS). To improve accuracy, the GPS was set to Degrees, Decimal Minutes (DDM). At this setting, the last integer (thousandth place of minutes) will change value in ~ 5 feet. 5. Two adjacent rows (totaling 22 columns) were deployed each time prior to water jetting. 6. The boat was anchored and positioned over the ~ center of the rows, accounting for wind and current. 7. Dive gear was donned and the gas-powered pump was started prior to going over the side. 8. We started water jetting at one of the end buoys, then proceeded down the respective line of columns and double-backed up the adjacent line of columns. 9. The buoyant and brightly colored descenders (hovering ~ 3' off the bottom) were easy to spot in the limited visibility water.

	10. Each respective descender prussic loop was threaded onto the water jetting hose when each column was water jetted into the seafloor. The initial 11 columns were surveyed after the plot was completed. All had *Macrocystis* growing on them! Frond lengths ranged from ~ 2 feet to 10 feet. Coming out of an El Niño winter, this was not expected. The haptera were growing over and down each column. No change in the amount of each column protruding from the seafloor was observed.
Survey Performance Specifics:	
Date Range:	5-29-2017 through 6-3-2017
Method:	GPS, buoys, descenders, gas pump, water jet hoses and wand, SCUBA.
Performed By:	Greg Christman and Bob Kiel
Scope:	Completed the installation of the 110 columns which make up the central (200' x 200') plot. Checked initial 11 columns. All had kelp plants growing on them!

Survey Results/Observations:		
1	**Weather:**	Favorable.
2	**Visibility:**	15'
3	**Accounting for Installed Columns:**	Installed additional 99 columns to complete installation of central plot in site-1. Surveyed initial 11 columns.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	All original 11 columns had *Macrocystis* kelp plants growing on them.
8	**Type of kelp recruited:**	*Macrocystis*.
9	**Size and condition of Kelp:**	2' to 10' long fronds. All looked healthy.
10	**Size of "hold-fast" at columns (if present):**	Haptera were growing on and down each column.

11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.

Column with descender sitting on seafloor. Bob Kiel getting ready to water jet hole into seafloor for column.

Multiple descenders on surface. Each descender prussic loop was threaded onto the water jet hose and they eventually worked their way to the surface. Note marker buoy in right of photo.

Note sample pictures of kelp plants growing on first 11 columns below.



September 2016:

Greg swam out to the plot. Visibility was 10-20 feet. Used hand-held GPS in water-proof case. Did not see any fronds.

Mid-October, 2016:

BEACON

Kelp Anchor Demonstration Project

Monitoring Report

Report Date: October, 2016

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test sites 1 & 2.
Kelp Anchor Installation:	Bob and Greg installed (64 additional) columns along the north and south extension lines from the center of the central plot (32 columns to the north and 32 columns to the south). Also, installed 15 columns in "site-2" (closer to Goleta Point). It took a couple test water-jetting efforts (moving west to east from the point) to find adequate sediment overburden (see aerial with CAD overlay). The decision was made to not do a site-3 for the time being. The columns in site-2 are ~ 7-8 feet apart. The north and south GPS coordinates were determined. Visibility was limited. Did not have time to survey all of the original eleven columns.
Survey Performance Specifics:	
Date:	10/23-28/2016
Method:	GPS, buoys, descenders, gas pump, water jet hoses and wand, SCUBA.
Performed By:	Greg Christman and Bob Kiel.
Scope:	Deployed and installed 64 columns in the north and south legs of site-1. Deployed and installed 15 columns in site-2.

Survey Results/Observations:		
1	**Weather:**	Nice!
2	**Visibility:**	10’
3	**Accounting for Installed Columns:**	Saw ~ 15 columns within the site-1 central plot.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	Algae fuzz on columns. Some spade-shaped blades, characteristic of juvenile *Macrocystis*.
8	**Type of kelp recruited:**	Unknown.
9	**Size and condition of Kelp:**	NA
10	**Size of “hold-fast” at columns (if present):**	NA
11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.

December, 2016:

BEACON

Kelp Anchor Demonstration Project

Monitoring Report

Report Date: December, 2016

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25.
Kelp Anchor Survey:	Greg and Casey surveyed columns within the central plot of site-1. All columns appeared to be protruding from the seafloor as originally set. Kelp on the original 11 columns was dead or dying. The remaining fronds were < ~ 3 feet long and had the appearance of being chewed on.
Survey Performance Specifics:	
Date:	12-17-2016
Method:	SCUBA.
Performed By:	Greg Christman and Casey Morse.
Scope:	Surveyed columns within central grid of site-1.

Survey Results/Observations:		
1	**Weather:**	Calm
2	**Visibility:**	15+ feet
3	**Accounting for Installed Columns:**	Saw ~ 30 columns within the site-1 central plot.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	Algae fuzz on columns. Some spade-shaped blades, characteristic of juvenile *Macrocystis*. All kelp plants on original 11 columns were dead.
8	**Type of kelp recruited:**	Unknown.
9	**Size and condition of Kelp:**	All kelp plants on original 11 columns were dead.
10	**Size of "hold-fast" at columns (if present):**	NA

11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.

April, 2017:

BEACON

Kelp Anchor Demonstration Project

Monitoring Report

Report Date: April, 2017

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test Site-1.
Kelp Anchor Survey:	Greg and Bob surveyed portions of the grid on site-1, and all 64 columns in the north and south legs. Each of the original 11 columns had a dead holdfast "cap" on top of them. ~ 10% of columns had plants < 6 feet growing on them, ~ 10% of columns had plants > 6 feet growing on them, and all remaining columns had varying degrees of algal "fuzz" growing on them. All columns appeared to be protruding from the seafloor as originally set.
Survey Performance Specifics:	
Date:	4-15-2016
Method:	SCUBA.
Performed By:	Greg Christman and Bob Kiel.
Scope:	Surveyed portions of grid on site-1 and all 64 columns in the north and south legs of site-1.

Survey Results/Observations:		
1	**Weather:**	Calm
2	**Visibility:**	15'
3	**Accounting for Installed Columns:**	Saw ~ 100 columns within site-1.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	Algae fuzz on columns. Some spade-shaped blades, characteristic of juvenile *Macrocystis*. Each of the original 11 columns had a dead holdfast cap on them.
8	**Type of kelp recruited:**	*Macrocystis*.
9	**Size and condition of Kelp:**	New kelp growth looked healthy.

10	**Size of "hold-fast" at columns (if present):**	Holdfasts were small but developing nicely.
11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.

Shark sighting posted on Goleta Beach. Sighted day before our dive.

Typical dead holdfast which was growing on one of the initial 11 columns.

August, 2017:

BEACON

Kelp Anchor Demonstration Project

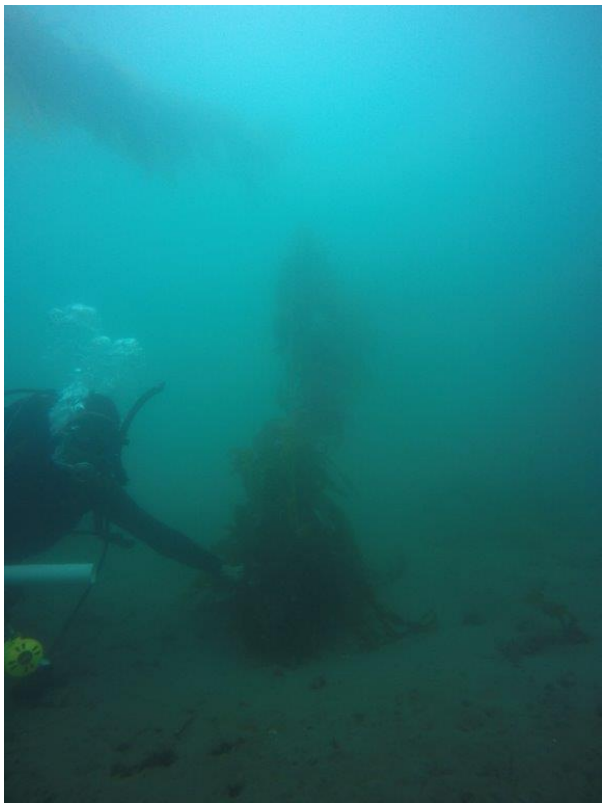
Monitoring Report

Report Date: August, 2017

Project Background:	
Reference:	Appendix 2, page 24 and Appendix 3, page 25. Test Site-1.
Kelp Anchor Survey:	A short visit to Santa Barbara by Bob (along with many other commitments) left minimal opportunities to perform survey dives. Greg and Bob performed two dives total on the central grid of site-1: one on Friday the 25th and the other on Sunday the 27th. A noticeable increase in the number and size of kelp plants on the columns was observed. ~ 50 % of the columns had kelp plants growing on them. Some plants (~ 10%) had fronds > 30 feet long with well-developing holdfasts. A slight current was drawing the fronds down, which prevented the ability to see them from the surface. The other columns had various species of small algae growing on them. All columns appeared to be protruding from the seafloor as originally set. The establishment of growth-centers (individual holdfast structures growing on sand bottom) relies on the colonization of worm tubes amongst the holdfast. Extending over a foot into the seafloor, large numbers of worm tubes growing within a holdfast effectively anchor the holdfast to the seafloor. In an attempt to optimize this process, time was spent during each dive setting some of the columns deeper into the seafloor (amount protruding reduced from 6-7 inches to 2-3 inches). Nine columns were reset over the two dives. *Diopatra ornata* worm tubes were observed colonizing around the perimeter of the larger holdfasts, which are growing down to and over the seafloor. Some time was spent on Sunday testing an ROV at the site-1 grid. More practice and testing in its operation is needed. The north and south legs of site-1 were not monitored and neither was site-2. Because of the difficulty in trying to perform monitoring dives at different locations, we discussed the idea of

	removing the columns from site-2 and possibly reinstalling them in site-1.
Survey Performance Specifics:	
Date:	4-25 & 27-2017
Method:	SCUBA.
Performed By:	Greg Christman and Bob Kiel.
Scope:	Surveyed portions of grid on site-1.

Survey Results/Observations:		
1	**Weather:**	Light breeze.
2	**Visibility:**	15’
3	**Accounting for Installed Columns:**	Saw ~ 60 columns within site-1.
4	**Column Burial:**	None, same as when set.
5	**Vertical or horizontal Movement of Installed Columns:**	None.
6	**Scour evident:**	None.
7	**Kelp Recruitment:**	Looking very good! Possibly 50 % of columns had kelp growing on them.
8	**Type of kelp recruited:**	*Macrocystis*.
9	**Size and condition of Kelp:**	New kelp growth looked healthy.
10	**Size of “hold-fast” at columns (if present):**	Holdfasts developing nicely. Many were growing across the seafloor with *Diopatra* colonizing around the haptera.
11	**Review of Other Features in the Navigable Water Way:**	This is an open bay with no harbor and very limited recreational boating activity. There is an existing recreational pier to the east. This work did not make any changes to the navigable waterway.
12	**Presence of Eelgrass:**	Sparse and random.
11	**Presence of Invasive Species on Columns:**	None.



Next scheduled monitoring dives:

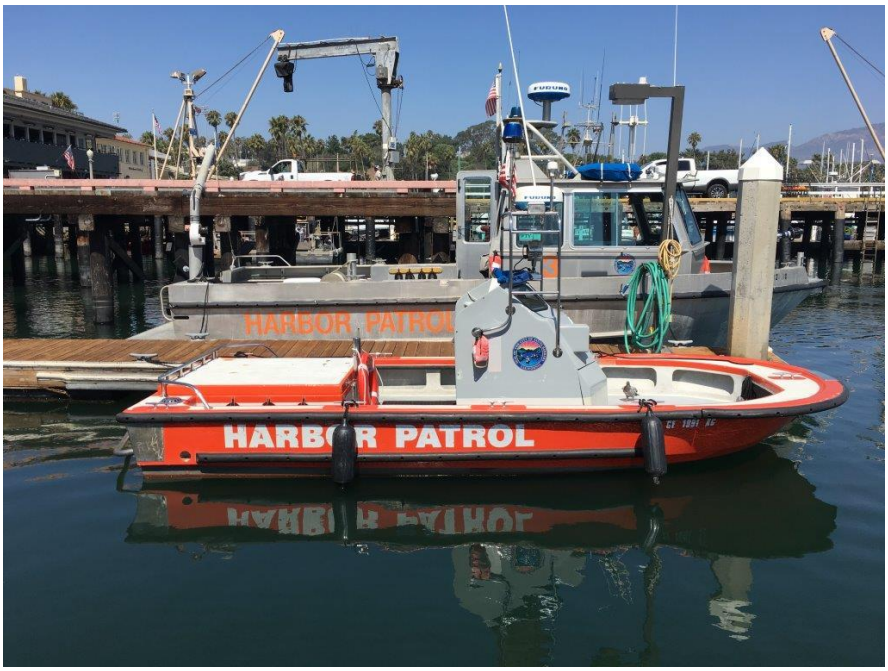
Bob is planning on making a trip to SB in mid-November. Conditions permitting, the plan is to perform dives on as much of the survey sites as possible. We may also attempt to remove the 15 columns from site-2 (abandoning the site) and reinstalling them somewhere within site-1.

Bob is in the process of testing an alternative method to water jetting for installing columns, which may be tested in November as well. If this method proves to be preferable to water jetting, it would be used to set existing columns deeper and/or relocate the columns removed from site-2.

Conclusion

The 189 columns installed within the test sites (174 in site-1 and 15 in site-2) appear to be stable. *Macrocystis* kelp is recruiting onto the columns naturally. Kelp fronds are growing to the surface and the holdfasts are growing down to and over the seafloor, with *Diopatra ornata* worm tubes colonizing among the haptera. No invasive algae (*Caulerpa taxifolia*) has been observed within the test sites.

Greg's classic (Thompson) wooden boat is taking a beating with the use it's been getting on this project. This boat is not designed for the conditions we've been exposing it to and has developed multiple leaks. Bob met with Don Radon in August. Don informed Bob he had made a new Harbor Patrol boat and the old boat was going up for auction. Bob checked out the boat and met with Karl Treiberg to discuss the possibility of acquiring the boat for this project.

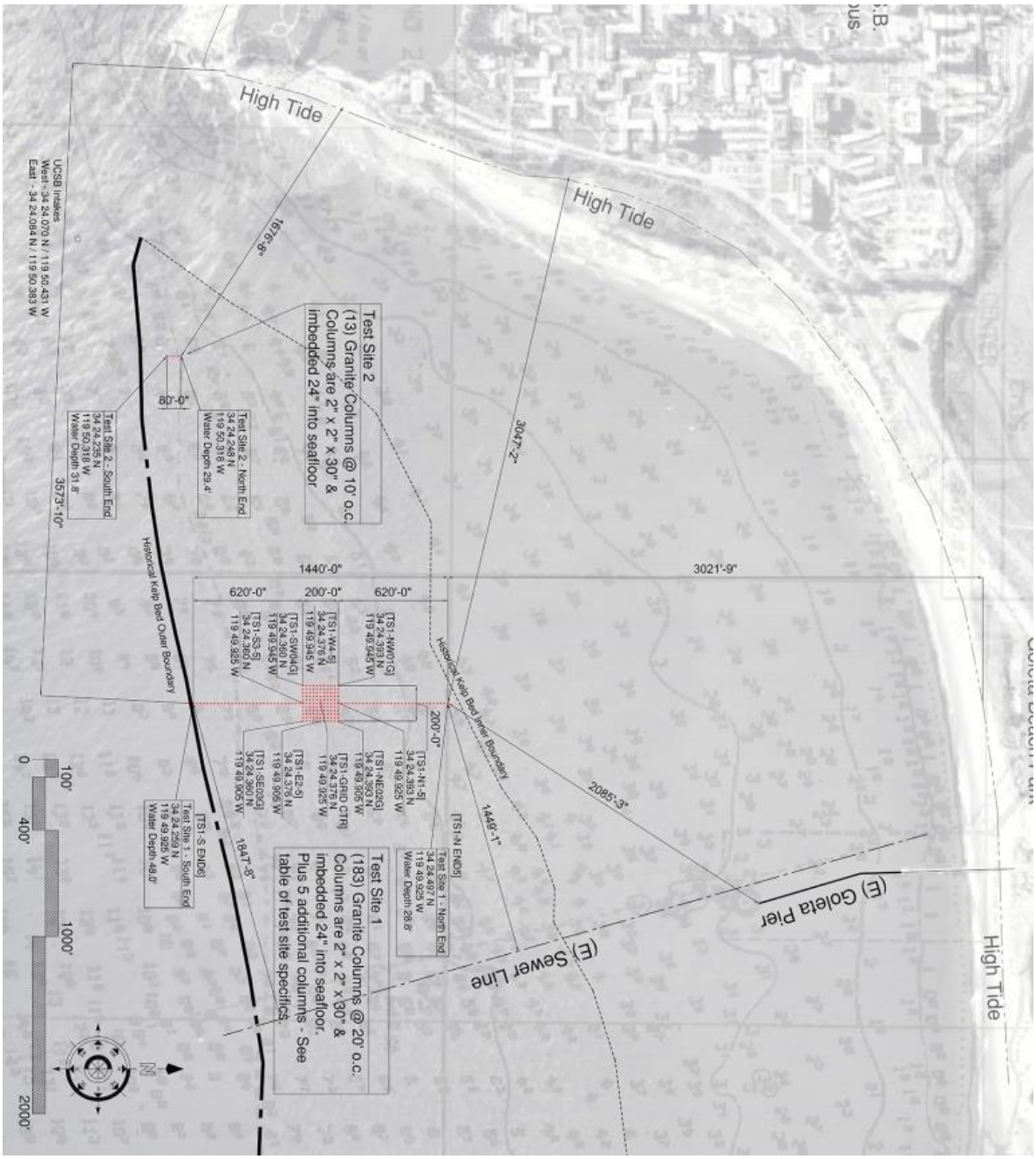


Appendix-1

Original site plan showing proposed test sites 1, 2 & 3:

Appendix 2

Revised site plan showing test sites 1 & 2:



Appendix 3

Test site-1 center grid:

Goleta Bay Kelp Restoration Project
Installation Log

Test Site 1
Center Grid Area

	A	B	C	D	E	F	G	H	I	J	K
1	TS1-NW 01 G 34° 24+B2:D12.393' N	34 24.393 N 119.49.941 W	34 24.393 N 119 49.937 W	34 24.393 N 119 49.933 W	34 24.393 N 119 49.929 W	TS1-N 1.5 34° 24.393' N 119° 49.925' W	34 24.393 N 119.49.921 W	34 24.393 N 119 49.917 W	34 24.393 N 119 49.913 W	34 24.393 N 119 49.909 W	TS1-NE 02 G 34° 24.393' N 119° 49.905' W
2	34° 24.389' N 119° 49.945' W	34 24.389 N 119.49.941 W	34 24.389 N 119 49.937 W	34 24.389 N 119 49.933 W	34 24.389 N 119 49.929 W	34° 24.389' N 119° 49.925' W	34 24.389 N 119.49.921 W	34 24.389 N 119 49.917 W	34 24.389 N 119 49.913 W	34 24.389 N 119 49.909 W	34° 24.389' N 119° 49.905' W
3	34° 24.385' N 119° 49.945' W	34 24.385 N 119.49.941 W	34 24.385 N 119 49.937 W	34 24.385 N 119 49.933 W	34 24.385 N 119 49.929 W	34° 24.385' N 119° 49.925' W	34 24.385 N 119.49.921 W	34 24.385 N 119 49.917 W	34 24.385 N 119 49.913 W	34 24.385 N 119 49.909 W	34° 24.385' N 119° 49.905' W
4	34° 24.382' N 119° 49.945' W	34 24.382 N 119.49.941 W	34 24.382 N 119 49.937 W	34 24.382 N 119 49.933 W	34 24.382 N 119 49.929 W	34° 24.382' N 119° 49.925' W	34 24.382 N 119.49.921 W	34 24.382 N 119 49.917 W	34 24.382 N 119 49.913 W	34 24.382 N 119 49.909 W	34° 24.382' N 119° 49.905' W
5	34° 24.379' N 119° 49.945' W	34 24.379 N 119.49.941 W	34 24.379 N 119 49.937 W	34 24.379 N 119 49.933 W	34 24.379 N 119 49.929 W	34° 24.379' N 119° 49.925' W	34 24.379 N 119.49.921 W	34 24.379 N 119 49.917 W	34 24.379 N 119 49.913 W	34 24.379 N 119 49.909 W	34° 24.379' N 119° 49.905' W
6	TS1-W 4.5 34° 24.376' N 119° 49.945' W	34 24.376 119.49.941	34 24.376 119 49.937	34 24.376 119 49.933	34 24.376 119 49.929	TS1-GRID CTR 34° 24.376' N 119° 49.925' W	34 24.376 119.49.921	34 24.376 119 49.917	34 24.376 119 49.913	34 24.376 119 49.909	TS1-E 2.5 34° 24.376' N 119° 49.905' W
7	34° 24.373' N 119° 49.945' W	34 24.373 N 119.49.941 W	34 24.373 N 119 49.937 W	34 24.373 N 119 49.933 W	34 24.373 N 119 49.929 W	34° 24.373' N 119° 49.925' W	34 24.373 N 119.49.921 W	34 24.373 N 119 49.917 W	34 24.373 119 49.913	34 24.373 119 49.909	34° 24.373' N 119° 49.905' W
8	34° 24.370' N 119° 49.945' W	34 24.370 N 119.49.941 W	34 24.370 N 119 49.937 W	34 24.370 N 119 49.933 W	34 24.370 N 119 49.929 W	34° 24.370' N 119° 49.925' W	34 24.370 N 119.49.921 W	34 24.370 N 119 49.917 W	34 24.370 119 49.913	34 24.370 119 49.909	34° 24.3870 N 119° 49.905' W
9	34° 24.367' N 119° 49.945' W	34 24.367 N 119.49.941 W	34 24.367 N 119 49.937 W	34 24.367 N 119 49.933 W	34 24.367 N 119 49.929 W	34° 24.367' N 119° 49.925' W	34 24.367 N 119.49.921 W	34 24.367 N 119 49.917 W	34 24.367 119 49.913	34 24.367 119 49.909	34° 24.367' N 119° 49.905' W
10	34° 24.364' N 119° 49.945' W	34 24.364 N 119.49.941 W	34 24.364 N 119 49.937 W	34 24.364 N 119 49.933 W	34 24.364 N 119 49.929 W	34° 24.364' N 119° 49.925' W	34 24.364 N 119.49.921 W	34 24.364 N 119 49.917 W	34 24.364 119 49.913	34 24.364 119 49.909	34° 24.364' N 119° 49.905' W
11	TS1-SW 04 G 34° 24.360' N 119° 49.945' W	34 24.360 119.49.941	34 24.360 119.49.937	34 24.360 119.49.933	34 24.360 119.49.929	TS1-S 3.5 34° 24.360' N 119° 49.925' W	34 24.360 119.49.921	34 24.360 119.49.917	34 24.360 119.49.913	34 24.360 119.49.909	TS1-SE 03 G 34° 24.360' N 119° 49.905' W

Column Installation Log Legend

- Oak stakes installed Nov. 15, 2015 — G. Christman / H. Christman
- Oak stakes and Granite column installed Dec. 15-16, 2015 — R. Kiel / G. Christman
- Granite Column installed Dec 15-16, 2015 — R. Kiel / G. Christman
- Oak stakes installed Dec 15-16, 2015 — R. Kiel / G. Christman
- Granite Column installed June 4, 2016 — R. Kiel / G. Christman
- Granite Column installed May, 30 2016 — R. Kiel / G. Christman
- Granite Column installed May, 29 2016 — R. Kiel / G. Christman
- Granite Column installed May, 28 2016 — R. Kiel / G. Christman