Southern California Open Coast Eelgrass Survey Summary:

2018 Field Season

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Background

Eelgrass (*Zostera* spp.) is a suite of marine flowering plants that provide numerous biological benefits and ecosystem services including juvenile fish nursery habitat, carbon sequestration and shoreline protection. They are found worldwide and in southern California are common in bays and harbors as well as along the mainland coast and Channel Islands. Eelgrass beds are dynamic, often changing distribution in response to available space, nutrients, light and other limiting factors. Given the benefit of this species to both the natural environment and humans, data on distribution, structure and habitat utilization are highly valuable. These data are particularly crucial as anthropogenic stressors have reduced seagrass coverage, including eelgrass, globally (Orth et al. 2006). While eelgrass distribution and fish data have been taken in some of southern California's bays and estuaries (i.e., Coastal Resources Management. Inc. 2007 and 2016; Merkel and Associates, Inc 2014; Obaza et al. 2015), less is known about open coast eelgrass along the mainland and the Channel Islands (but see Engle and Miller 2005; Santa Barbara Channelkeeper 2010). Therefore, researchers from Paua Marine Research Group, Coastal Resources Management, Inc. and University of Southern California seek to fill data gaps on open coast eelgrass by addressing the following questions:

1) What is the spatial distribution and areal coverage of selected open coast eelgrass beds in southern California? Where possible, how do the results compare with previously collected data?

2) What is the structural (e.g. density, blade length and width) composition of open coast eelgrass beds?

3) What is the fish community composition in open coast eelgrass beds? Do those communities vary across different regions?

This study is not a comprehensive survey of all open coast eelgrass in southern California. Instead, it should be viewed as a first step towards improving and enhancing the available data base on open coast eelgrass beds and their ecosystem function.

Methods

Surveys of the open coast eelgrass beds and associated fish communities were conducted offshore of Santa Barbara, Malibu, La Jolla, and on the eastern (leeward) and western (windward) sides of Catalina Island between July and December, 2018. Sampling season was established as July through December 2018 in accordance with results from Tanner et al. (in review) on eelgrass structure, distribution and fish abundance. This sampling season is not in accordance with the California Eelgrass Mitigation Policy (NOAA Fisheries West Coast Region 2014) and we opted to follow the Tanner et al. July through December sampling period based on the availability of recent, location specific-data for our survey sites. In addition, one bed on the backside of Catalina Island was not sampled until January 5th 2019 due to adverse oceanographic conditions but was still included in this report.

Offshore eelgrass bed sampling locations were identified through the existing literature (Engle and Miller 2005; Santa Barbara Channelkeeper 2010, Bernstein et al. 2011); online databases (e.g. Ecoatlas.org); or general knowledge of specific areas by local individuals (specifically the La Jolla open coast eelgrass bed).

Eelgrass presence or absence and locations of each bed for this study were established by a combination of reconnaissance SCUBA dive surveys and/or using a downlooking sonar system while towing a remotely deployed camera lowered over the side of a vessel to produce real-time video of the benthos. GPS coordinates were collected at all sites.

Eelgrass Data Collection

Areal Cover. Two methods were used to quantify eelgrass areal cover. Method #1 involved a biologist-diver and a surface support biologist to map eelgrass beds using a Trimble R1 GNSS receiver linked with a smartphone. This mapping was accomplished by a biologist- diver swimming around the perimeter of the eelgrass bed while towing a Pelican Float^{tm} while the second surface-support biologist followed this path with a Trimble R1 GPS receiver on the surface. The GPS receiver, enabled with real-time SBAS correction, provided sub-meter accuracy during mapping. All data were exported to the Trimble Terraflex cloud system for review and are available as shapefiles. Method #2 involved the remote mapping of larger beds (e.g., several square miles), using a Lowrance Carbon HD Touch Chartplotter/Ecosounder sonar system from the Coastal Resources Management, Inc. 22 ft support vessel. This remote mapping technique was used to acoustically collect data on bottom depth and vegetation from the unit's 200-kilohertz (kHz) transducer acoustic signal associated with a Wide Area Augmentation System (WAAS)-corrected global positioning system (GPS) position. In addition, a 455/800 kHz transducer and power module with dual channels (Structurescan and downlooking sonar) provided a 180-degree view and a downlooking view of the seafloor (data were logged on the 800-kHz channel).

Eelgrass Turion Density. Density data were collected in all eelgrass beds by counting turions within a PVC quadrat (0.07 or 0.25 m^2) and scaled up to attain a turions/m^2 measurement. *Zostera* canopy height was recorded (to the nearest cm) as 80% of the mean length of ≥10 haphazardly selected leaf shoots. Blade width was measured to the nearest mm using the marked edge of a dive slate or tracing the width of a shoot on waterproof paper and later, while on shore, measuring width with a ruler. Eelgrass width is significant in part because it signifies the difference between two species in southern California. Wider eelgrass (> 1 cm) is *Zostera pacifica* and thinner eelgrass (< 0.5 cm) is *Zostera marina*. Both species are known to exist along the open coast of southern California (Figure 1).

Fish Data Collection

Biologist-divers using SCUBA conducted timed "roving" fish surveys during which they identified, counted, and estimated total length in centimeters (cm) of fishes within 1 meter (m) of the seafloor and 1 m on each side of the diver. Roving surveys were conducted at the eelgrass/bare soft-bottom edge (1 m in unvegetated habitat and 1 m in vegetated habitat) and in the vegetated, middle portion of the bed (a minimum of 1 m eelgrass on each side of diver). Roving is defined as the diver being free to follow the habitat during surveys (edge or middle of seagrass bed) and not confined to a straight line. Time was recorded for each roving survey and was five minutes in all but a few cases when divers ran out of novel eelgrass habitat. Three roving surveys were completed in both middle and edge habitat in each bed, provided sufficient habitat was present. Visibility was required to be at least eight feet in order to collect accurate data. All efforts were made to incorporate data on cryptic fishes (e.g. flatfish and syngnathids) during the surveys. Species specific encounter rates and lengths were averaged across

sites for comparison. In addition, the relative encounter rates for each species was averaged across roving transects to create a site-specific community assemblage. Non-metric multi-dimensional scaling plots were generated to visualize differences in fish communities by eelgrass species and survey region. Statistical significance of these community differences were tested using Analysis of Similarity (McCune and Grace 2002).

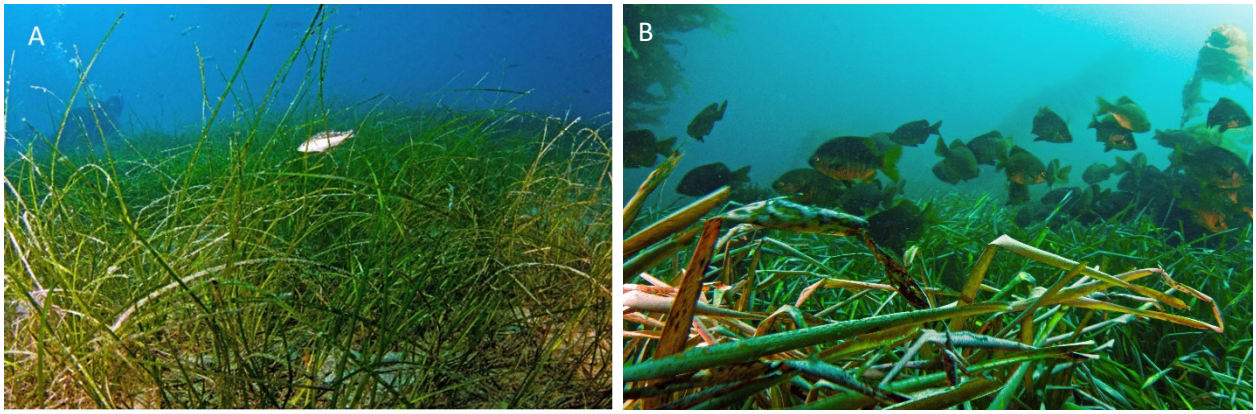

Figure 1. Images of A) narrow bladed *Z. marina* and B) wide bladed *Z. pacifica*

Results

Eelgrass Areal Cover

Divers visited 19 sites throughout the Southern California Bight (Table 1). Thirteen of these sites contained eelgrass and were surveyed for fish, and ten were mapped while eelgrass was absent at six sites that historically contained beds. Some of the larger eelgrass beds were not mapped because they were too large and disparate to be mapped with the technology available in the field at that time. Seven sites, all on the lee side of Catalina or Catalina Harbor, contained *Z. marina* and six, on the backside of Catalina or the mainland coast, were comprised of *Z. pacifica*.

Eelgrass beds ranged in size from 453 m^2 (Ripper's Cove) to 277,422 m^2 (Palisades) with a median size of 1,812 m^2. In comparison with Engle and Miller (2005), six beds decreased in size, one new bed was surveyed (Two Harbors), two beds increased in size and four beds were within the 2005 size range (Figure 2). These changes followed a geographic pattern, where beds on the eastern, leeward side of Catalina were either reduced or totally absent and beds on the western windward side had either expanded or were within the range of Engle and Miller (2005) (Figure 3). In addition, beds at Empire Landing and Ripper's Cove, had shifted from the geographic location provided in Engle and Miller (2005) while others were generally within the same geographic location identified in Engle and Miller (2005). Maps of all beds surveyed are included in Appendix I.

Eelgrass Turion Density and Shoot Length

Eelgrass density ranged from 35.7 turions/ m^2 at Goleta Beach to 170 turions/m^2 at Catalina Harbor (Table 2). No trend across regions or species was readily apparent. Shoot (blade) length was between 40 and 50 cm at 8 of the 11 sites reported, although shoot length was substantially longer in the La Jolla eelgrass bed. Shoot widths at beds determined to be *Z. pacifica* were approximately one cm while widths at *Z. marina* beds were all less than 0.5 cm.

Table 1. Summary of survey activities during 2018

Site Name	Region	Area Surveyed	Eelgrass Present	Date Surveyed
Big Fisherman's Cove	Lee Side Catalina	Yes	Yes	7/12/2018
Big Geiger	Lee Side Catalina	Yes	Yes	8/16/2018
Button Shell Beach	Lee Side Catalina	NA	No	12/6/2018
Catalina Harbor	Backside Catalina	Yes	Yes	1/5/2019
East End	Backside Catalina	Yes	Yes	9/14/2018
Empire Landing	Lee Side Catalina	Yes	Yes	10/17/2018
Goleta Beach	Mainland Coast	No	Yes	12/10/2018
Hen Rock	Lee Side Catalina	NA	No	12/6/2018
La Jolla	Mainland Coast	Yes	Yes	9/6/2018
Little Geiger	Lee Side Catalina	Yes	Yes	9/10/2018
Malibu Bluff	Mainland Coast	No	Yes	10/19/2018
Palisades	Backside Catalina	Yes	Yes	9/13/2018
Pebbly Beach	Lee Side Catalina	NA	No	9/14/2018
Refugio Beach	Mainland Coast	NA	No	12/4/2018
Rippers Cove	Lee Side Catalina	Yes	Yes	11/5/2018
Solstice Canyon	Mainland Coast	No	Yes	10/19/2018
Two Harbors	Lee Side Catalina	Yes	Yes	11/5/2018
West Willow Cove	Lee Side Catalina	NA	No	9/14/2018
White Cove	Lee Side Catalina	NA	No	12/6/2018

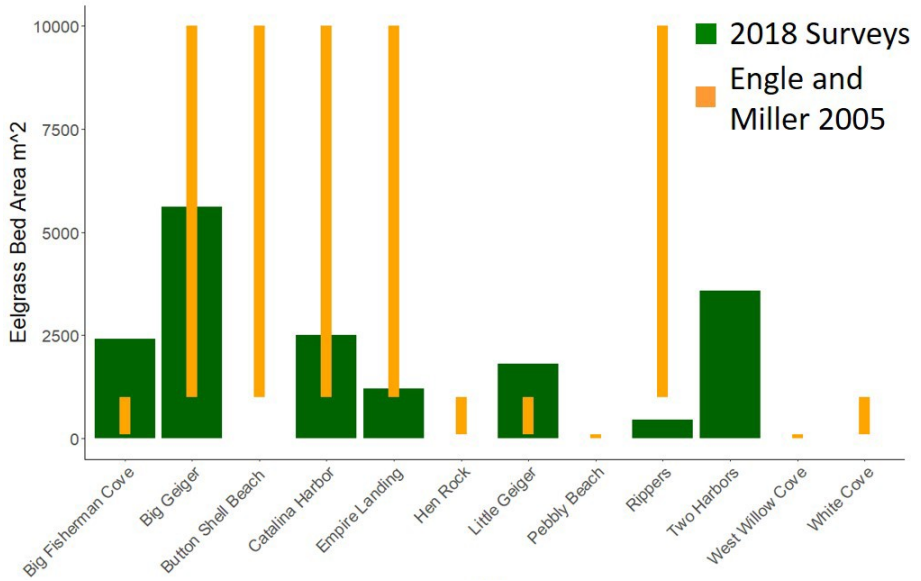

Figure 2: Comparison of eelgrass bed size at Catalina with range provided in Engle and Miller 2005. Palisades was not included in this plot because Engle and Miller (2005) listed as > 10 hectares and therefore not a range bounded on both sides. East End was not included in this plot because the surveyed area of 104,813 m^2 was too great to accurately view other size ranges.

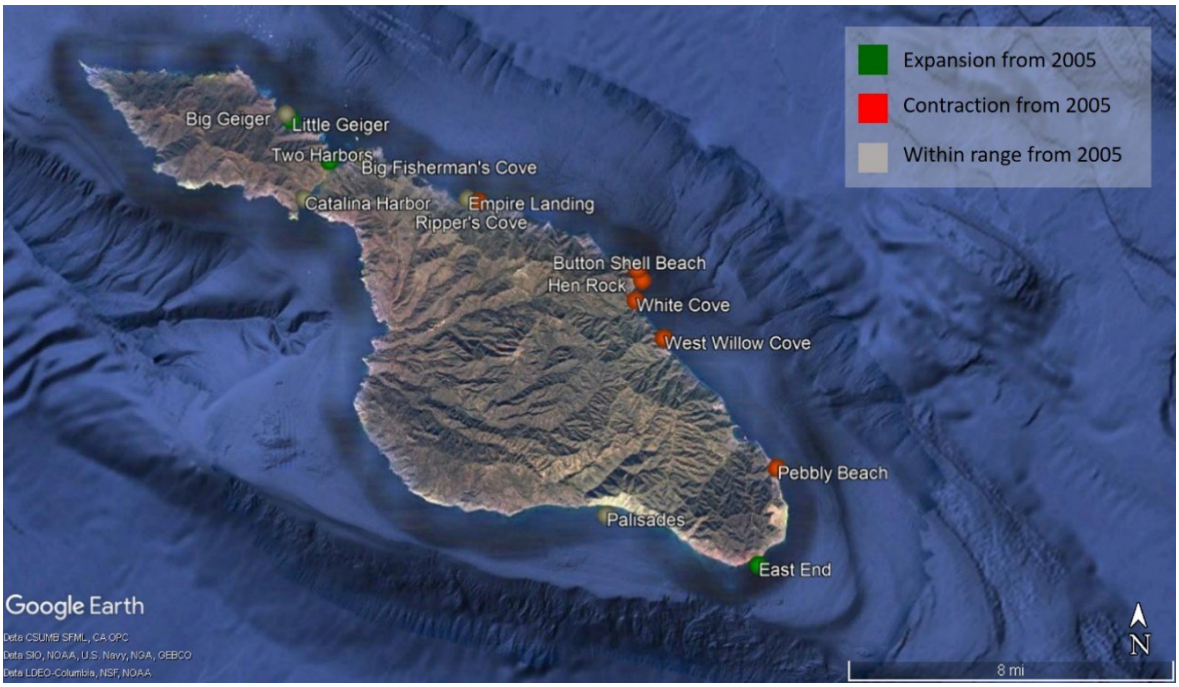

Figure 3: Map of changes in eelgrass coverage as compared with Engle and Miller 2005.

Table 2. Eelgrass structural data comparisons between sites. Depth reported is mean depth (ft) of the bed.

Site Name	Depth (feet)	Density ± SD (turions/m^2)	Shoot Length (cm) ± SD	Shoot Width (cm) ± SD
Goleta Beach	24	35.7 ± 18	29.3 ± 10	0.98 ± 0.08
Big Geiger	30	79.1 ± 22.3	49.9 ± 13.3	0.36 ±0 .22
Little Geiger	27	91 ± 31.2	40.7 ± 5.6	No data
Two Harbors	10	118.2 ± 30.7	43.8 ± 11.3	0.25 ± 0.05
Catalina Harbor	17	170 ± 82.7	42.5 ± 8	0.38 ± 0.07
Big Fisherman's Cove	27	74.4 ± 35.6	49.1 ± 7.4	0.41 ± 0.04
Empire Landing	25	109.8 ± 34.3	43.7 ± 8.8	0.28 ± 0.02
Rippers Cove	30	102.2 ± 26.2	42 ± 4.4	0.21 ± 0.05
Palisades	48	93.4 ± 30	43.7 ± 9.3	0.94 ± 0.19
East End	60	105.2 ± 26.4	74.1 ± 15.5	1.04 ± 0.13
La Jolla	38	70.3 ± 23.3	96.1 ± 15.1	1.26 ± 0.16

Fish Analysis

A total of 2,773 fishes were observed during 344.5 minutes of dive time at all thirteen eelgrass beds. Fishes encountered were comprised of 28 species, and included a range of sizes from small cryptic species like the orangethroat pikeblenny (*Chaenopsis alepidota*) to the extremely large giant seabass (*Stereolepis gigas*). The most frequently encountered species included rock wrasse (*Halichoeres semicinctus*, 2.78 individuals/minute); kelp bass (*Paralabrax clathratus*, 1.79 individuals/minute); and señorita (*Oxyjulis californica*, 0.91 individuals/minute). A complete list of species encountered during the project is provided in Appendix II.

An Analysis of Similarity test showed fish communities varied significantly by eelgrass species type ($R = 0.5$, $p = 0.005$) and region ($R = 0.55$, $p = 0.003$; Figures 4A and B). Note that these two factors are closely related as all eelgrass on the mainland coast and backside of Catalina Island was *Z. pacifica* (with the one exception of Catalina Harbor) and only *Z. marina* was found on the lee side of Catalina Island. Data from Goleta Beach were not included in this analysis because only a single fish was found during those surveys. A Similarity Percentage (SIMPER) procedure suggested that differences in the fish community across eelgrass species were driven by higher numbers of *H. semicinctus*, *P. clathratus* and *Oxyjulis californica* in *Z. marina* beds. The same procedure, when applied to regions, suggested that the fish community on the backside of Catalina Island was dominated by *P. clathratus*, *O. californica* and *Embiotoca jacksoni;* the lee side of Catalina Island was dominated by *P. clathratus, H. semicinctus* and *Cymatogaster aggregata;* and the mainland open coast was dominated by both *P. clathratus* and *P. nebulifer*.

Fish length also varied across eelgrass species (Figure 5). Fishes in *Z. marina* were often below the size at maturity reported in the literature or other available information (Stepien 1986; Love et al. 1996) while those in *Z. pacifica* were above that value. The only information readily available on *H. semicinctus* length at maturity was from a fish company web page (http://www.danapointfishcompany.com/rock-wrasse-halichoeres-semicinctus/) and should be interpreted with caution. No length at maturity was available for *O. californica*, either but their size discrepancy across eelgrass species' types warranted inclusion. Similarly, while no *P. nebulifer* were found in *Z. marina*, their large size in *Z. pacifica* was also considered relevant.

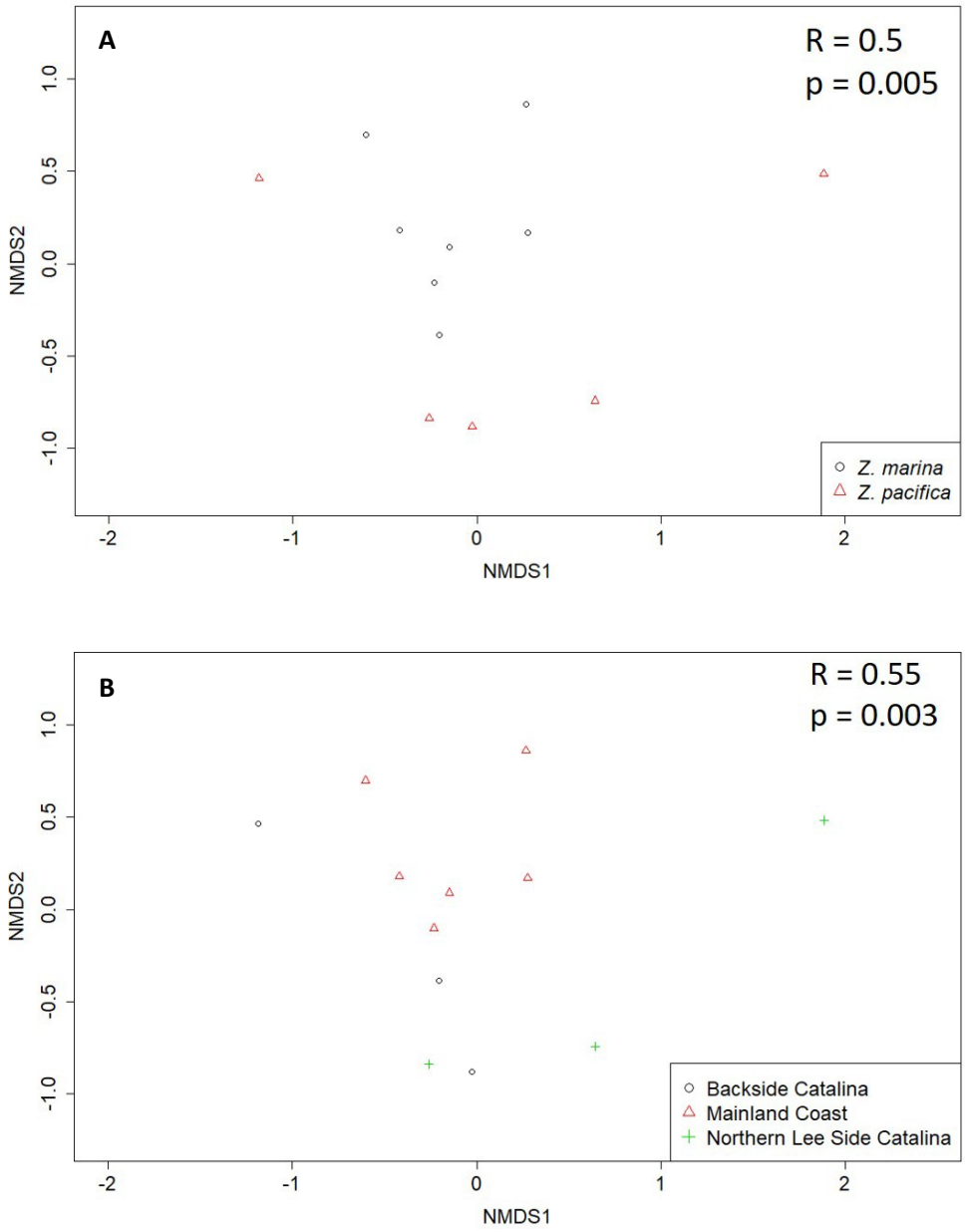

Figure 4. Non-metric multi-dimensional scaling plots of fish community by A) eelgrass species and B) survey region

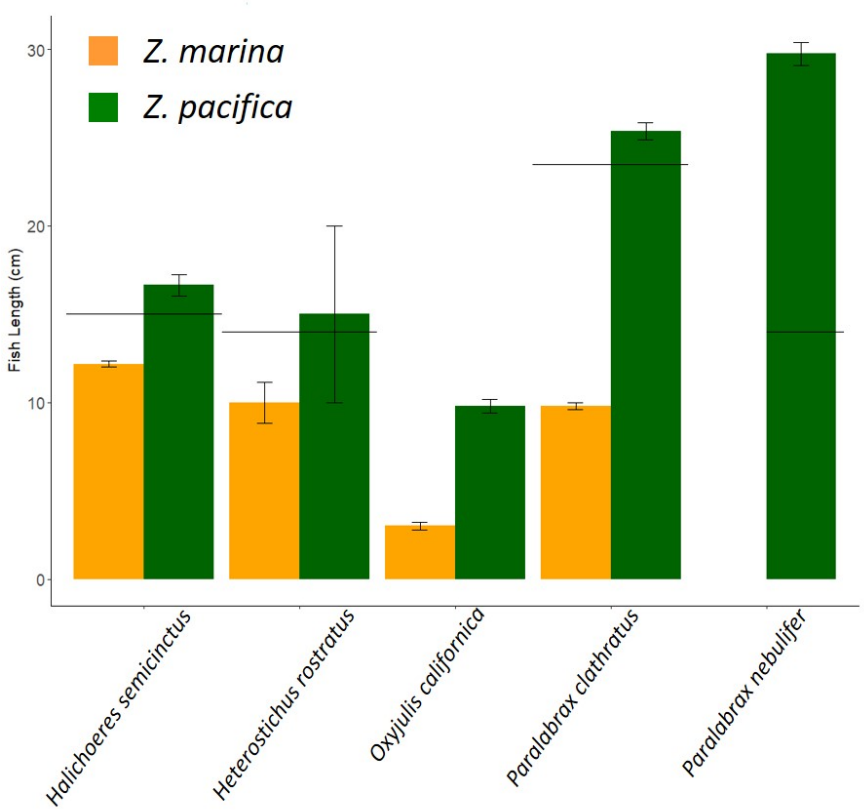

Figure 5. Mean fish size recorded in each eelgrass species type. Error bars are standard error and horizontal segments are the length at maturity found in the literature.

Conclusions

This preliminary examination of open coast eelgrass beds and fish communities associated with these beds in 2018 has led to several preliminary conclusions, listed below:

- Eelgrass bed areal sizes and spatial distribution patterns have changed over time compared to earlier documented studies (Engle and Miller, 2005). However, the large loss of eelgrass habitat on the leeward side of Catalina Island warrants further study as to the conditions that caused the loss. Eelgrass restoration in the future is a possibility if site conditions are favorable.

- Eelgrass is often considered a universal fish nursery habitat. However, our results suggest that not only are the fish communities significantly different by eelgrass species type and region, fish length is substantially different across species. With little work completed on fishery utilization of eelgrass habitat in Southern California, more data are necessary to explore this functional difference.

Acknowledgments

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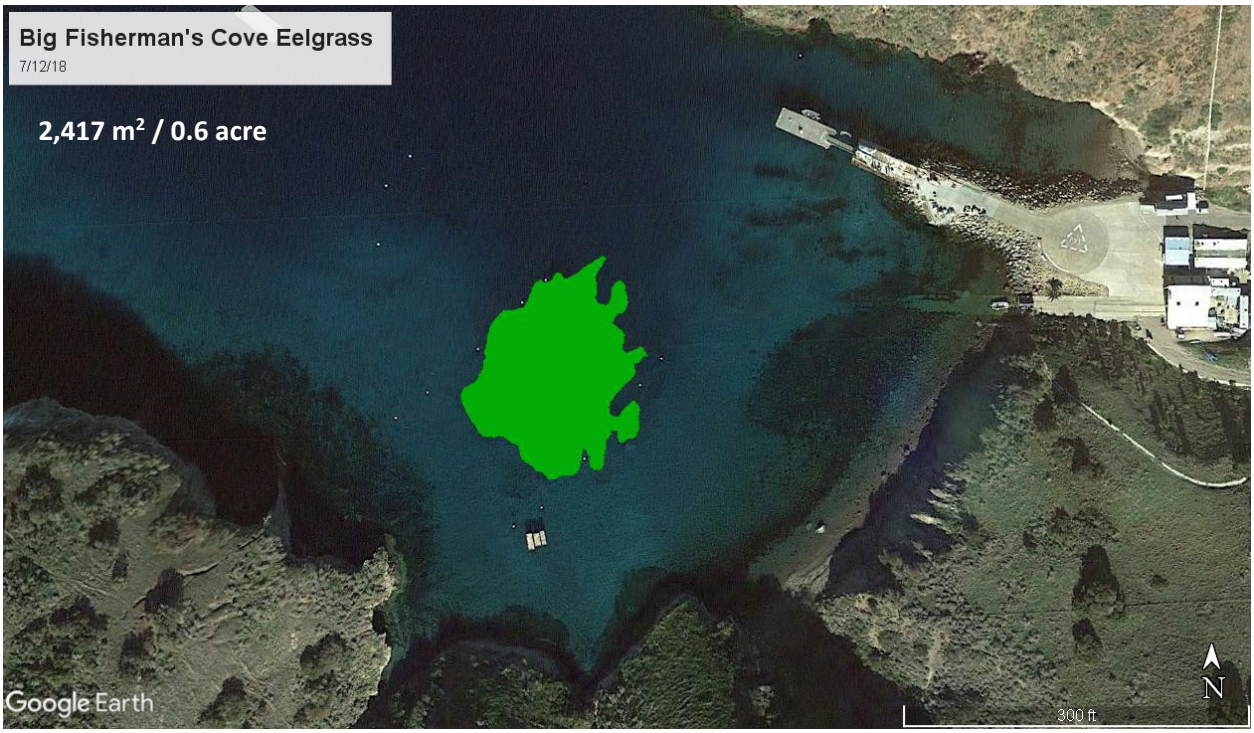
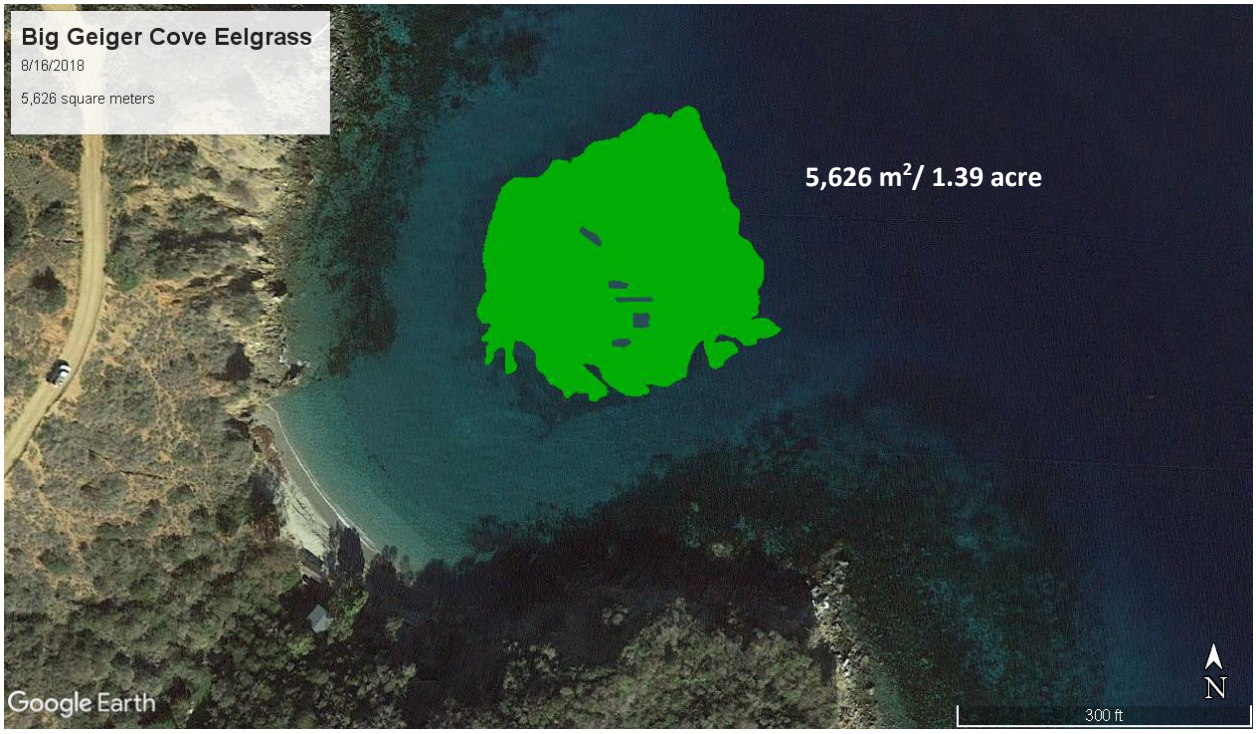
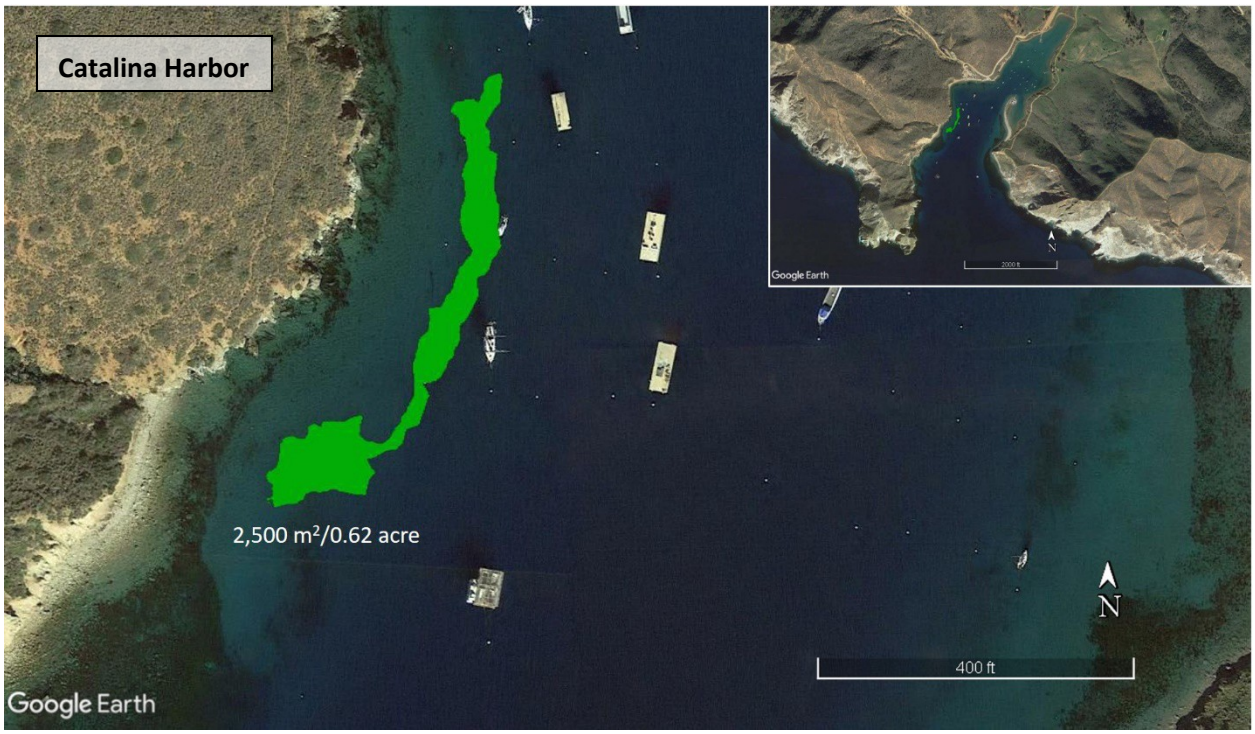
Appendix I. Eelgrass Maps



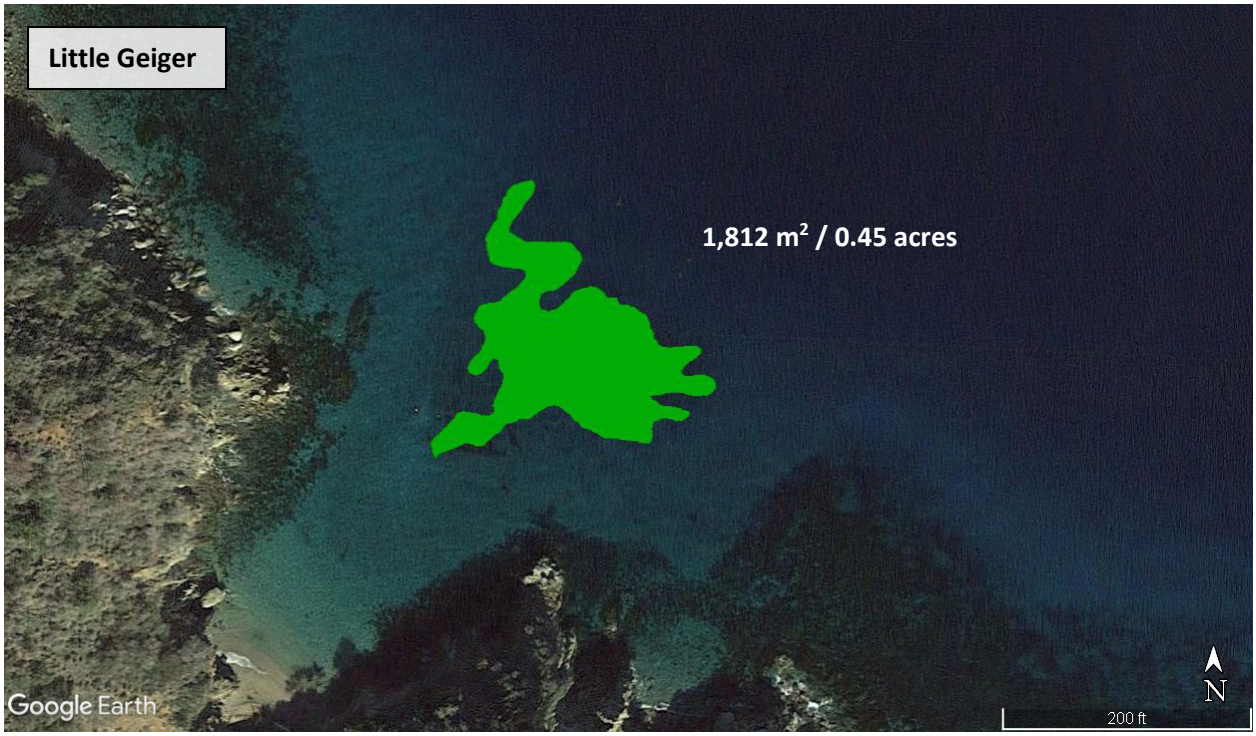

Big Geiger Cove Eelgrass
8/16/2018
5,626 square meters
5,626 m²/ 1.39 acre
Google Earth
300 ft
N

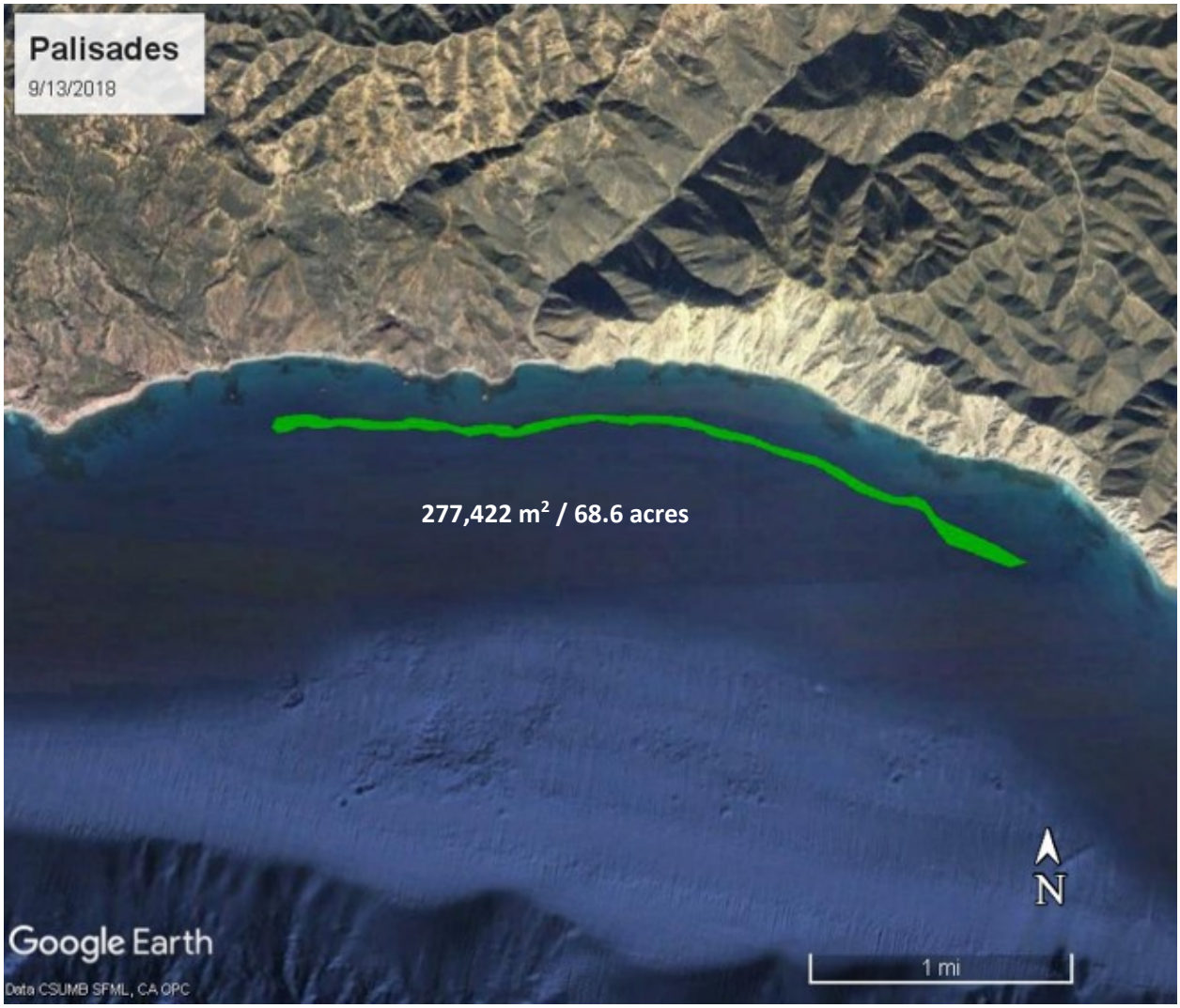

Catalina Harbor
2,500 m²/0.62 acre
N
400 ft
Google Earth
Google Earth
N

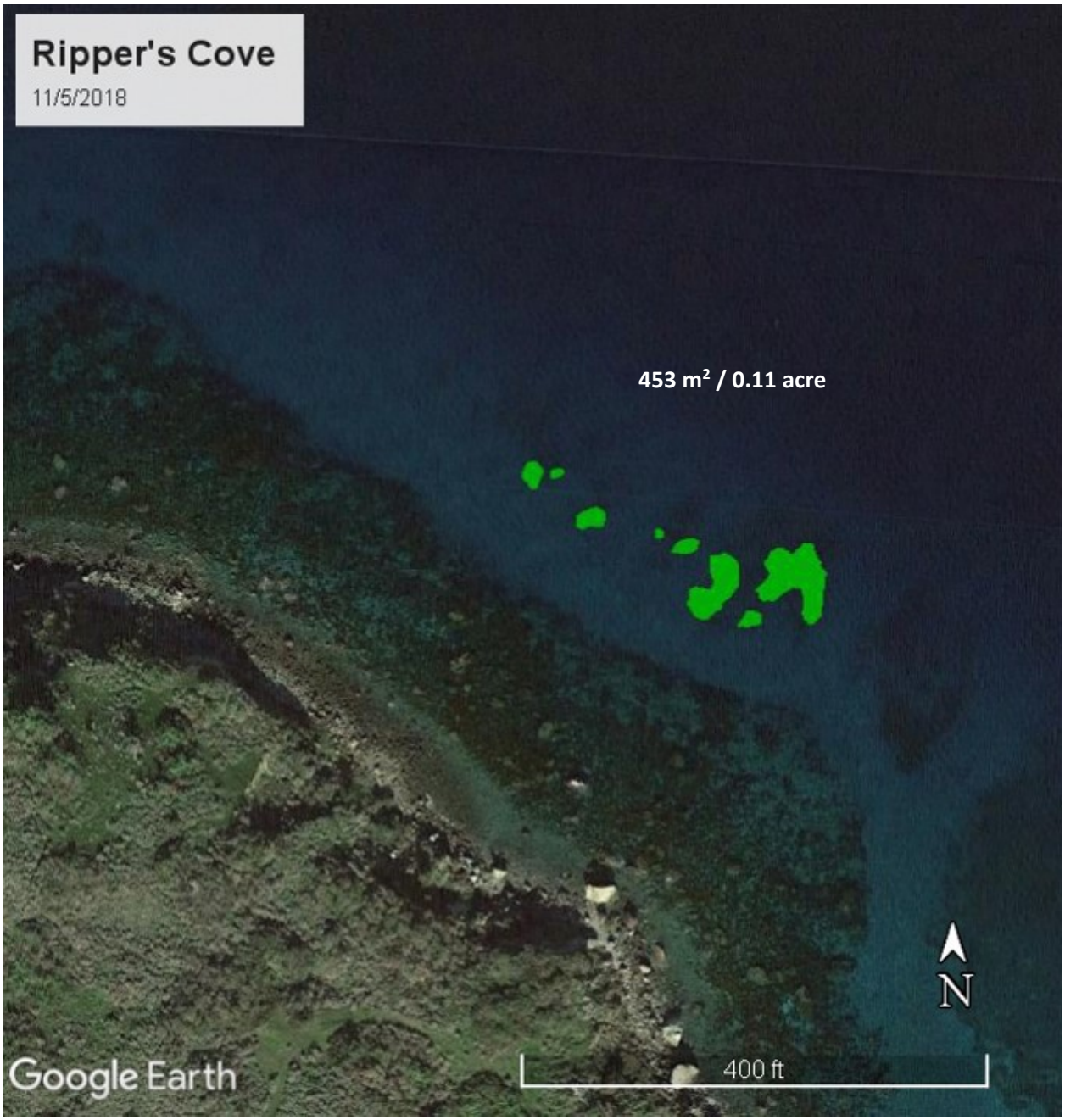

East End
9/14/2018
104,813 m² / 25.9 acres
N
Google Earth
Image © 2019 TerraMetrics
1000 ft


Empire Landing
1,199 m² / 0.3 acres
N
800 ft
Google Earth


La Jolla
Scripps Canyon
Google Earth
400 ft
N
0.55 acre
2,221 m²
Google Earth
©2018 Google
Image © 2018 TerraMetrics
©2018 INEGI
N
3000 ft


Little Geiger
1,812 m² / 0.45 acres
Google Earth
N
200 ft


Palisades
9/13/2018
277,422 m² / 68.6 acres
N
Google Earth
Data CSUMB SFML, CA OPC
1 mi


Ripper's Cove
11/5/2018
453 m² / 0.11 acre
N
Google Earth
400 ft


Two Harbors
3,580 m^2 / 0.89 acre
N
Google Earth
500 ft

Appendix II. Fishes encountered during surveys.

Species	Big Fisherman's Cove	Big Geiger	Catalina Harbor	East End	Empire Landing	Goleta Beach	La Jolla	Little Geiger	Malibu Bluff Cove	Palisades	Rippers Cove	Malibu Solstice Canyon	Two Harbors
Atherinopsis affinis													X
Atherinopsis californiensis									X				X
Chaenopsis alepidota					X						X		
Chromis punctipinnis				X	X						X		X
Cymatogaster aggregata		X										X	X
Embiotoca jacksoni				X						X		X	X
Girella nigricans		X						X					
Halichoeres semicinctus	X	X	X	X	X			X	X	X	X		X
Heterdontus francisci							X						
Heterostichus rostratus	X	X	X	X	X			X					
Hypsypops rubicundis	X				X			X					X
Medialuna californiensis		X			X								
Myliobatis californica		X											
Oxyjulis californica	X	X	X	X	X		X			X	X		
Paralabrax clathratus	X	X	X	X	X		X	X	X	X	X		X
Paralabrax nebulifer							X	X				X	
Phanerodon furcatus									X			X	
Platyrhinoidis triseriata						X							
Pleuronichthys ceonosus	X				X			X					
Rhacochilus vacca							X					X	
Semicossyphus pulger	X	X		X				X			X		X
Sphyraena argentea				X					X				X
Stereolepis gigas				X									
Sygnathus leptorhynchus									X				
Trachurus symmetricus		X										X	
Urobatis halleri					X						X		
Xenistius californiensis													X