Tracking Number: (2023-27MPA)

To request a change to regulations under the authority of the California Fish and Game Commission (Commission), you are required to submit this completed form to: California Fish and Game Commission, (physical address) 1416 Ninth Street, Suite 1320, Sacramento, CA 95814, (mailing address) P.O. Box 944209, Sacramento, CA 94244-2090 or via email to FGC@fgc.ca.gov. Note: This form is not intended for listing petitions for threatened or endangered species (see Section 670.1 of Title 14).

Incomplete forms will not be accepted. A petition is incomplete if it is not submitted on this form or fails to contain necessary information in each of the required categories listed on this form (Section I). A petition will be rejected if it does not pertain to issues under the Commission's authority. A petition may be denied if any petition requesting a functionally equivalent regulation change was considered within the previous 12 months and no information or data is being submitted beyond what was previously submitted. If you need help with this form, please contact Commission staff at (916) 653-4899 or FGC@fgc.ca.gov.

SECTION I: Required Information.

Please be succinct. Responses for Section I should not exceed five pages

1. **Person or organization requesting the change (Required)**
Name of primary contact person: Azsha Hudson
Address: 906 Garden Street, Santa Barbara, CA 93101
Telephone number: 805.963.1622
Email address: ahudson@environmentaldefensecenter.org

2. **Rulemaking Authority (Required) -** Reference to the statutory or constitutional authority of the Commission to take the action requested: Authority cited: Sections 200, 205(c), 265, 399, 1590, 1591, 2860, 2861 and 6750, Fish and Game Code; and Sections 36725(a) and 36725(e), Public Resources Code

3. **Overview (Required) -** Summarize the proposed changes to regulations: This petition seeks to reclassify the Anacapa State Marine Conservation Area (SMCA) as a State Marine Reserve (SMR) or at a minimum reclassify the portion of the SMCA from shore to at least 30 meters depth to better protect eelgrass habitat.

4. **Rationale (Required) -** Describe the problem and the reason for the proposed change:

   Numerous state and federal policies underscore the importance of eelgrass as an important yet vulnerable species that provides nursery habitat for fish, reduces coastal erosion, acts as a carbon sink, and increases species diversity by providing three-dimensional structure on sandy bottomed habitats.

   Based on a scientific study conducted at the Anacapa SMCA from 2016 to 2019, and a growing body of literature on eelgrass recruitment and ecology, there is compelling evidence that seasonally occurring lobster trapping and anchoring in the SMCA is destroying eelgrass beds that are otherwise thriving in the adjacent Anacapa SMR.

   - At Anacapa Island the main threat to eelgrass, as found by the study conducted by Jessica Altstatt, are hard bottomed objects.

- Dive surveys found the transplanted eelgrass meadows at Frenchy's Cove within Anacapa SMCA to be damaged and greatly reduced. Concurrent interviews with mariners and National Park rangers revealed that Frenchy's Cove was being fished heavily by spiny lobster fishermen during the two months (November and December) that the brown pelican Special Closure was open.
- Boaters that come to the Channel Islands prefer areas that overlap with eelgrass habitat, leaving the eelgrass susceptible to damage from anchoring.

The limited subset of pelagic fishing methods allowed at the Anacapa SMCA also creates challenges for enforcement by requiring officers to board vessels and confirm compliance on an individual basis. This petition requests Fish and Game Commission (FGC) approval to support the goals of the Marine Life Protection Act (MLPA), align with state and federal policies focused on eelgrass resilience and health, and protect important eelgrass and associated marine life at Anacapa Island.

SECTION II: Optional Information

5. Date of Petition: 11/30/2023

6. Category of Proposed Change

☐ Sport Fishing
☐ Commercial Fishing
☐ Hunting
X Other, please specify: MPAs, Section 632.

7. The proposal is to: (*To determine section number(s), see current year regulation booklet or https://govt.westlaw.com/calregs*)

X Amend Title 14 Section(s): Westlaw regulations.
☐ Add New Title 14 Section(s): Click here to enter text.
☐ Repeal Title 14 Section(s): Click here to enter text.

8. If the proposal is related to a previously submitted petition that was rejected, specify the tracking number of the previously submitted petition Click here to enter text.
Or X Not applicable.

9. Effective date: If applicable, identify the desired effective date of the regulation.
If the proposed change requires immediate implementation, explain the nature of the emergency:
November 1, 2024

10. Supporting documentation: Identify and attach to the petition any information supporting the proposal including data, reports and other documents:

- Petition narrative on eelgrass at Anacapa SMCA: Anacapa-MPA-Petition-Narrative_FINAL_2023_11_30
- White paper research from Jessica Alstatt: Altstatt_Eelgrass report_2021_03_01
- Sign on letter for support: Frenchys-Cove-Sign-On_FINAL_2023_11_29

11. Economic or Fiscal Impacts: Identify any known impacts of the proposed regulation change on revenues to the California Department of Fish and Wildlife, individuals, businesses, jobs, other state agencies, local agencies, schools, or housing:

This petition protects habitat that confers biodiversity and biomass benefits that enhance the health of Anacapa Island and surrounding ecosystems. Eelgrass beds filter nutrients, stabilize sediments, and increase complexity of the substrate and effective habitat for marine life. As demonstrated by numerous reports of lobster traps "fishing the line" of the Anacapa SMR, fishers perceive the nearby fully protected MPA has created a beneficial habitat for lobster trapping. Notably, a recent study on the California spiny lobster fishery determined that the short-term losses from a restrictive MPA is compensated by an over 200% increase in total catch after about 6 years of MPA designation.

This petition would close the Anacapa SMCA to lobster trapping year round and would also prevent anchoring damage from pelagic fishing efforts. While converting this SMCA into an SMR may have short term impacts on recreational and commercial fishing, any such impacts will be offset by the long-term ecosystem wide benefits of protecting eelgrass function at this valuable site.

12. Forms: If applicable, list any forms to be created, amended or repealed:

Click here to enter text.

SECTION 3: FGC Staff Only

Date received: 11/30/2023

FGC staff action:

☐ Accept - complete
☐ Reject - incomplete
☐ Reject - outside scope of FGC authority

Tracking Number

Date petitioner was notified of receipt of petition and pending action: ________________

Meeting date for FGC consideration: ______________________________

FGC action:

☐ Denied by FGC
☐ Denied - same as petition ______________________
Tracking Number
☐ Granted for consideration of regulation change

Petition Narrative

Overview

This petition seeks to reclassify the Anacapa State Marine Conservation Area (SMCA) as a State Marine Reserve (SMR) or at a minimum reclassify the portion of the SMCA from shore to at least 30 meters depth to better protect eelgrass habitat. Numerous state and federal policies underscore the importance of eelgrass as an important yet vulnerable species that provides nursery habitat for fish, reduces coastal erosion, acts as a carbon sink, and increases species diversity by providing three-dimensional structure on sandy bottomed habitats.

Based on a scientific study conducted at the Anacapa SMCA from 2016 to 2019[1], and a growing body of literature on eelgrass recruitment and ecology, there is compelling evidence that seasonally occurring lobster trapping and anchoring in the SMCA is destroying eelgrass beds that are otherwise thriving in the adjacent Anacapa SMR.

The limited subset of pelagic fishing methods allowed at the Anacapa SMCA also creates challenges for enforcement by requiring officers to board vessels and confirm compliance on an individual basis. This petition requests Fish and Game Commission (FGC) approval to support the goals of the Marine Life Protection Act (MLPA), align with state and federal policies focused on eelgrass resilience and health, and protect important eelgrass and associated marine life at Anacapa Island.

Importance of Eelgrass Habitat

Eelgrass, specifically *Zostera marina*, is a marine plant that provides significant ecosystem services in shallow, sandy-bottom habitats. Eelgrass beds support complex food webs, filter nutrients, and improve water quality, stabilize sediments, and serve as important refuge and nurseries for marine vertebrates and invertebrates.[2] Eelgrass beds are typically found from shallow waters down to depths of up to 30 meters (98 feet).[3]

Given its ecological importance, eelgrass habitat restoration and conservation has been identified as a high priority by numerous federal and state policies and planning documents. The National Oceanic and Atmospheric Administration (NOAA) has released several policies related to eelgrass, including the 2014 “California Eelgrass Mitigation Policy and Implementing Guidelines” that emphasize the importance of recovering and sustaining eelgrass across California.[4] Eelgrass is designated as Essential Fish Habitat for various federally managed fish species within the Pacific Coast Groundfish and Pacific Coast Salmon Fisheries Management

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[1]Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities

[2]Engle, J. M., & Miller, K. A. (2005, November). Distribution and morphology of eelgrass (Zostera marina L.) at the California Channel Islands. In *Proceedings of the Sixth California Islands Symposium. Institute for Wildlife Studies, Arcata, CA* (pp. 405-414).

[3] marinespecies.wildlife.ca.gov/eelgrass/

[4]https://www.fisheries.noaa.gov/resource/document/california-eelgrass-mitigation-policy-and-implementing-guidelines

Plans and is a habitat area of particular concern for various species within the Pacific Coast Groundfish Fishery Management Plan.[5]

California state policy also recognizes the critical importance of eelgrass; see California Senate Bill 1363 (2016), the Ocean Protection Council (OPC) Strategic Plan (2020-2025) and OPC Ocean Acidification Management Tool (Nielsen et al. 2018), and California Coastal Act sections 30230, 30231. Specifically, the OPC Strategic Plan lists eelgrass preservation and recovery as a priority in its Strategic Plan Target 3.1.4 and aims to protect 15,000 acres of California's eelgrass and create 1,000 new acres by 2025.[6] OPC's Ocean Acidification Action Plan also prioritizes protection and conservation of eelgrass due to its associated carbon storage benefits in sections 4.1.2 and 4.1.3.[7] Globally, eelgrass populations have declined during the past 25 years through a combination of natural and anthropogenic deterioration.[8,9]

While eelgrass restoration efforts have been conducted in the West Coast for over 60 years at significant effort and cost, restoration projects have had mixed success, demonstrating the importance of both protecting existing eelgrass habitat and prioritizing restoration projects that result in successful eelgrass reintroduction.[10]

Ecological Benefits

There have also been a suite of studies demonstrating both the ecological benefits of eelgrass habitat and of fully protected areas, which include higher abundance of commercially important species and that fully protected areas can better support climate adaptation and resilience than lightly protected areas.[11,12] The Channel Islands are home to some of the greatest biodiversity in California and are a critical habitat for a wide range of commercially, recreationally, and culturally important species. Because healthy eelgrass habitat is both ecologically valuable and limited, protecting areas where it can thrive should be a high priority for the State.

Anacapa Island Eelgrass: Need for Improved Protection

Eelgrass used to be abundant at multiple sites at Anacapa island until white urchin (*Lytechinus anemesus)* populations increased and locally extirpated eelgrass following the 1983 El Nino.[13]

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[5]https://www.fisheries.noaa.gov/feature-story/importance-eelgrass
[6]https://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20200226/OPC-2020-2025-Strategic-Plan-FINAL-20200228.pdf
[7] https://www.opc.ca.gov/webmaster/_media_library/2018/10/California-OA-Action-Plan-Final.pdf
[8] Short, F.T. and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrasses. Environmental Conservation 23:17–27.
[9] Hemminga, M.A. and C.M Duarte. 2000. Seagrass Ecology. Cambridge University Press, Cambridge, UK, 298 pp.
[10] Melissa Ward and Kathryn Behestri. Lessons learned from over thirty years of eelgrass restoration on the US West Coast. Ecosphere,Volume14, Issue 8, August 2023.
[11] Front Ecol Environ 2018; 16(7): 381–387, doi:10.1002/fee.1934
[12] Roberts, C. M., O'Leary, B. C., McCauley, D. J., Cury, P. M., Duarte, C. M., Lubchenco, J., ... & Castilla, J. C. (2017). Marine reserves can mitigate and promote adaptation to climate change. *Proceedings of the National Academy of Sciences*, *114*(24), 6167-6175.
[13] Jessica Altstatt, Richard Ambrose, Jay Carroll, James Coyer, Joseph Wible, John Engle "Eelgrass Meadows Return to Frenchy's Cove, Anacapa Island: Recovery Ten Years after Successful Transplantation," Monographs of the Western North American Naturalist, 7(1), 500-517, (1 January 2014)

Frenchy's Cove, which is located within the Anacapa SMCA, historically sustained the largest eelgrass meadow around all Anacapa Island. Researchers at Anacapa Island found that there had been no sign of recruitment at Frenchy's Cove since 1991 up until the 2000s when efforts were made to reintroduce eelgrass into the area.[14,15] Transplanting efforts in 2002 restored eelgrass at several sites at Anacapa Island.

In dive surveys conducted by Jessica Altstatt and her team from 2016 to 2019 at transplantation sites at Anacapa Island and other Channel Islands, Anacapa eelgrass sites had 13-14 species of fish recorded, except for Frenchy's Cove (which had no remaining eelgrass), which only reported six species.[16] Similarly, the lowest densities of kelp bass were largely found at the sites with little to no eelgrass; and the lowest number of observed fish species was at the Frenchy's Cove restoration site, over barren sand.[17] These findings underscore that healthy eelgrass beds have been shown to support increased fish biodiversity and enhance marine life and function at sites around Anacapa Island, and the lack of eelgrass is correlated with diminished marine biodiversity and richness.

The eelgrass species at Anacapa Island, *Zostera marina*, is especially vulnerable to disturbance as it grows in soft sediments and can be easily uprooted by activities like trap fishing, which drag along the sandy bottom and disturb vulnerable habitat. Eelgrass beds at Anacapa Island are typically 20-45 feet in depth, and they expand through fragmentation of the stems and through seed dispersal at short distances, meaning that localized protections are important for eelgrass reproduction.[18]

Dive surveys conducted in 2016 and 2019 found the transplanted eelgrass meadows at Frenchy's Cove within Anacapa SMCA to be damaged and greatly reduced.[19] Concurrent interviews with mariners and National Park rangers revealed that Frenchy's Cove was being fished heavily during the two months (November and December) that the brown pelican Special Closure was open.[20] In November 2019, Channel Islands National Marine Sanctuary staff reported at least 100 lobster traps within the Anacapa SMCA, some as shallow as 17 feet, with another 100 traps along the Anacapa SMR boundary line.[21] Fishing block data for the mainland showed that effort

[14] Ruckelshaus, M.H. 1996. Estimation of genetic neighborhood parameters from pollen and seed dispersal in the marine angiosperm Zostera marina L. Evolution 50:856–864.
[15] Reusch, T.B.H., W.T. Stam and J.L. Olsen. 2000. A microsatellite-based estimation of clonal diversity and population subdivision in Zostera marina, a marine flowering plant. Molecular Ecology 9:127–40.
[16] Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities
[17] *Id.*
[18] Olesen, B., Krause-Jensen, D. & Christensen, P.B. Depth-Related Changes in Reproductive Strategy of a Cold-Temperate Zostera marina Meadow. Estuaries and Coasts 40, 553–563 (2017). https://doi.org/10.1007/s12237-016-0155-4
[19] Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities
[20] *Id.*
[21] *Id.*

more than doubled within blocks containing fishing areas adjacent to SMRs.[22] Notably, eelgrass continued to thrive within the Anacapa SMR itself, 200 meters to the east of the SMCA.[23]

In the summer and fall of 2016, the research team also marked and reported four abandoned lobster traps within Frenchy's Cove, with one along the boundary with the Anacapa SMR. The other three traps were within a mapped footprint of the eelgrass restoration site within the SMCA, where there was no longer any eelgrass remaining.[24] In a 2019 survey, an abandoned trap was found "ghost fishing" and was filled with live lobsters along the Anacapa SMR boundary.[25]

The impact of lobster trapping and boat anchoring (from lobster trapping, as well as other fishing and recreational sources) within Anacapa SMCA has been to denude transplanted eelgrass beds and prevent ongoing recruitment and growth of this important species and habitat.[26] Disturbing and harming the sandy bottom has a conclusively negative impact on eelgrass survival. Converting this area to an SMR is necessary to protect future eelgrass recovery efforts and all the associated benefits to fish and marine ecosystems.

Notably, the Altstatt paper from 2021 contained the following specific policy recommendation:

> Re-classify the shallow soft-sediment bottom within the Frenchy's SMCA as SMR or No Entry (it is already a Special Closure 10 months out of the year). Suitable habitat for eelgrass within Frenchy's Cove only exists within certain hydrodynamic and depth parameters (20'-45'), and over soft bottom not rock. This area historically sustained the largest eelgrass meadow at all of Anacapa Island. Our restoration work showed that eelgrass will rapidly colonize and thrive if anthropogenic disturbance (trapping) were to cease.[27]

Impact of Hard Bottom Objects on Shallow Root Eelgrass (*Zostera marina)*

Eelgrass faces many threats in Southern California, including increased turbidity, dredging, construction, and pollution.[28] At Anacapa Island the main threat to eelgrass, as found by the study conducted by Jessica Altstatt, are hard bottomed objects.[29] Lobster traps are not the only

[22] Lenihan, H. S., Gallagher, J. P., Peters, J. R., Stier, A. C., Hofmeister, J. K., & Reed, D. C. (2021). Evidence that spillover from Marine Protected Areas benefits the spiny lobster (Panulirus interruptus) fishery in southern California. *Scientific Reports*, *11*(1), 2663.
[23] Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities
[24]*Id.*
[25]*Id.*
[26]*Id.*
[27]Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities
[28] Merkel, K.W. 1991. The use of seagrasses in the enhancement, creation, and restoration of marine habitats along the California Coast: Lessons learned from fifteen years of transplants. Technical Advisory Panel presentation to Marine Board, National Research Council Committee on the role of technology in marine habitat protection and enhancement. 20 March 1991. San Francisco, CA.
[29]Jessica Altstatt (2021). Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities

object that can reduce transplantation success. A study conducted in Puget Sound on seagrass that has a similar makeup to the eelgrass present in the waters surrounding Anacapa Island looked at the impact of Dungeness crab traps set in an eelgrass bed. It was determined that traps could lead to the destruction of the eelgrass immediately beneath it and create a scour hole that would also be devoid of eelgrass.[30] Recovery of the eelgrass after a few months saw less than 50% recovery, but no further growth was found after eight months.[31]

Anchors are also detrimental to survival and expansion of eelgrass. Boaters that come to the Channel Islands prefer areas that overlap with eelgrass habitat, leaving the eelgrass susceptible to damage from anchoring.[32] In areas that attract boaters there is a cumulative impact from the setting and dragging of the many anchors used over time.[33] Hard bottomed objects resting on top of eelgrass for extended periods cause blades to become broken or abraded, which may disrupt normal blade function.[34] Other impacts to the eelgrass include blades of grass being crushed into the underlying anoxic sediments, likely suffocating the plants and leading to eventual deterioration of above-ground plant, and shading by traps that reduces light availability, thereby inhibiting photosynthetic function.[35]

Increasing Enforcement Efficacy

This petition requests that the Anacapa SMCA be converted to an SMR, removing commercial and recreational lobster fishing and pelagic fishing from the allowable activities. Current regulations for the Anacapa SMCA state the following:

> It is unlawful to injure, damage, take, or possess any living, geological, or cultural marine resource, EXCEPT:
>
> Recreational take of lobster and pelagic finfish (northern anchovy, barracudas, billfishes, dorado (dolphinfish), Pacific herring, jack mackerel, Pacific mackerel, salmon, Pacific sardine, blue shark, salmon shark, shortfin mako shark, thresher shark, swordfish, tunas, Pacific bonito, and yellowtail) is allowed.[36]

Converting Anacapa SMCA into an SMR will support law enforcement effectiveness as officers will be able to assess compliance from a distance and not required to individually contact, board, and verify each fishing vessel to determine the species and gear being deployed. It is notable that the ocean salmon fishery has closed as of 2023 due to poor fish survival, so removing this species from allowable activities would have no impact on the industry in the near term.

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[30] June J. , Antonelis K. 2009. Marine Habitat Recovery of Five Derelict Gear Removal Sites in Puget Sound. Natural Resources Consultants, Inc, Seattle, WA. Report for the Northwest Straits Initiative. 19 pp.
[31] *Id*.
[32] https://www.nps.gov/chis/learn/nature/seagrass-beds.htm
[33] Santa Barbara Channel Keeper (2009-2010). The Role of Eelgrass Beds as Fish and Invertebrate Habitat. https://www.sbck.org/wp-content/uploads/2013/06/Eelgrass-Report.pdf
[34] Uhrin, A. V., Fonseca, M. S., and DiDomenico, G. P. 2005. Effects of spiny lobster on seagrass beds: damage assessment and evaluation of recovery. American Fisheries Society Symposium, 41: 579–588.
[35] *Id*.
[36] https://wildlife.ca.gov/Conservation/Marine/MPAs/Anacapa-Island.

Socioeconomic Impacts

This petition protects habitat that confers biodiversity and biomass benefits that enhance the health of Anacapa Island and surrounding ecosystems. Eelgrass beds filter nutrients, stabilize sediments, and increase complexity of the substrate and effective habitat for marine life. As demonstrated by numerous reports of lobster traps "fishing the line" of the Anacapa SMR, fishers perceive the nearby fully protected MPA has created a beneficial habitat for lobster trapping. Notably, a recent study on the California spiny lobster fishery determined that the short-term losses from a restrictive MPA is compensated by an over 200% increase in total catch after about 6 years of MPA designation.[37]

This petition would close the Anacapa SMCA to lobster trapping during the months of November and December and would also prevent anchoring damage from pelagic fishing efforts. While converting this SMCA into an SMR may have short term impacts on recreational and commercial fishing, any such impacts will be offset by the long-term ecosystem wide benefits of protecting eelgrass function at this valuable site.

Advancing Goals of the MLPA

This petition advances MLPA goals 1, 2, 3, and 5.

- Goal 1: Converting the Anacapa SMCA to an SMR will directly "protect the natural diversity and abundance of marine life, and the structure, function and integrity of marine ecosystems" by removing a significant and specific threat to eelgrass – recreational and commercial lobster fishing. In its absence, the 2019 study authors explicitly state: "Our restoration work showed that eelgrass will rapidly colonize and thrive if anthropogenic disturbance (trapping) were to cease."

- Goal 2: This petition also "sustains, conserves, and protects marine life populations" of both eelgrass and a wide range of marine species that rely on and benefit from eelgrass, as shown by studies indicating higher biodiversity in areas with eelgrass versus the bare sandy bottom that results from lobster trapping and damage from boat anchors. Global research has also shown that fully protected MPAs confer biodiversity and biomass benefits, which further supports the request of this petition.

- Goal 3: Anacapa's transplanted eelgrass beds are a critical "study opportunity" for understanding how to restore eelgrass in other parts of California and temperate climates. Anacapa Island is an important natural laboratory that has been used by researchers to inform broader eelgrass management efforts since the 1980s. Increasing eelgrass research and recovery is a priority for agencies including OPC and NOAA. The proposed conversion to an SMR can support that important work by helping restore eelgrass beds where they are currently harmed by fishing pressures.

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[37] Lenihan, H.S., Gallagher, J.P., Peters, J.R. et al. Evidence that spillover from Marine Protected Areas benefits the spiny lobster (Panulirus interruptus) fishery in southern California. Sci Rep 11, 2663 (2021). https://doi.org/10.1038/s41598-021-82371-5

- Goal 5: As the state considers adaptive management of the MPA network, it is important to make decisions that support “effective management measures and adequate enforcement and are based on sound scientific guidelines.” The current allowable activities at the SMCA include take of select pelagic fish, which creates complexity for enforcement officers who must ensure individual compliance with regulations. Commercial and recreational lobster fishing is also allowed; but as described above, recent surveys and studies demonstrate that there is a clear and specific fishing-related threat to eelgrass beds at the Anacapa SMCA, and that converting to an SMR will remove that pressure and allow for ecosystem recovery. Prohibiting these fishing pressures will support enhanced enforcement and align with recently available scientific findings about the significant damage caused by lobster traps and boat anchoring.

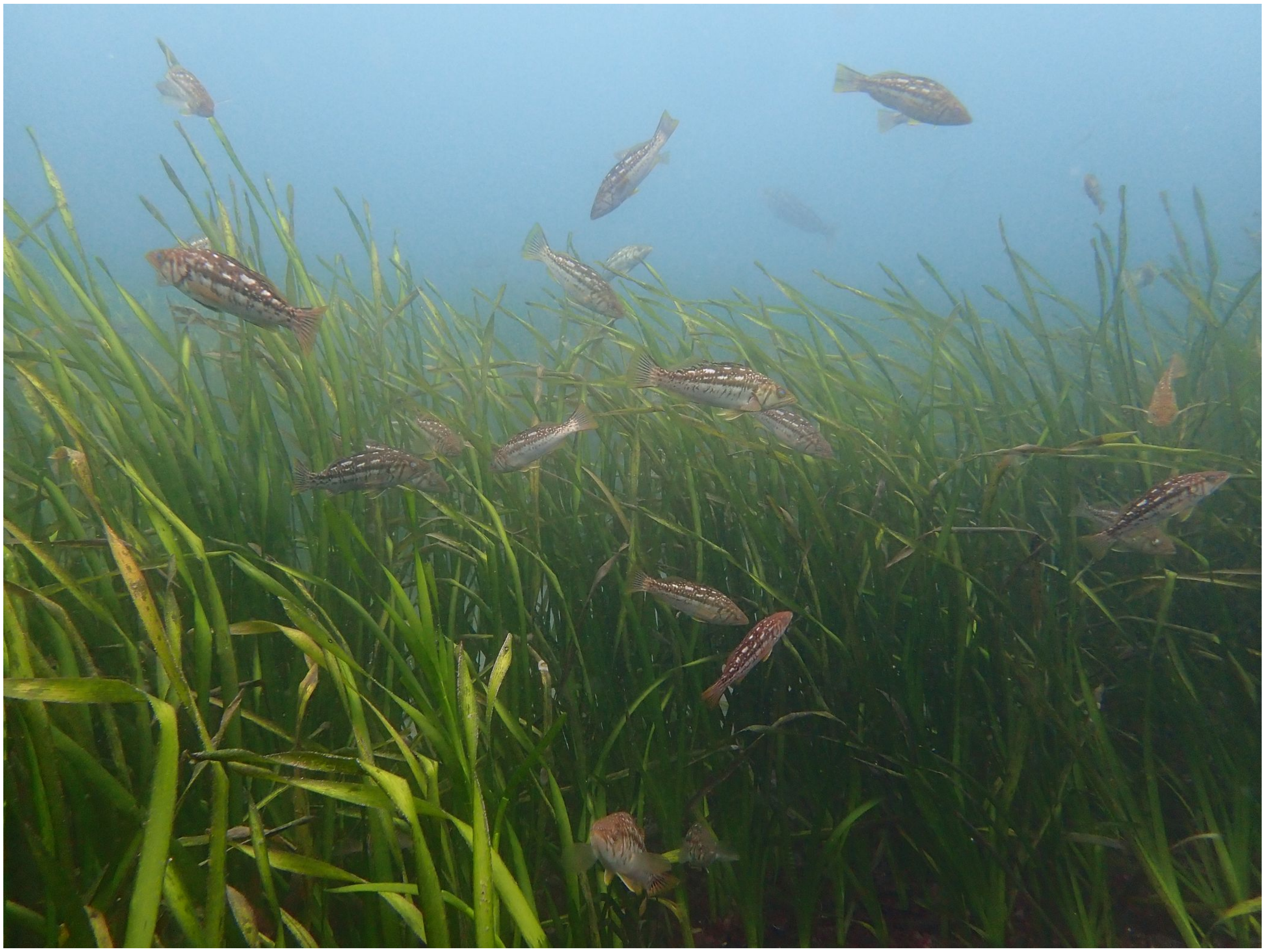
Alignment with Decadal Management Review

This petition supports the Decadal Management Review (DMR) recommendation #4: “Apply what is learned from the first Decadal Management Review to support proposed changes to the MPA Network and Management Program.” Over the past decade, significant research has been conducted in the Anacapa SMCA and surrounding ecosystems to better understand how policy protections can support eelgrass ecosystem recovery and safeguard this critical species. The DMR report and recommendations also underscore that enhancing MPA enforcement is a continued priority, so creating regulations that facilitate compliance and simplify allowable activities is a clear pathway for addressing this ongoing management goal.

Available data demonstrates that lobster traps and boat anchors in Anacapa SMCA cause significant harm to eelgrass recovery efforts. Eelgrass beds in the nearby Anacapa SMR were healthy, while those in the SMCA were degraded or nonexistent following lobster season. When combined with the benefit of streamlining enforcement by removing piecemeal fishing allowances, this petition clearly responds to the DMR and confers multiple benefits for MPA management.

By approving the conversion of Anacapa SMCA to an SMR, the FGC will integrate the best available science into MPA policy; support the goals of the MLPA; advance federal and state policies advocating for the recovery and protection of eelgrass; and directly support the DMR’s goal of adaptively managing MPAs based on findings from the past decade.

Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition, Health and Extent of Beds and Biological Monitoring of Associated Fish and Invertebrate Communities



March 1, 2021

Jessica Altstatt

Island Eelgrass (*Zostera pacifica*): Focused Assessment of Condition and Extent of Meadows and Biological Monitoring of Associated Fish and Invertebrate Communities

Abstract

Eelgrass (*Zostera pacifica*) meadows were present along the northern shores of Anacapa Island prior to the late 1980s, when sea urchin over-grazing led to local extirpation. No natural recruitment occurred over 12 years and in 2002, ~500 eelgrass (*Zostera pacifica*) shoots from two large meadows at Santa Cruz Island (Smugglers, Prisoners) were transplanted to Frenchy's Cove, Anacapa Island. The short-term survivorship and growth of eelgrass at the transplantation site and continuing expansion of eelgrass from the restoration site to the east along Middle Anacapa Island was documented over a 17 year period, along with conditions at naturally occurring beds at Santa Cruz and Santa Rosa islands. Eelgrass bed dynamics and associated fish and invertebrate communities were characterized in 2016 and 2019 and compared with existing conditions within the donor beds and other Channel Islands eelgrass meadows. At Anacapa, eelgrass meadows have persisted longer post-transplantation (2003-2019) than was documented without natural recovery prior to our efforts (1991-2002), and are fully functioning habitat as shown by fish and invertebrate communities, and when compared to natural meadows at Santa Cruz Island.

Introduction

Seagrasses are flowering plants that have evolved from land plants to live in the ocean, forming lush green underwater meadows. These meadows or beds are an important coastal habitat and support complex food webs, provide refuge for animals, filter out nutrients, and stabilize sediments. Species diversity in seagrass beds can be nearly twice as high as on nearby sandy intertidal and subtidal habitats (Engle et al, unpublished data). Through photosynthesis, seagrass fixes carbon from carbon dioxide dissolved in seawater, and transfers that carbon to the sediments. Growing interest in the potential of seagrass as a ‘green carbon’ solution to climate change is amplified by recent evidence that subtidal seagrass beds could play a critical role in slowing or reversing the deleterious effects of ocean acidification on marine larval invertebrates and fishes. The focus of most seagrass research has been in intertidal estuaries but submerged beds occurring along the open coast may contribute as much or more value. Thus, the need for up-to-date information on the size, health and habitat function of the major seagrass beds around the Channel Islands and Santa Barbara mainland coast is ever-more relevant and timely.

There are two types of seagrasses found along the California coast- surfgrass and eelgrass. Surfgrass (genus *Phyllospadix*) grows in rocky wave-swept environments while eelgrass (genus *Zostera*) grows in soft sediment found in sheltered coasts, bays and estuaries. *Zostera sp*. was historically abundant in California’s shallow inlets but has been especially damaged by coastal development and up to 90% of its historic range has been lost. DNA analysis has defined two species occurring at the California Channel islands—*Z. marina* and *Z. pacifica* (Coyer *et al*. 2007).

Although both surfgrass and eelgrass are flowering plants and produced seeds, eelgrass is especially vulnerable to disturbance as it grow in soft sediments and can be uprooted. Additionally, eelgrass beds expand through vegetative growth of rhizomes and the chance of long-range dispersal of seeds is very low. Thus, its ability to naturally spread over long distances happens only over a very long time scale. Evidence from genetic studies suggest that the largest eelgrass beds around the Channel Islands are mostly clonal and may be thousands of years old (Coyer *et al.* 2007).

Expeditions of the Channel Islands Research Program (CIRP) in the 1980s and 1990s yielded information on location and size estimates of major eelgrass meadows around the Channel Islands, as well as data on associated fish and invertebrate density (Engle and Miller 2005). These meadows (along with several along the mainland coast) were then re-surveyed in 2007-9 by some of the same research cruise participants.

Up until the mid 1980s, eelgrass had been abundant at multiple Anacapa Island locations from Frenchy's Cove to Cathedral Cove. An unusual recruitment event of the white urchin *Lytechinus anemesus* following the 1983 el Niño led to over-grazing and extirpation of eelgrass from all of Anacapa. In 2002, a trial restoration project was initiated to test whether or not eelgrass recruitment could be 'jump-started' by using vegetative material from nearby Santa Cruz Island. Over ten years, a meadow coalesced, expanded, and spread from within the Anacapa Special Closure and State Marine Conservation Area (SMCA), towards the east into the State Marine Reserve (SMR). The project was deemed a success with eelgrass spreading most of the length of Middle Anacapa Island (Altstatt *et al.* 2014).

Observations and data collected at the restoration site in 2011 and 2012 suggested that something was impacting the soft bottom habitat within Frenchy's Cove. Information gained from mariners and National Park rangers confirmed that the cove was being targeted by trap fishing during the commercial season months of November and December.

MPAs are even more critical for providing resilience and refuge within a changing ocean. Eelgrass habitat, limited by water clarity and exposure, faces very real threats from climate change-related physical disruption from increased wave activity and storm severity. In addition, sea level rise may reduce the resiliency of some beds due to steep shore topography and reflection from waves.

2016-2019 Project Purpose

We assessed eelgrass condition, density and abundance within major beds at Santa Cruz and Santa Rosa Islands, and along the north side of Anacapa Island that include our restoration site and "downstream" areas of restored meadows (seeded from the restored population). We also gathered information on density and abundance of associated invertebrate and fish species. Information gathered was then compared to that from large-scale, multi-island surveys performed in 1994-1997 (Engle, CIRP) and in 2007- 2009 (Altstatt, CIRP). Additional opportunistic surveys occurred at various sites between this range of dates.

Anacapa and eastern Santa Cruz island sites were visited in 2016 but survey scope was limited. Enough information was gathered, however, to determine that the commercial lobster trap fishery had severely impacted the epicenter of our restored eelgrass bed within the Anacapa State Marine Conservation Area at Frenchy's Cove. Eelgrass occurring within the neighboring marine reserve was flourishing. This unexpected and very interesting result needs focus, as it has implications for soft-bottom (and other) habitats that fall just outside of marine reserves. In light of the recent years of unprecedented warm water, the health of the beds is unknown and potentially facing dramatic change due to disease, increased predation from recruitment of warmer water species, or physical disruption from increased wave activity during el Niño storms.

We envisioned that the 2019 season of surveys could be the first in a much larger multi-year effort, that will collect information needed to conduct stock assessments for threatened species, the ability of specific seagrass meadows to adapt to changes in sea levels and storm damage due to climate change, and could help address the capacity of eelgrass meadows to buffer changing pH levels.

Primarily, this study was conducted to address the following questions:

-how stable over time are shoot density and meadow extent in naturally occurring eelgrass beds?

-how similar in size and density are the meadows at Anacapa to naturally occurring beds at Santa Cruz and Santa Rosa?

-do the restored eelgrass meadows at Anacapa perform at the same habitat level as naturally occurring beds at Santa Cruz?

Additional questions include:

-does eelgrass extent/coverage/patchiness affect determine fish and invert species richness, abundance?

-do eelgrass beds within Marine Reserves and their associated fish and invertebrates differ from those outside?

-are there implications for management of Marine Protected Areas, and what are the recommendations?

Methods

Site Descriptions

We surveyed thirteen island eelgrass meadows between April 24 and July 27 2019. We chose meadows that were known to be temporally stable, and/or that had been sampled repeatedly since the 1990s. One site was at Santa Rosa Island, eight sites at Santa Cruz Island, and four sites at Anacapa Island including the original restoration site within Frenchy's Cove (Figure 1).

We also chose two locations that we suspected may have changed (East Prisoners) or that had been mapped in 2015 (Merkel 2015) that we wanted to ground-truth (East Scorpion). In general, the most protected sites were closest to shore and those sites subject to wave action were deeper and farther offshore. Specific dive locations were chosen with the help of our previous maps and notes to ensure that a full survey could fall within eelgrass meadow rather than sandy plain.

Most sites were visited at least twice; Old Ranch, Eagle Canyon, East Scorpion, and Smugglers, only once.

Divers mapped the western and inner meadow edge at Scorpion, and this data was then provided to the National Park Service (NPS) to assist in their process planning for construction of the new pier. The trackline created by this dive is shown in Figure 2.

Santa Rosa Island

Old Ranch

This expansive eelgrass meadow was not known to CIRP during the 1990s. It is far enough offshore that it escaped detection until we were alerted by a commercial crab fisherman in 2002 who found his traps fouled with eelgrass. Dives occurred in 2002 and 2003 for mapping and general description, but no qualitative surveys were done. We surveyed this bed in August 2008, with additional scouting. Work in Fall 2009 was aborted after one dive as the current was too strong. The 2019 surveys did not reach the outer edge of the mapped eelgrass bed, which we estimated to be another 150-200m to the east, as it was approximately 600m offshore and thus subject to strong currents.

This eelgrass meadow is more than 800 meters long and at least 350m wide. The sediment is white clean sand and meadows occur from 35' to 50' depths. We sampled two sites each ~430m off of the beach.

Santa Cruz Island

Prisoners Harbor

Prisoners Harbor is perhaps the most sheltered location on the island, tucked inside a large bight on the north side of the island. The NPS maintains a pier and mooring can in shallow water (~17'). This is a popular location with pleasure boats, especially northwest of the pier. Holes in the eelgrass bed from anchoring are evident in this area. The western headland protects the nearshore habitat from even strong westerly swells. The area is only rarely affected by strong Santa Ana winds that produce steep wind waves from the NE. These meadows are 135m off the beach and 80m off the western headland. The eelgrass bed to the west of the pier extends roughly N-S for hundreds of meters and in to 11' depth inside of the pier. The sediment in the inner harbor is fine and dark. We sampled two areas (~60m apart) in 2019.

In the surveys of the 1990's, it was thought that a separate bed lay 2 km to the east at Cañada del Agua. During our 2009 mapping study, we swam this stretch of coastline and documented that a solid band of eelgrass extends the entire distance. This bed is fairly defined both on the shallow and deep edge. Moving easterly from the pier, the north side of the island becomes more exposed to prevailing swell and current, and the eelgrass meadows are in deeper water.

East Prisoners

This site is east of the pier off to the first headland. The sediment immediately offshore of the Cañada del Puerto wetlands and creek mouth bears evidence of occasional terrestrial inputs of branches, cobbles and boulders. There has been a narrow canyon carved out from previous heavy flows that is up to 10' deeper than surrounding areas. The creek mouth is closed off from the ocean most of the time but it is evident that when the creek is discharging, eelgrass habitat is affected. In 2001 the eelgrass was described in this area as very patchy (Richards 2001), but was more continuous and uniform when mapped in 2009. It is unknown what the long-term effects of the on-going Cañada del Puerto watershed restoration by NPS will be, although it is possible that the wetlands will prevent the 'flashiness' of previous high water years, and thus could reduce scouring in the nearshore environment.

This area is 110m – 150m offshore.

There are several minor headlands to the east of Prisoners that provide protection from prevailing swell. We sampled three of these areas in 2019. The locations in the eastern lee of these headlands are Eagle Canyon, Cañada del Agua and Aguaje Escondido.

Eagle Canyon

The only time that we dove here in the past was for mapping in 2009. The eelgrass meadow is 90 meters offshore.

Cañada del Agua

In 1997, Cañada del Agua meadows were described as isolated and no grass was detected to the east. In 2001, it was noted that this area was the east end of roughly 1.5 km of eelgrass patches and meadows stretching from the Prisoners pier. In 2003 using the ship's fathometer, the bed was estimated at between 1-10 hectares with 0.5 km or less of shoreline. In 2009, during diver surveys it appeared that eelgrass tapered off past the cove and was not continuous to the east.

The eelgrass meadows are 130 meters off the headland and roughly 100 meters wide, centered at 28' depth.

Aguaje Escondido

This area was not surveyed in the 1990s, as at that time it was limited to several small patches. In 2003, eelgrass habitat at this location was less 2.5 acres and less than 500 meters of shoreline. It did not appear that the area was contiguous with eelgrass to the west.

During the cruises conducted 2008-09, based on these earlier observations, we did not chose to re-survey or map here. The 2015 NMFS sonar surveys found that this bed had expanded and was now a continuous band with eelgrass to the west.

The eelgrass meadows are 110 meters off of the headland and are up to 250 meters wide.

Scorpion

There has been a meadow in this sheltered location as least as far back as 1981 (Engle, personal communication). Grazing by white urchins occurred in the late 1980s and surveys in 1994 found the bed to be 0.1-1 hectare with less than 0.5 km of shoreline. A flash flood in December 1997 caused extreme flooding within Scorpion Canyon, leading to deposition of sediment and debris into the cove, leading to an estimated reduction in eelgrass by 30% or more (Richards, personal communication). In 2001, the eelgrass bed was a series of very dense patches 3-8 meters in diameter. This eelgrass bed is in a heavily used anchorage in font of the National Park island headquarters and popular visitor area. Two mooring balls were placed within Scorpion for use by NPS and concessionaire vessels in the 1990s. Since then, the bed has been a mosaic of meadows with circular open areas resulting from periodic relocation of the NPS mooring anchors and chain, and old anchor scars. Advocacy work in 2007-8 temporarily resulted in NPS suspending the chain off the sea floor by using a sub-surface float. Within a few years, however, the subsurface floats were removed by maintenance staff and the chain once again was on the bottom. This Marine Protected Area will continue to be affected by the chains on the bottom, and routine maintenance of the mooring chain every time the anchors are pulled up and redeployed in a new location, until NPS decides to modify their practices.

This eelgrass meadow is approximately 300 meters long and at least 74 m wide. The bed was mapped as 5.8 acres in 2009.

East Scorpion

This site is 500 meters east of Scorpion and is somewhat less protected. We chose to survey this location as it had been mapped as a solid eelgrass meadow (130 x 100 meters) in 2015 (Merkel 2015). The area is is 130 meters offshore and 100 meters west of Scorpion Rock.

Smugglers Cove

Smugglers Cove, at the east end of Santa Cruz Island, is a wide embayment sheltered from prevailing northwest swell. The bay is exposed to long-period south swells which are common during the summer and fall months. During such events, sediments are suspended near shore and the visibility drops to near zero. Smugglers is both the farthest offshore and the deepest bed at Santa Cruz Island. To the south, there are eelgrass meadows closer to Yellowbanks, but that area is even more susceptible to bad visibility due to the fine sediment and much of this eelgrass is interspersed with low-lying rocky reefs.

Based on previous mapping efforts, the Smugglers eelgrass meadow is more than 1,300 meters long and up to 265 meters wide, and nearly 500 meters offshore. occurring from 38’-50’ depths

Anacapa Island

CIRP records of eelgrass at Anacapa in 1979-1981 found extensive eelgrass meadows of 1-10 hectares along the north side of all three islets, and at Cat Rock on the south side of West Anacapa. All the Anacapa beds disappeared in the late 1980’s, due to overgrazing by the white urchin, *Lytechinus anemesus* following an extraordinary post- el Niño recruitment event (Engle et al., unpublished data). By 1991 all eelgrass was gone (with the exception of a small patches at Cat Rock and Cathedral Cove, which persisted for a few more years). In April 2003, the entire north side of Anacapa became either a State Marine Reserve or State Marine Conservation Area.

The boundary between the Marine Protected Area (no take, to the east) and the Anacapa Marine Conservation Area (to the west, which allows for take of pelagic fin fish and lobster) runs N-S through Frenchy’s Cove. Our two sites straddle this line. There is also a Special Closure to the west of the line for Brown Pelican breeding that closes the area within 1000’ of shore to vessel traffic from January through October, but historically it has not been regularly enforced.

Frenchy’s Cove, West Anacapa

Historic beds here in the 1980’s ranged from 20-45’ depths (Engle and Miller 2008). In 1981 this extremely sheltered location area supported the largest bed at Anacapa. By 1991, the eelgrass had been extirpated and CIRP established a permanent transect to monitor yearly for recovery. In 2001 we developed a trial restoration plan for this location with a site within the Seasonal Pelican Closure in the western part of the cove (Altstatt, 2005, Altstatt et al. 2014) with regular monitoring in subsequent years (with the exception of 2013-2015). In 2009 the bed was mapped as 2.9 acres.

Frenchy's Cove is the most protected area at Anacapa Island, offering moderate protection from NW winds and swell. Inshore of about 20' the sand turns to gravel, cobble and shell hash, which limits the inshore distribution of eelgrass. In deeper water, the parchment tube worm *Chaetopterous* has been common to abundant here, building 'reefs' of tubes at or just under the sediment surface. Offshore to the east, there is a rocky outcrop in 60-75' which is at least 100 meters offshore of the eelgrass bed. In cool water years, there is seasonal recruitment of giant kelp and other brown algae onto worm tubes, pebbles and cobble, but this algae rarely persists year-round. The historic eelgrass bed was 100m from shore.

East Frenchy's

This area is just 300 meters to the southeast of the restoration site. Within the first year of restoration planting at Frenchy's, most of the shoots had been dislodged and carried away by water motion. Upon surveying East Frenchys, we found single shoots with new growth, and we realized that these resulted from our work up-current. The eelgrass spread initially from vegetative material that re-rooted, and then from both seed dispersal and vegetative extension of rhizomes. We have monitored growth and spread in to patches here and to the east since 2004.

Current meadows are 90 meters from shore.

Keyhole, Middle Anacapa

This location is ~ 1 km to the east from East Frenchy's. In 1980 eelgrass was dominant here at 25' - 40' depths. We first observed single eelgrass shoots here in 2004. Eelgrass meadows are 85 meters from shore.

East NPS, Middle Anacapa

In 1982, substantial eelgrass meadows were found here from 30-40'. There was no eelgrass here in 2004 or 2005, but by 2011 and 2012 there were scattered patches in 33' to 40' depths. Eelgrass meadows are 150 meters from shore.

Cathedral Cove, East Anacapa (scouting only)

A few small patches of eelgrass persisted here during the urchin over-grazing until 1998. Diver observations through 2012 did not find any remaining eelgrass here. Sonar mapping suggested that sparse eelgrass was present (Merkel 2015).

2019 Survey protocols

The amount of effort at each site varied, but was designed to collect the minimum information needed for site characterization.

A full survey consisted of the following:

- quantitative fish transect 30m x 2m band
- band transect for large invertebrates and algae 30m x 2m band
- 0.25m² quadrats for eelgrass leaf shoot, flowering shoot and seedling density, urchin counts, % cover tubeworms and other sessile invertebrates,
- point-intercept for eelgrass extent and cover along transect line (10cm intervals)

General Dive Plan

All SCUBA activities were approved either by the University of California, Santa Barbara Diving Safety Officer, NOAA scientific diving program, or both. Divers were either NOAA or American Academy of Underwater Scientists (AAUS)-certified and familiar with species identification and survey protocols.

Dive sites were chosen based on our knowledge of preexisting eelgrass bed locations and conditions (Table 1). We planned for one central dive location at the smaller sites and two dive sites at the larger beds (Prisoners, Smugglers, Scorpion, Old Ranch). The anchor was dropped on predetermined GPS coordinates. Transects generally were laid out in cardinal directions (headings of 360, 90, 180 and 270 degrees) starting at the boat's anchor location, resulting in transects that generally ran alongshore, offshore and onshore. A complete survey required two teams of diver buddy-pairs. The first team laid out the tape while doing the fish survey and then conducted band transects and eelgrass extent point intercept survey on way back, leaving the tape in place. The second team scored quadrats and reeled in the tapes. The depth was measured along the transect at each quadrat location.

A typical survey at one dive location would yield four 30m fish transects + up to four extra 30m transects as extensions from the core transects, four 60m² bands, and fifteen 0.25m² quadrats per core transect for 60 quadrats total.

Although the site locations were chosen generally for the probability that they were within the last known extent of eelgrass, once on the bottom we did not abandon or re-route the transects to choose areas of higher density or extent.

Quadrat method

Quadrats were 0.25m² area (0.5m square) and were placed at set locations (every other meter) along the tape, yielding 15 per transect. Counts were conducted within each quadrat for the number of eelgrass turions (shoots), seedlings, and reproductive (flowering) shoots. Divers also searched for urchins and estimated percent cover of brittlestars and parchment tube worms. Depth was recorded for each quadrat.

Point-intercept method

We performed point-intercept counts every 10cm along each transect in order to estimate how much of the transect fell within an eelgrass patch or meadow. We scored the extent of eelgrass beneath the transect line by assessing the substrate at 10cm intervals along the transect. This yielded a percent of each 30m transect that was either eelgrass bed, bare sand, or other (e.g. worm tubes). These points were tallied and the categories were converted to percentages. For analysis and comparison with previous survey years where detailed point-cover was not consistently recorded for all transects, point-cover was converted to a 1-4 density scale (Orth et al 2021) where 0-10% cover is Very Sparse, 10-40% is Sparse, 40-70% is Moderate, and 70-100% is Dense. This measure gives an idea of the ‘patchiness’ of the eelgrass at a dive location, and potential compatibility with other seagrass studies.

*Quantitative Fish transect*s

The diver performing the fish survey would slowly swim in the designated direction, extending the meter tape until 30 meters was reached. Any fish observed within the 2m wide transect corridor would be recorded. Fish were scored into four size categories: young of the year (YOY), <15cm, 15-30cm, and >30cm. The diver could pause during the count while recording in order not to miss other fish. Divers usually completed the transect within 3-5 minutes. Most surveys included additional fish transects that extended an additional 30m past the end of each main transect, on the same heading.

Roving Diver Fish Counts

We conducted 30-minute roving diver fish counts (CINP Kelp Forest Monitoring Program 1997) to determine indices of species presence, abundance and diversity. Fish species were scored both on the 5-minute time intervals during which they were encountered, and on abundances recorded during the overall 30-minute survey which were scored into four categories (single [1], few [2-10], common [11-100], and many [>100]). For analysis, we created a weighted abundance index that combined the ‘Time Interval Code’ and ‘Abundance Code’ (if a species was not tallied the Abundance Code was zero). The index was the (TIC/10)*AC. This gives more weight to fish seen earlier in the 30-min count, so for example a species with an overall abundance of common (3) seen in the second time interval (9) would have a weighted index of 2.7.

At least one Roving Diver Fish survey was performed at all but two of the dive locations (due to time constraints no Roving Diver Fish surveys were performed at Eagle Canyon or East Scorpion).

Band Transects

The dive team would visually search within 1m bands to each side of the main transect tape and record any major invertebrate or macroalgae encountered, yielding 60m² search area per transect. We did not sample sediments for infauna other than for obvious bivalves, tube anemones and tube worms extending above the surface. Epifauna was only scored if larger taxa (urchins, sea hares, etc).

In addition to the core methodology, notes, photos and video were taken as time allowed.

2016 Surveys

We did an abbreviated suite of diver surveys at six sites in the summer of 2016 (Table 3). This included quantitative fish transects, invertebrate band transects, and quadrats for eelgrass metrics. In addition we scouted and mapped eelgrass along Middle Anacapa and ground-truthed some reports of eelgrass from a 2015 National Marine Fisheries Service-contracted acoustical mapping effort (Merkel 2015).

2008-2009 Surveys

We collected monitoring data at six islands beds during the 2008-09 field seasons, using methods as described above. During the twelve days of these cruises, between four and seven divers participated each day, collecting the following information: 865 ¼ m^2 quadrats for shoot density and sessile invertebrates, 200 30m quantitative fish transects, and 133 30m band transects for motile invertebrates.

A total 156 individual dives were performed.

1990s Surveys

Three dedicated soft-bottom survey Channel Islands Research Program multi-day cruises to the northern Channel Islands took place in August of 1994, 1995, and 1997. Surveys targeted known or suspected eelgrass beds to determine areal extents, depth ranges, plant density, and community composition, and were repeated at three core sites (Prisoners, Scorpion, Smugglers) in subsequent years to assess annual and multi-year changes. Surveys included detailed eelgrass meadow infaunal and epibiont surveys, and comparisons with non-eelgrass bed sandy habitats. Results were complied in a draft report to the California Coastal Commission in 1998 and major findings were published in Engle and Miller 2005. The density, meadow extent, and fish and major invertebrate transect data are used in the current study to determine meadow function and stability over time.

Statistical Analysis

To account for differences in sampling effort, eelgrass abundance was scaled to the same spatial unit across sites and years. Due to challenges with some transects located almost entirely outside of eelgrass meadows, only quadrats with eelgrass present were included in statistical analysis. To address small sample sizes and non-normal distributions, non-parametric statistics, including median, confidence interval, and interquartile range were included. The Kruskall-Wallace test was used as a nonparametric test between two samples (Conover 1999). All statistics and graphing were conducted in R version

4.0.3 (ref), using packages ggplot2, using packages *ggplot2, PerformanceAnalytics, tidyverse,* and *Hmisc.*

Results

In general, eelgrass meadows at the largest sites appeared unchanged in location or scale, with the expected suite of species present. Highlights and exceptions are noted in the following sections.

Quadrats Results

A total of 1,095 quadrats were scored during the 2019 study.

Eelgrass Shoot Density

As the dive locations were not adjusted once underwater, some transects ran through patchy or sparse meadows or across bare sand rather than through a dense bed. We excluded those quadrats that fell onto bare sand outside of meadows from analysis of shoot density. The 2019 mean shoot density for 11 sites is shown in Figure 3 (East Scorpion and Frenchy's are excluded as density was ~ 0%). In general, density ranged from 31 to 65 shoots/m².

Sites grouped by similarity in density. Prisoners (65/m²), Eagle Canyon (65/m²) and Scorpion (58/m²) were the highest in density and not significantly different. The three Anacapa SMR sites were not significantly different from each other in density, with a mean of 46/m². Smugglers and Old Ranch (42/m²) were similar, and East Prisoners, Cañada del Agua, and Aguaje Escondido were similar (~33/m²).

Variation in density with depth

At each site, our design ensured that we scored quadrats along 60m of transect that was parallel to shore at a constant depth, and along 60m of transects that crossed the bed from shallow to deep. Depending on the site, the cross-section transects may have captured the inshore edge of the eelgrass, the offshore edge, both, or neither. Two Anacapa beds, East NPS and Keyhole, are shown in Figure 4. The width of the bed at East NPS was ~120m, while at Keyhole the bed was 68m wide. In both cases, eelgrass shoot density tended to increase in shallower water.

Eelgrass patchiness and extent

Mean point-intercept and a four-point density scale for eelgrass are summarized in Figures 5 and 6. Old Ranch, Prisoners, Cañada del Agua, Scorpion, Smugglers, Keyhole and East NPS were categorized as mostly or entirely dense meadows. Eagle Canyon, Aguaje Escondido and East Frenchy's were categorized as moderately dense. East Scorpion and East Prisoners were mostly very sparse. Frenchy's was entirely bare sand but categorized as very sparse (0-10% cover).

Site Conditions

Frenchy's, the original restoration site, had no remaining eelgrass meadows and only a couple of single shoots were observed. Across the cove at East Frenchy's, there were good eelgrass meadows to the east but much of the permanent transect line towards the west and close to the marine reserve boundary was denuded. We did observe meadows off the transect in shallower water.

The greatest increase in meadow extent was found at East NPS, where by 2016 there were extensive uniform (100% cover) meadows in 30-40'. Keyhole was slightly less uniform and similar density. There was no significant difference in shoot density between East NPS, Keyhole and East Frenchy's, although East Frenchy's meadows were the most fragmented. All three Anacapa sites had higher shoot density than Smugglers, which was one of the original donor material locations. Smugglers was extremely uniform in meadow extent (100%) but with moderate density (42 shoots/m^2).

Large bare scars were observed just off the transect corridors at Scorpion, near each of the two mooring anchors, and the mooring cans were no longer held up by sub-surface floats. The NW and inner edge of the bed was similar to previous years. Our tracklines from June 2019 (green) are shown with bed extent mapped by SCUBA in 2009 (purple) and eelgrass delineated by sonar in 2015 (red) in Figure 2. It appears that the bed may have expanded from 2009 to 2015 in all directions, and then contracted by 2019.

The meadows at Aguaje Escondido also expanded from 2009-2019, but were moderately patchy compared to Cañada del Agua. We sampled two locations at each of these sites, and patchiness differed more between the two dive sites at Aguaje Escondido than at Cañada del Agua.

At Eagle Canyon, one of three transects fell entirely on bare sand, but the eelgrass on the other two was the highest mean density observed during the study, 65 shoots/m^2 with a single quadrat at 112/m^2.

Another big change was that the meadow at East Prisoners (in front of the wetland and canyon mouth) had mostly disappeared and the eelgrass that we did encounter was the lowest mean density of the study- 31/m^2.

Both Prisoners and Old Ranch at Santa Rosa Island have remained fairly uniform in cover.

Our site-checks at Cathedral Cove on East Anacapa found no evidence of eelgrass returning to this location (ship's fish finder and by SCUBA on 9/20/2016, and by ship's fish finder on 6/20/2019).

Flowering and Seedlings

Eelgrass flowering was detected at varying density within quadrats at nine sites (Figure 7). The greatest densities were found at Keyhole (4/m^2), Smugglers (2.9/m^2) and East NPS (1.53/m^2). Seedlings were found at seven sites, with the highest density at East NPS (1.13/m^2) and Keyhole (0.6/m^2). No flowers or seedlings were found within quadrats at Prisoners Harbor, although developing flowers were documented at the site by photograph in April. Neither flowers nor seedlings were found at Frenchy's, East Scorpion, or East Prisoners.

Other quadrat categories

The white urchin *Lytechinus* was present in 16% of quadrats at Frenchy's (1.14/m²), and a single urchin was found at East Prisoners. Parchment tube worms (mostly *Chaetopterus sp.*) were present in low numbers at all sites but were greatest at predominantly sandy sites (Frenchy's, East Scorpion, East Prisoners). The small red sea cucumber *Pachythione rubra* was found at two sites, Aguaje Escondido and Old Ranch, where they were only in a few of the quadrats but in especially high numbers at Old Ranch.

Fish Results

During site visits, sea lions were observed at Anacapa Island (East NPS and East Frenchy's) and harbor seals at Eagle Canyon, Santa Cruz Island.

Quantitative Transects

We completed 136 quantitative fish transects during the study. Each 30m x2m transect took 4-6 minutes to complete. Data for all transects are summarized in Table 4.

Size

Fish were generally recorded in 3 size categories (>30cm, 15-30cm, <15 cm), plus young of the year (YOY) but the three sizes have been lumped for density analysis, with the exception of a discussion of kelp bass sizes below.

Species

39 different species categories were found in total across all transects and all sites (Table 3). Density of the eight most common fish are shown in Figure 6. The two most commonly encountered species were kelp bass, *Paralabrax clathratus,* which were scored at all sites except for Frenchy's and East Frenchy's and in 65% of all transects; and senorita, *Oxyjulis californica,* which occurred in 40% of all transects. The third most common fish was black perch, *Embiotica jacksonii*, found at six sites and in 20% of all transects.

12 species were only encountered once. 9 of these fish taxa were bottom-dwellers.

YOY species

Surveys occurred too early in the year to catch many young of the year (YOY) fish. Fall surveys would have captured recent recruitment of typical species such as kelp bass, senorita, rockfishes and perches. Our surveys found YOYs of 4 categories: kelp bass, unidentified rockfish, black eye goby and giant kelpfish. Of these, giant kelpfish were by far the most common, occurring in 12.5% of all fish transects and at 6 of the 12 sites.

Kelp bass

The size classes of kelp bass found at all sites are shown in Figure 7. Size classes could help distinguish between legal and sub-legal size of kelp bass, a popular recreationally-fished species. However, in 2013 the DFG commission increased the minimum harvest size from 12” (~30cm) to 14” (35.6cm) length over all. We did not change our estimated size categories after this regulation was enacted, but it is not clear whether it would make a difference in results.

The greatest density of kelp bass overall (nearly twice that of other sites) was found at Scorpion. This SMR site had fish of all three size categories plus YOYs, and the largest fraction of small and medium kelp bass at any site. The lowest densities of kelp bass were found at the sites with little to no eelgrass, with the exception of East Frenchy's. A large sea lion was observed there during the monitoring, perhaps contributing to the general lack of fish seen on this particular survey as kelp bass were commonly encountered during the roving diver fish counts on a later date. The largest proportion of legal-sized (or close to legal) kelp bass were found at Keyhole and Scorpion, both within State Marine Reserves.

Perch

We encountered seven species of perch. The most perch and four out of the six most common species were found at Prisoners Harbor. Large schools of shiner perch were present over the transects at Prisoners, accounting for 27% of the total fish observed. Rainbow perch only were found at the two deep sites, Smugglers and Old Ranch. Black perch were at six sites, and white perch at four sites. No perch were seen at the predominantly sand habitat sites (East Frenchy’s, Frenchy’s, East Scorpion). No YOY perch were observed.

Elasmobranchs

We found three taxa of elasmobranchs along quantitative transects: horn sharks, leopard sharks and bat rays. Horn sharks were scored at East Frenchy’s, Scorpion, and Aguaje Escondido; leopard sharks at Aguaje Escondido, Cañada del Agua, and Prisoners. Bay rays were scored at Scorpion, Cañada del Agua, East Prisoners and Old Ranch.

Sheephead

Sheephead were found at seven sites. The greatest density was at Scorpion (0.86/transect). Males were only seen along transects at Scorpion and Cañada del Agua. No YOY sheephead were found.

Schooling Fish

We found three taxa of schooling fish: jack mackerel (two sites), topsmelt (three sites) and barracuda (three sites). All three occurred at both Scorpion and Cañada del Agua.

Senorita

*S*enorita were the most numerous common fish found and occurred at six sites and all three islands. The greatest number were found at Old Ranch SRI (22/transect).

Miscellaneous Fish

We found ~ a dozen taxa that were represented by single individuals at one or more sites. Scorpion had four of these species. Of note was the orangethroat pikeblenny, a benthic fish that shelters in empty shells or parchment worm tubes. In 1994 the published northern-range limit of this pikeblenny was extended to Frenchy's Cove, Anacapa Island, as reported by CIRP researchers. In April 2019, we found them at two locations on Anacapa (East Frenchy's, Frenchy's), and at East Prisoners, Santa Cruz Island where they were common on and off transects. At Prisoners we scored a moray eel and a white seabass, both unusual for a quantitative transect.

Roving Diver Fish Counts

A total of 33 combined species were recorded from Roving Diver Fish Counts at ten sites (Figure 10). Due to the restricted level of field effort, Roving Diver (RD) counts were not performed at all sites in replicate numbers and no surveys occurred at East Prisoners, Eagle Canyon, or East Scorpion. RD surveys were done in late June and July. A single survey was performed at two sites (Scorpion, Old Ranch), while the rest had 2-4 surveys each. Results shown are the Fish Average Abundance Index averaged for all observations at that site. The Fish Average Abundance Index takes into account the number of a particular fish seen and the time during the dive that the fish is first observed.

Anacapa eelgrass sites had 13-14 species, with the exception of Frenchy's Cove (no eelgrass) which reported 6 species. Santa Cruz sites ranged from 10 (Smugglers) to 17 species at Aguaje Escondido, the most species observed during a RD survey. Old Ranch at Santa Rosa had 8 species. The greatest number of species within an individual single 30 min count were recorded at East Frenchy's. It should be noted that on the day that the quantitative surveys were done at East Frenchy's, there was a sea lion actively swimming through the area and fish were scarce. The lowest number of fish species observed was at the Frenchy's restoration site, over barren sand.

Kelp bass and Senoritas were universal across all sites. Opaleye, the only predominantly herbivorous fish seen, were found at all sites except for Frenchy's and Old Ranch. Sheephead were common within the SMR at Scorpion. They were uncommon along middle Anacapa SMR sites, rare at Northern SCI sites and absent from Prisoners and Old Ranch.

Shiner surfperch are schooling fish. They were common to abundant at Scorpion, Prisoners, and Old Ranch, and rare at East NPS, Aguaje, and Cañada del Agua. Black perch were found at all sites except at Frenchy's. They were common at Smugglers and Prisoners. White perch were only found at the four northern SCI sites, where they ranged from rare to common. Pile perch were found at all sites except at Frenchy's and Smugglers.

Many taxa were only recorded as individuals and/or at one site, or in one survey at a particular site.

These include schooling fish such as yellowtail (Frenchy's), barracuda (Scorpion, Aguaje) and salema (Prisoners). The stand-out was giant sea bass, where two individuals were seen at the end of the fish count at Keyhole, Middle Anacapa Island in June 2019.

Four taxa of flatfish were observed. Three of these were found at only Anacapa sites (halibut, c-o turbot, sand dab), while one fantail sole was observed at Old Ranch.

Four taxa of elasmobranchs were observed during RD counts, with most seen at Prisoners, Cañada del Agua, and Aguaje Escondido. Angel sharks were seen at East NPS and Cañada del Agua.

Comparison of Methods

Both Roving Diver (RD) and Quantitative transects were performed at ten of the thirteen sites. At six of these, RD yielded more species. Because the observer swims throughout the eelgrass meadow during the count, Roving Diver surveys, at 30 minutes in length, may constitute a more comprehensive snapshot of fish assemblages. Transect surveys only record those fish that swim within the transect corridor. The two methods, while distinct, are complementary in describing fish assemblages.

Fish Species Richness

We calculated fish species richness as the total number of fish taxa seen at a site considering all methods (Figure 8). By far the greatest number of taxa (22) and the most fish per transect (44.43) were found at Scorpion, followed by Cañada del Agua and Aguaje Escondido. Eagle Canyon and East Scorpion had the fewest fish and were the least diverse.

2019 Band transects results

Invertebrates

76 individual band transects were counted, for a total of 4,560m² of sea floor habitat. 34 different taxa were recorded across all band transects during the study. Most taxa were not found at every site; sites varied in species richness and composition (Table 5).

In general, the major invertebrates found within eelgrass meadows are species that may also be present on bare sandy bottoms or on rocky reefs. This is not surprising, given that rocky reefs are bordered by sand and many of the smaller eelgrass sites are close to rock habitat. The eight most commonly encountered species are shown in Figure 11.

The most numerous animal found at any site was *Pachycerianthus fimbriatus,* a tube-dwelling ceriantheid anemone, which was extremely common at the four northern SCR sites from East Prisoners to Aguaje Escondido. The highest mean density occurred at Eagle Canyon with 128/60m^2, followed by 96/60m^2 at East Prisoners. Surprising, there were only 2/60m^2 at nearby Prisoners Harbor. Low densities occurred elsewhere, and none occurred at Smugglers or Scorpion.

The wavy top snail *Megastraea undosa* was common at all but three sites (East Scorpion, Scorpion and Old Ranch). The greatest density was found at East Frenchy's, at 45 snails/60m^2 transect.

Bivalves were also common at several sites, this category was comprised of at least 3 different genera (*Tresus*, *Zirfaea* and *Panopea*; species not always scored separately and so were lumped for this report). Bivalves were reported at eight out of the thirteen sites.

The sand star *Astropectin armatus* was found at eight study sites, with the greatest density at Frenchy's. The only other star found in our transects was the bat star *Patira miniata*, which was found at Old Ranch and in low abundances at Frenchy's and Aguaje Escondido.

The warty sea cucumber *Parastichopus parvimensis* was found at seven sites, and was the most common at Frenchy's and Eagle Canyon.

Seven taxa of crabs were found (Table 3) but in low numbers. They are shown combined for the category 'all crabs' in Figure 11. No crabs were found at any of the Anacapa sites in 2019.

The only sea urchin found during our surveys was the white urchin *Lytechinus anemesus,* found at Frenchy's at 28.2 per 60m^2 transect (equaling 0.47 per m^2).

The sea pen *Stylatula* and sea pansy*Renilla* were generally co-occurring. Sea pansies were the most common at Aguaje Escondido and Eagle Canyon.

Brown macroalgae were also scored in band transects (data not shown). Three taxa were found. The invasive *Sargassum horneri* was found at all four Anacapa Island locations, but individuals were very small and were growing on either small rocks or shells. Giant kelp recruits were found at East NPS and at Old Ranch, while *Stephanocystis osmundacea* was found at Smugglers and Prisoners. All brown algae were growing on hard surfaces.

By Site Comparisons of Invertebrates

We sampled three pairs of sites, that resulted with one a dense eelgrass meadow and the nearby second site mostly or all sand plain. This difference in eelgrass habitat appeared to make a difference in major invertebrate taxa. Prisoners and East Prisoners are 250 meters apart, but only shared four invertebrate species in common. There were nearly twice as many taxa found at East Prisoners than within the dense eelgrass bed within the cove. East Prisoners had been a continuation of the Prisoners meadow tens year prior (the sites are ~ 300 meters apart). It is possible that the sediment grain size and organic content is different between the two sites, due to the river mouth or along-island current patterns, as East Prisoners had very high densities of tube anemones.

Scorpion and East Scorpion, although 500 meters apart only shared rare wavy turban snails in common. The day that Scorpion surveys occurred, there was a lot of drift algae obscuring the bottom for much of the transects. We attempted to move it aside but it made surveys more difficult. We found no evidence that there had been a moderate size eelgrass meadow at East Scorpion. The sediment seemed fairly coarse, with scattered rocks, and the area is more exposed. We have no historical information on an eelgrass bed in this location.

Frenchy's and East Frenchy's, 265 meters apart, shared six species in common, but wavy turbans and bivalves were much more common at East Frenchy's. White urchins *Lytechinus* were only present at Frenchy's, at similar densities to wavy-top snails.

Major invertebrate composition and density were consistent throughout the larger sites that had two sampling locations similarly spaced (Smugglers, 560 meters apart, and Old Ranch, 260 meters apart), and that were moderate or dense eelgrass cover.

Invertebrate Species Richness

Invertebrate species richness at all dive sites is shown in Figure 13. The richest locations were East Prisoners and Aguaje Escondido, followed by Eagle Canyon. These three sites fall within a 1,200 meter stretch of of coastline.

Results and discussion of comparison with Reef Check

Our assumption was that the density and species richness of fish and invertebrates associated with eelgrass would be less than at near-by kelp beds, even when sampled at the coarse scale of this study. We compared our data to that collected by Reef Check, a program that has been monitoring rocky reefs inside and outside of Marine Protected Areas throughout California, including at the Channel Islands, since 2006, and that uses similar methods to those used in this study to score a set list of species. We compared means for several common species from three Reef Check sites (summarized in their Final Report, South Coast MPA Baseline Monitoring Report (data 2011-2014) with one of our nearby eelgrass sites. Kelp bass were three times as dense within Scorpion eelgrass, and four times as dense within Anacapa eelgrass, as on the corresponding rocky reefs. There were 35 times more wavy turban snails in the Anacapa eelgrass than on the rock reef. Overall, though, there were more taxa of major invertebrates on the reefs.

Data Correlations

We ran a Spearman's rank correlation to create a matrix of meadow extent, fish richness, and invertebrate richness, to examine and test for any relationships (Figure 14). The factors considered were Site ID (from west to east, representing gradient across channel), Meadow Percent (percent cover along transect), Meadow Class (density scale 1-4), Fish Species from Quantitative transects, Fish Species Richness Total, and Invertebrate Species Richness. There was a strong and significant positive correlation between Meadow Percent and Meadow Class, which was expected. There was also a strong positive correlation between Meadow Class and Fish Total Richness, with a weaker positive correlation between Fish Total Richness and Meadow Percent. There was a significant negative relationship between Invertebrate Richness and Meadow Class, and Meadow Percent.

To further examine these correlations, we ran regressions separately for species richness as a function of eelgrass meadow extent (percent cover), for fish and invertebrates (Figure 15). In both cases, there was a significant relationship between species richness and eelgrass meadow extent (positive for fish, negative for invertebrates).

We compared shoot density between six natural beds at Santa Cruz Island and three restored beds at Anacapa Island that resulted from our 2002 restoration effort (Figure 16). There was no significant difference based on overlap of the 95% confidence interval around the median.

We compared species richness between six natural beds at Santa Cruz Island and three restored beds at Anacapa Island that resulted from our 2002 restoration effort, for fish (Figure 17) and invertebrates (Figure 18). In both cases, there was no significant difference (Kruskal-Wallace test) between the mean species richness at restored meadows and natural meadows, even though there was a greater range in diversity at natural beds.

Finally, we compared eelgrass shoot density at six sites across multiple years (Figure 19).

Discussion

It is clear from our surveys that eelgrass madows create lush, three-dimensional habitat for a range of other species large and small. The majority of eelgrass meadows at Santa Cruz Island appear to be stable over time in location and scale, even after two years of elevated water temperature from el Niño and marine heatwaves in 2014-216.

How stable over time are shoot density and meadow extent in naturally occurring eelgrass beds?

We compared quadrat data from sites 1-3, 5, 7, 9 in 2019 to 2016, 2008-9, and 1994, 1995, 1997 (Figure 19). Not all sites were sampled at every period. Overall, there was a trend of declining and partially rebounding shoot density, with some sites more severe or significant than others. The most dramatic decline over the period was at Scorpion, where density has declined by two-thirds since 1997, and from a record high of 188 shoots/m² in 2001 (data not shown). We also compared eelgrass cover along transects at four Santa Cruz Island sites in 1994, 1995, 1997, 2009 and 2019 (Figure 20). Three of the sites are remarkably stable over time. East Prisoners, although only sampled twice, suffered massive losses of eelgrass habitat in addition to density over ten years. This site is in front of the river mouth at Cañada del Puerto.

How similar in size and density are the restored meadows at Anacapa to naturally occurring beds at Santa Cruz and Santa Rosa?

We compared quadrat data from pooled Anacapa sites 11-13 to pooled sites 1, 2, 5, 6, 7, 9 in order to test for differences between eelgrass meadow density (Figure 13). There was no significant difference in density between the two groups.

Do the restored eelgrass meadows at Anacapa perform at the same habitat level as naturally occurring beds at Santa Cruz?

To address this question, we compared the fish and invertebrate species richness levels at pooled Anacapa sites 11-13 to pooled SCR sites 2, 5, 6, 7, and 9 (Figures 17 and 18). There was no significant difference between total species richness of either fish or invertebrates between the sites. However, there was a greater range in fish diversity at Santa Cruz sites. The eastern Santa Barbara Channel experiences warmer currents coming up from the south and it is well known that the assemblages of fish and invertebrates are structured by the current regime, with assemblages more similar to southern islands than to the more western islands (as summarized in Airamé 2003). All of the eelgrass meadows within this study, with the exception of Old Ranch at Santa Rosa (removed from this analysis), fall within the eastern Channel regime and California Province (Hamilton *et al.* 2010), with Prisoners falling a few kilometers to the east of the accepted cold/warm current boundary. It is not too surprising that similar assemblages of fish and invertebrates were found at all sites. However, there were some differences, most noticeable with surf perch. Roving diver surveys found that pile and black perch were present at both islands but more common at Santa Cruz, while white and shiner were almost entirely absent from Anacapa. Our study did not sample for epifauna such as copepods, amphipods, and small mollusks, which are an important part of the food chain especially for fish predators. We hope to do this additional work in the future.

Do eelgrass beds within reserves and their associated fish and invertebrates differ from those outside?

We encountered more bat rays at Scorpion than at any other site. Interestingly, there were very few wavy turban snails within transects at Scorpion. At other locations, wavy turban snails are a major herbivore within eelgrass meadows. We have observed remnants of crushed turban snail shells within bat ray feeding pits at other sites, so it may be that rays can break apart the thick shell of even large turban snails with their stout jaws. Other known predators include seastars, lobsters, and fish such as sheephead and cabezon (mostly likely preying on smaller, younger snails). Scorpion also had the highest abundance of sheephead. Our findings suggest that the protective SMR status at Scorpion has fostered the survival and growth of large predators, allowing eelgrass to be released from grazing pressure.

Does eelgrass extent/coverage/patchiness affect determine fish and invert species richness, abundance?

There is evidence from seagrasses world wide that patchiness can affect both recruitment and survival of organisms living within (Bell *et al.* 2001, Healey and Hovel 2004, Lefcheck *et al.* 2016). From the present study, no fish were counted along 18% of the total core transects, and 83% of those transects without fish also had little to no eelgrass cover. We plan to compare species assemblage to eelgrass density categories (dense and moderate areas to sparse and very sparse) but this analysis has not concluded at the time of writing.

Implications for location of marine protected areas/ fishing boundaries

During the process of designating reserves in Federal waters around the Channel Islands, it was stated that "The existing State marine zones protect a variety of species of interest, including marine algae, seagrasses, invertebrates, and fishes… Eelgrass and surfgrass beds, which serve important roles as nursery habitat for young invertebrates and fishes, are protected in North Anacapa Island SMCA..." (54 FINAL_Resources_FEIS_4_13_07_v5, CINMS). The decision to create an area open to trap fishing was justified with "All extractive activities and injury to Sanctuary resources would be prohibited in the marine conservation area with the exception of lobster harvest." At the time of the initial island reserve designation process (2002-04), our eelgrass restoration project was underway but success was uncertain. The fact that the geographic orientation of Frenchy's Cove allowed for the historic persistence of the largest eelgrass bed throughout all of Anacapa Island, was not considered. There was intense pressure from the fishing industry to keep some part of the north side of Anacapa open, and the resulting boundary line was drawn within Frenchy's Cove at the separation between North and Middle Anacapa.

The effect of trap fisheries on the benthos has been examined mainly for rocky habitat with most researchers concluding that deployment of traps results in little lasting damage (Shester and Micheli 2011) especially when considering the value of the fishery (SCS 2004). As seagrass systems world-wide are targeted for a variety of trap-caught fishes and invertebrates, there has been interest in determining the environmental cost of fishing over soft-bottom habitat. The effect of trap fishing on two different species of Atlantic seagrass was investigated within the Florida Keys National Marine Sanctuary (Uhrin and Fonseca 2005). A key finding was that the two species within the study, which differed in root and rhizome structure, responded differently to the disturbance. The shallow rooted seagrass was more easily dislodged and slower to recover. Another consequence of frequent disturbance to seagrass is fragmentation of the bed. If the seagrass cannot respond through vegetative growth to keep up with or outpace the disturbance, then the fragments may continue to shrink until they lose the capacity to function as a cohesive habitat and drop below a sustainable threshold. Studies in the Mediterranean Sea have found that constant anthropomorphic disturbance leads to higher fragmentation of meadows (Montefalcone *et al.* 2010) which has implications for meadow function and recovery.

In California, fishermen are required to raise and service traps at intervals not exceeding 96 hours, weather permitting (FGC § 9004, revised from 72 hours). The trap is hauled, serviced and redeployed while the boat drifts out of gear (Altstatt, personal observation). At the beginning of the season, traps may be pulled and redeployed daily. *Zostera pacifica* is shallow rooted with rhizomes extending only a few centimeters in to the sediment. There is ample evidence of significant damage from vessel anchors, which, like traps, are heavy metal objects that are frequently deployed and redeployed, in all of the Channel Islands eelgrass sites. Based on the total loss of our restoration site within an area that has only recently become heavily fished, and decades of other observations, we surmise that *Z. pacifica* is extremely susceptible to disturbance from trap fishing.

The California Department of Fish and Wildlife acknowledges that the recent increase in commercial fishing effort has raised questions about the… 'negative consequences on the fishing grounds and associated ecosystems from increased gear usage' (California Spiny Lobster Fishery Management Plan, April 2016). The Plan states that hard bottom is the primary lobster habitat and that traps are set on the bottom in rocky areas. There does not appear to be any expectation that traps will be set in areas that are not hard bottom, and especially not in sensitive seagrass habitat.

In 2014, we learned from mariners that Frenchy's Cove was being fished heavily during the two months (November, December) that the brown pelican Special Closure was open. We were unable to return for dive surveys until the summer of 2016, four years after our last survey visit in 2012. In the summer and fall of 2016, we marked and reported 4 abandoned lobster traps within Frenchy's Cove, with one along the boundary with the SMR. The other three traps were within the 2012 mapped footprint of the eelgrass restoration site, where there was no longer any eelgrass remaining. On November 4 2016, NPS rangers reported "hundreds of traps" within the SMCA. In June 2019, we discovered an abandoned trap "ghost fishing" and filled with live lobsters along the SMR boundary line. In November 2019, CINMS staff reported at least 100 traps along the SMR boundary line, with another 100 to the west further within the SMCA, some as shallow as 17' (note that DFW prohibits commercial trapping in water depths shallower than 20'). Eelgrass continues to thrive within the SMR, 200 meters to the east.

The marine reserve network at the Channel Islands went in to effect in 2003. Frenchy's Cove was not traditionally an area targeted by lobster fisherman as nearly all of the shallow bottom substrate is soft rather than rocky (Altstatt, personal observation). However, a network of reserves was establish on the mainland in 2012, excluding fishers from no-take areas and concentrating that effort elsewhere. Fishing block data for the mainland showed that effort more than doubled within blocks containing fishing areas adjacent to SMRs (Lenihan *et al.* 2021). Visual inspection of the trap marker floats in November 2019 reveal that at least nine different fishermen set traps along the SMR/SMCA boundary and within Frenchy's Cove. Even though California's marine reserve system may be 'an integrated, well-enforced network of no-fishing zones designed to protect productive subtidal rocky reefs that are essential habitat to populations of many target species' (Lenihan *et al.* 2021) it is apparent that the intentional and dramatic increase in fishing effort along all SMR boundaries (regardless of bottom type) has degraded the eelgrass meadow habitat and has extirpated eelgrass from within the Anacapa SMCA. Although we had originally chose a location that we believed to be protected for 10 months out of the year (within the Anacapa Special Closure), the intensity of the fishing effort during the open two months was enough to disturb, and eventually eliminate, the restored eelgrass meadow within the SMCA. This unexpected finding showcases the need and value of marine reserves and has serious implications for habitats that are exposed to trapping. Although our restoration work has restored more than 30 acres of eelgrass meadows, it could have failed had there not been a SMR established adjacent to our original site, and if the implementation of the mainland reserves occurred sooner.

A next step to further understand how fishing has changed around Anacapa after the mainland reserves went in to effect, and the resulting impact to the seafloor, would be to analyze the catch data from reporting block 684 (North Anacapa Island). This information has been requested from the Department of Fish and Wildlife (March 2021).

Changing Climatic Regime

Zostera beds at the Channel Islands face increasing threats from multiple stressors, including increasing frequency and severity of storms, as seen by the dramatic change in eelgrass bed size, density and extent at East Prisoners between 2009 and 2019. Factors may have included a combination of big rainfall years and change in hydrological function of Cañada del Puerto following NPS wetland and canyon restoration. There was evidence of scour, evidence of deposition of cobbles and tree limbs into the eelgrass meadow habitat immediately offshore of the canyon mouth as far as 30' depth. Google Earth photo shows extreme turbidity where we had mapped eelgrass in 2009 and where is lacking now. We witnessed a similar event happen at Scorpion in December 1997, where a historic micro-burst created a flood within Scorpion Canyon leading to sediment deposition and loss of more than a third of the eelgrass bed (data not shown).

Warm water events

Multiple large-scale warm water events have occurred during the time frame of our eelgrass monitoring, beginning with the 1983 el Niño. The long-term trend of increasing sea surface temperatures (SST) apparently contribute to the duration and intensity of marine heatwaves events (MHW) (Fumo *et al.* 2020). In 2014 a large MHW event known as 'the Blob' persisted and combined with warming from the 2015-2016 el Niño to create one of the strongest and longest-lasting SST warming events on record (SCCOOS). Indeed, positive temperature anomalies persisted in to 2020.

Depth may not be a refugia from such events as glider data found that the temperature anomaly extended to more than 100m in the water column.

Lab studies have shown that for the sympatric species, *Z. marina*, plants exposed to elevated temperatures (7C above ambient) respond with significantly reduced growth, shoot density, productivity and biomass (Kim *et al.* 2019). The MHW event in Southern California produced long-lasting temperatures elevated 4C above ambient, but similar studies have not been done for *Z. pacifica* nor did the authors test a range of elevated temperatures. Our photos of eelgrass from 2016 clearly show a progression of yellowing in leaves that is more pronounced in September of that year. Yellowing can be related to loss of tissue and chlorophyll and is an indication of overall stress. It has been shown that depth may serve as a refugia (Aoki *et al.* 2020) for intertidal and shallow subtidal *Zostera marina* in Virginia USA, but whether that holds for our much deeper, subtidal *Z. pacifica* when confronted by longer lasting, more extreme MHW events remains unclear.

Implications for disease

Several years of sustained unusually warm water resulting in bleached and yellowish *Z. pacifica* leaves with black spots of disease increasing throughout the summer of 2016 (Plate # 10). Anacapa sites look particularly bad by September, with leaves cropped, black and decomposing. This condition was documented throughout all Santa Cruz major eelgrass meadows to a lesser degree.

As reviewed in Sullivan *et al.* (2017) the risk to seagrasses from disease may be amplified by stressors from climate change. However, the possibility of a genetic component to resiliency to warming waters (Franssen *et al.* 2011) cannot be overlooked, especially at the Channel Islands where large meadows of *Z. pacifica* have likely existed for many thousands of years since diverging from *Z. marina* (Coyer *et al* 2007).

Loss of Blue Carbon

Arias-Ortiz *et al.* (2018) found that 36% of the largest expanse of Australian seagrass meadows were damaged by a MWH event in 2010/2011, leading to potential massive losses of stored 'blue carbon' from the sediment. In Virginia, documented declines in seagrass density and extent as a result of marine heatwaves led to the loss of stored carbon (Aoki et al 2021). To date, there have been no sediment analyses done in or near eelgrass meadows at the Channel Islands, but the contribution of stored carbon by eelgrass could be significant.

Vulnerability to mass recruitment events

Following the 1982-83 el Niño, white urchins and brittlestars recruited to mid-depth rocky reefs around Anacapa and the eastern end of Santa Cruz. The white urchins also settled on sand, which led to eventual over-grazing of Anacapa eelgrass meadows in the late 1980s. In 1991, urchin density remained high at $60/m^2$ at Frenchy's even though the eelgrass was gone, but had declined to $0/ m^2$ by the time our restoration began in 2003. Since then, subsequent warm water events have led to migration or recruitment of warm-water invertebrates such as pelagic red crabs, white urchins and wavy turban snails. All three of these were observed at Anacapa in 2016. Size frequencies of white urchins in 2019 at Frenchy's revealed smaller urchins (compared with historic CIRP data), most likely resulting from the prior wave of recruitment 3-4 years before. Even though urchin densities were the highest at Frenchy's out of all of the 13 sites surveyed in 2019, their numbers were still quite low when compared to the densities that persisted following the late 1980s eelgrass over-grazing event. Other seagrass overgrazing events have been linked to persistent urchin densities greater than $>22/m^2$ (Rose *et al.* 1999). Recruitment to this area may be tied to small-scale very localized hydrology as white urchin numbers were extremely low only 200 meters away across the cove.

Recommendations and Conclusions

Science

The scope of the present study was extremely limited, but given the findings, additional work is both warranted and necessary to help resource managers prioritize future conservation measures.

- quantify the contribution of seagrass to carbon storage—perform sediment/CN grain size analysis for all eelgrass bed sites- old beds vs young beds;
- re-survey the 3 main beds at SCR plus ANA sites using detailed survey methods from CIRP 1994-97 cruises to quantify complete ecosystem function of restored beds, and whether main beds are still serving same role as 25 years ago—collect infauna/sediment cores, and perform detailed epifaunal survey at each site;
- primary production and biomass estimates;
- fish surveys in fall to capture recruitment events;
- C-14 analysis of fish and inverts in and out of eelgrass beds to quantify contribution.
- Using finding from this report, and from future work, identify island eelgrass meadows that provide most ecosystem benefit and those that are at highest risk from climate change.

Policy

We recommend specific actions that would have immediate and direct positive impact on eelgrass meadows.

1. **Re-classify the shallow soft-sediment bottom within the Frenchy's SMCA as SMR or No Entry (it is already a Special Closure 10 months out of the year).** Suitable habitat for eelgrass within Frenchy's Cove only exists within certain hydrodynamic and depth parameters (20'-45'), and over soft bottom not rock. This area historically sustained the largest eelgrass meadow at all of Anacapa Island. Our restoration work showed that eelgrass will rapidly colonize and thrive if anthropogenic disturbance (trapping) were to cease.

2. **Act to reduce damage from anchoring and mooring within eelgrass beds, particularly within SMRs (Scorpion).** This is surely the easiest and most cost-effective way to reduce anthropogenic disturbance, especially where it is as well documented as the eelgrass meadow within the Marine Protected Area at Scorpion.

3. **Use adaptive management to protect the meadows providing greatest ecosystem benefit and are at highest risk from climate change, and consider restoration in key locations that may provide refugia from a changing ocean environment.**

The majority of nearshore habitat around the northern Channel Islands is sandy, and yet only a small fraction of that can sustain persistent eelgrass meadows due to exposure, depth and sediment gain size/ nutrient content. Eelgrass meadows, like kelpbeds, provide a suite of functions that greatly enhance their value far past that factored only on sea floor extent. Our surveys show that island beds contribute food, shelter and habitat to fish and invertebrate species, this function has been stable over decades at the largest beds, and that restored beds (15+ years post restoration) are providing the same function at Anacapa. This study should serve as justification for more in-depth work to look at long-term food chain biodiversity, nutrient cycling, resiliency to changing climatic factors, and carbon storage. And, as eelgrass is universally valued as Essential Fish Habitat, every effort must be made to protect it both inside and outside of SMRs.

Acknowledgments

This work was made possible through grants by Resources Legacy Fund and Sea Forward Fund, in partnership with Channel Islands National Marine Sanctuary and the Casselle lab at UC Santa Barbara.

Much thanks to the many 2016 and 2019 field participants, including (in alphabetical order): Julie Bursek, Peter Carlson, Jake Eisaguirre, Lauren Enright, Claire Fackler, Andy Fredell, Ryan Freeman, Ivan Girling, Chris Honeyman, Cheyenne Jarmen, Katie Davis Koehn, Derek Lerma, Libby Mackie, Selena MacMillan, Chris Mobley, Zac Montgomery, Avrey Parsons-Field, Dan Richards, Pike Spector, Dave Witting.

Special thanks to Jill Murray for her help with statistical analyses and figure preparation, and to Mari Cajandig at Channel Islands National Marine Sanctuary for site map preparation.

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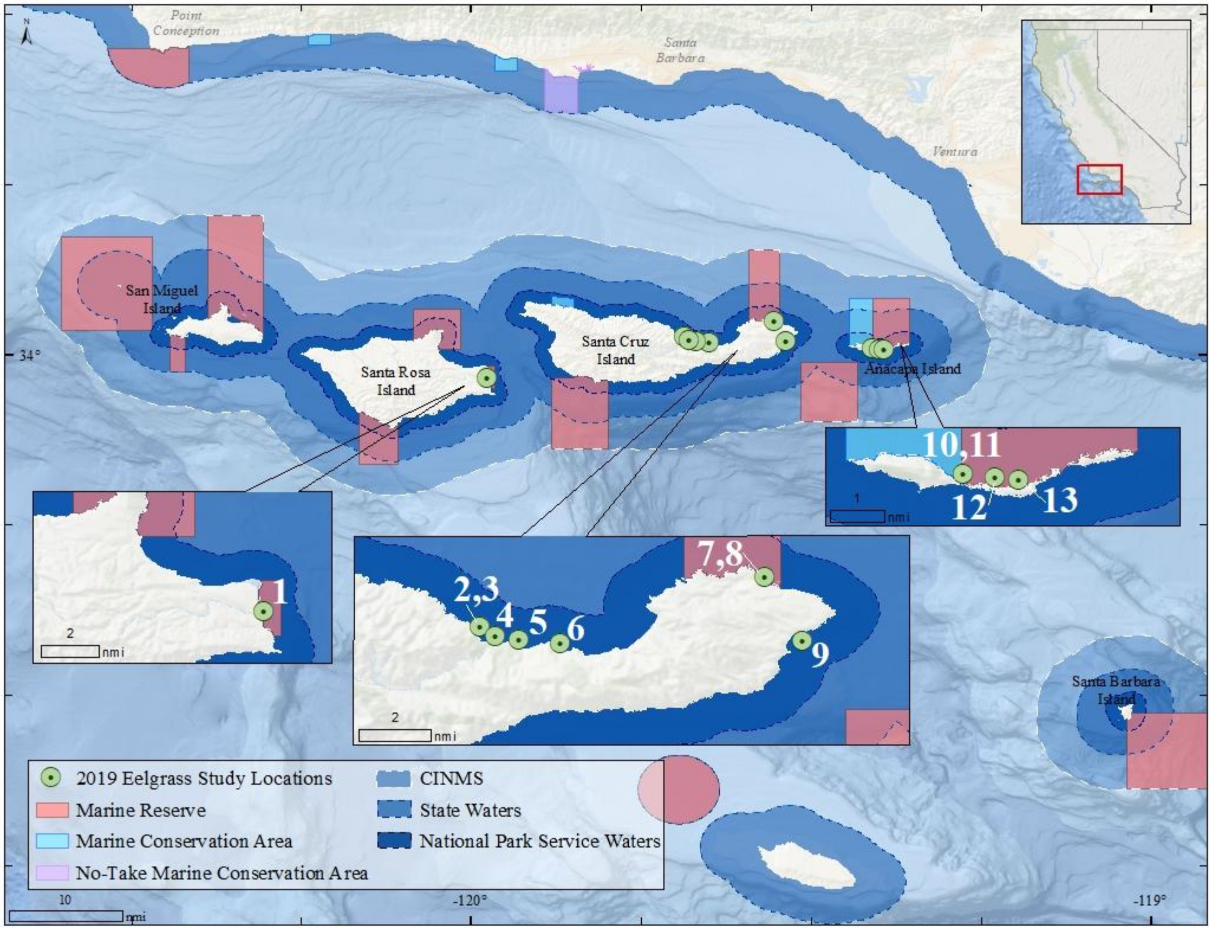
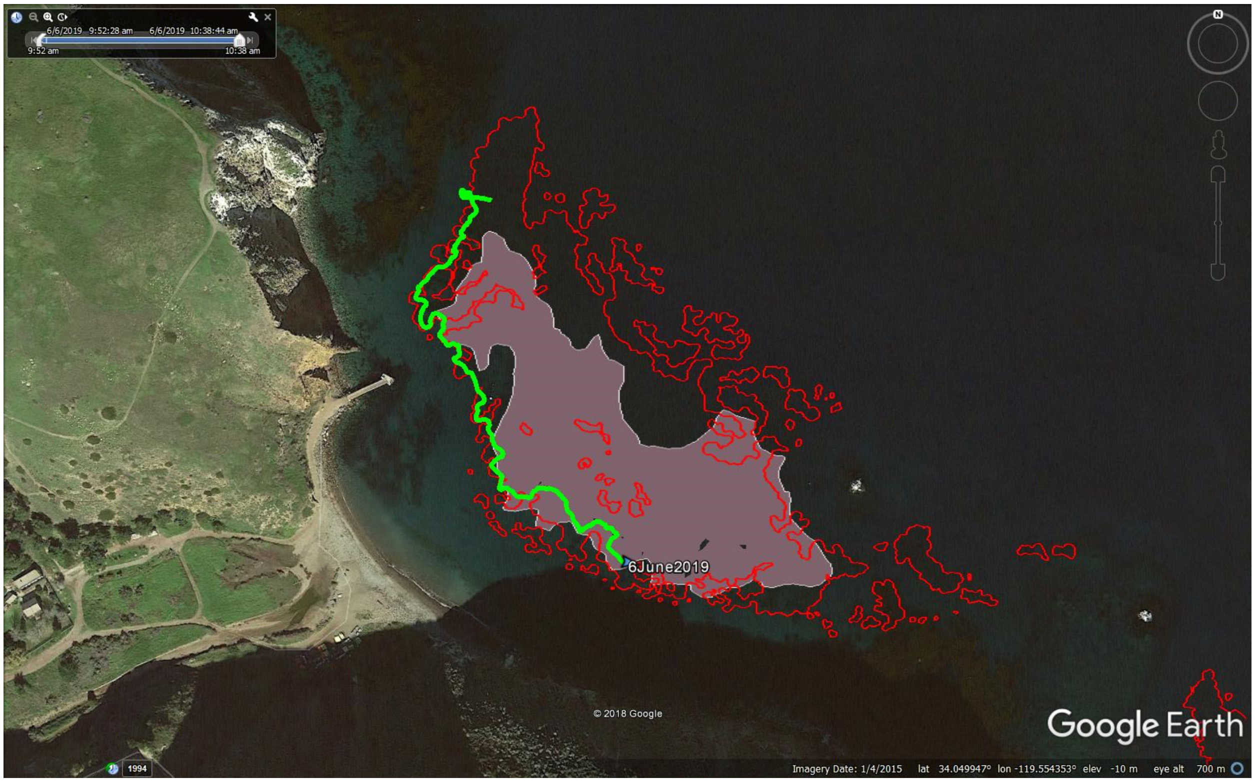


Figure 1. Location of study sites for 2019 eelgrass surveys. Sites are numbered 1-13 from west to east. Numbers refer (in order) to site names: Old Ranch SRO, Prisoners SCR, East Prisoners SCR, Eagle Canyon SCR, Cañada Agua SCR, Aguaje Escondido SCR, Scorpion SCR, East Scorpion SCR, Smugglers SCR, Frenchy's ANA, East Frenchy's ANA, Keyhole ANA, East NPS ANA. SRO= Santa Rosa, SCR= Santa Cruz, ANA= Anacapa. Other known locations of eelgrass not shown.



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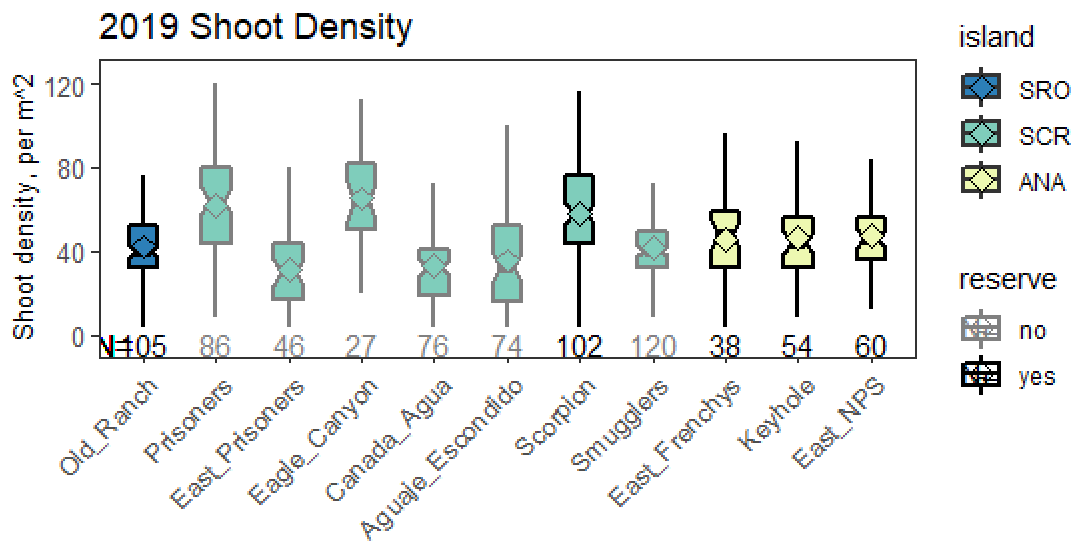

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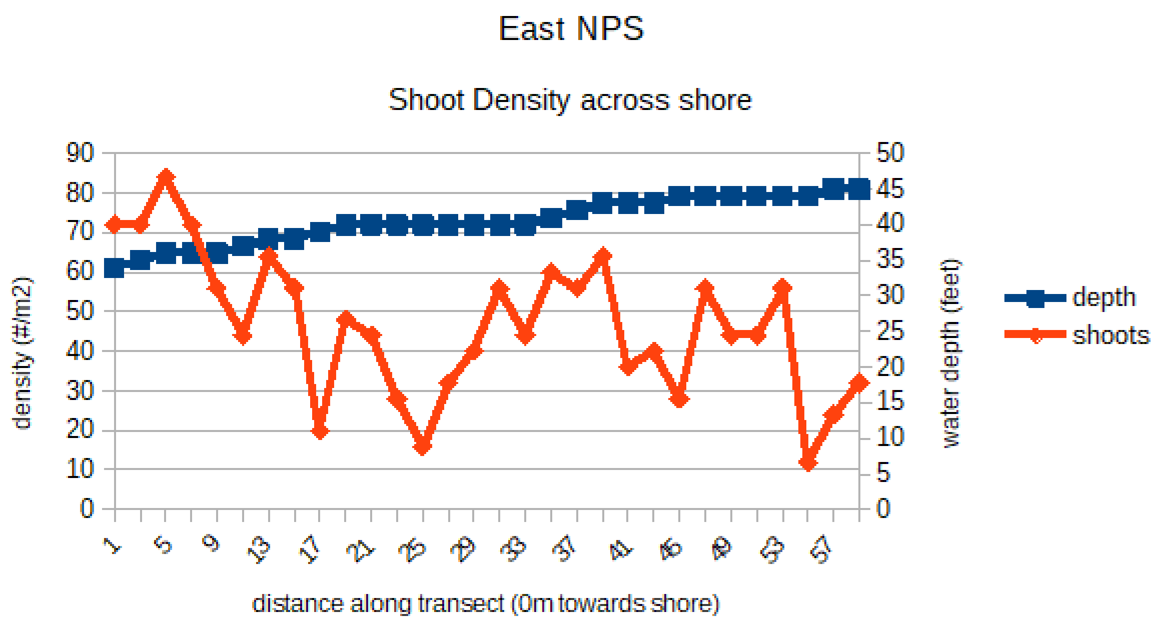

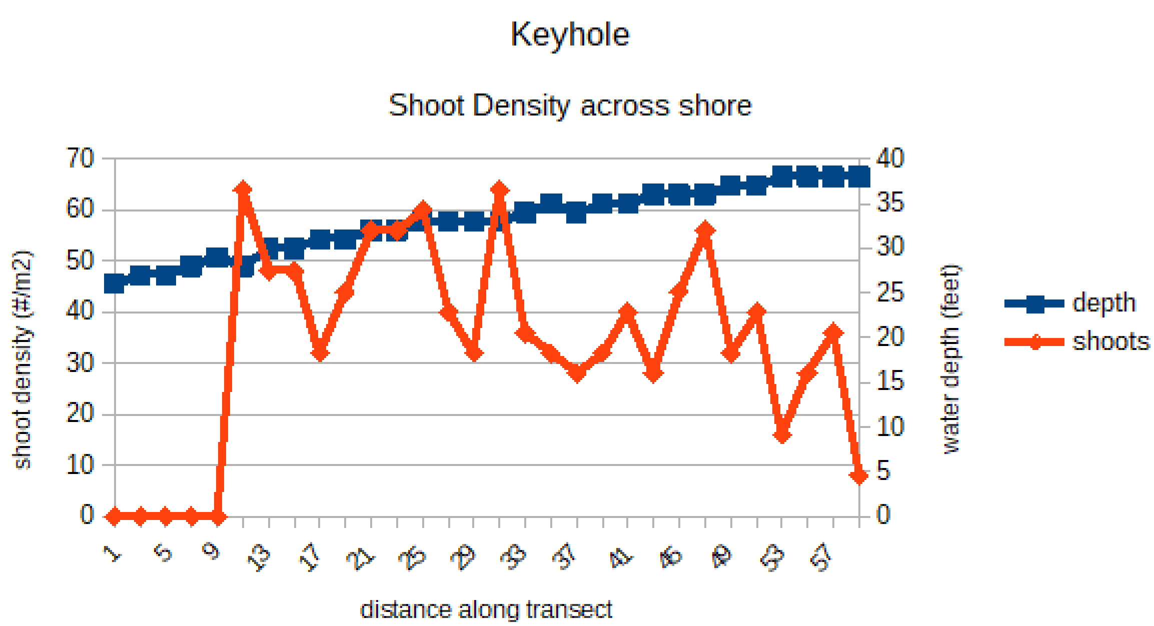

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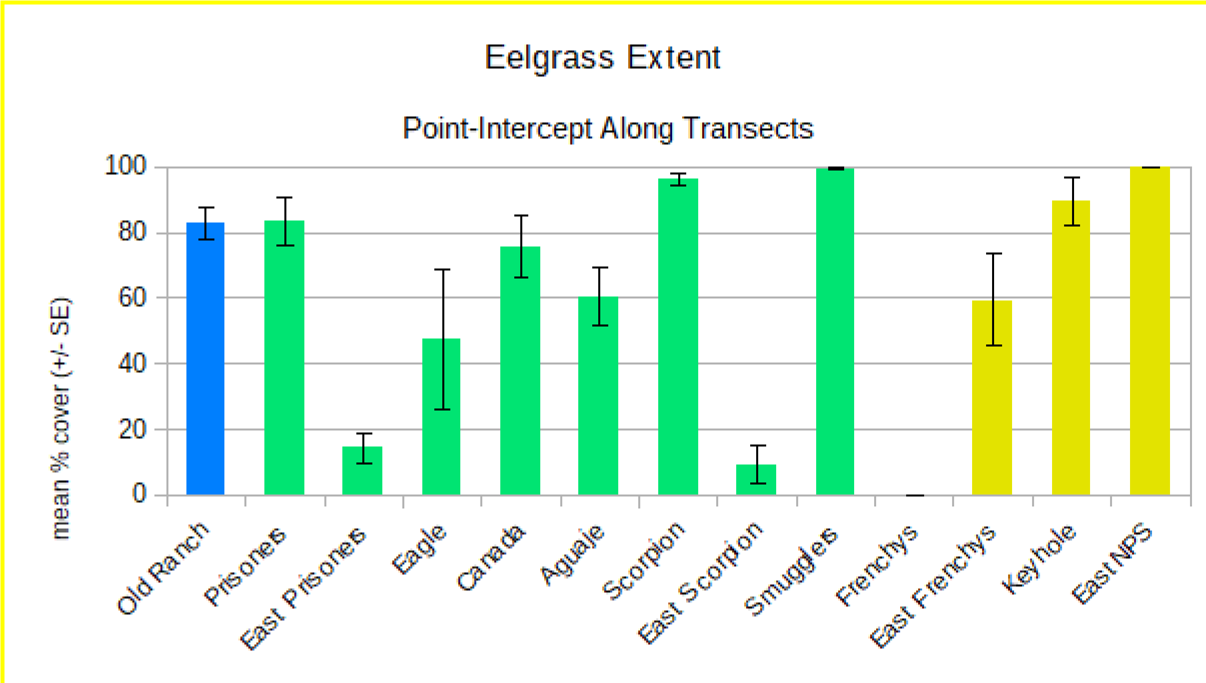

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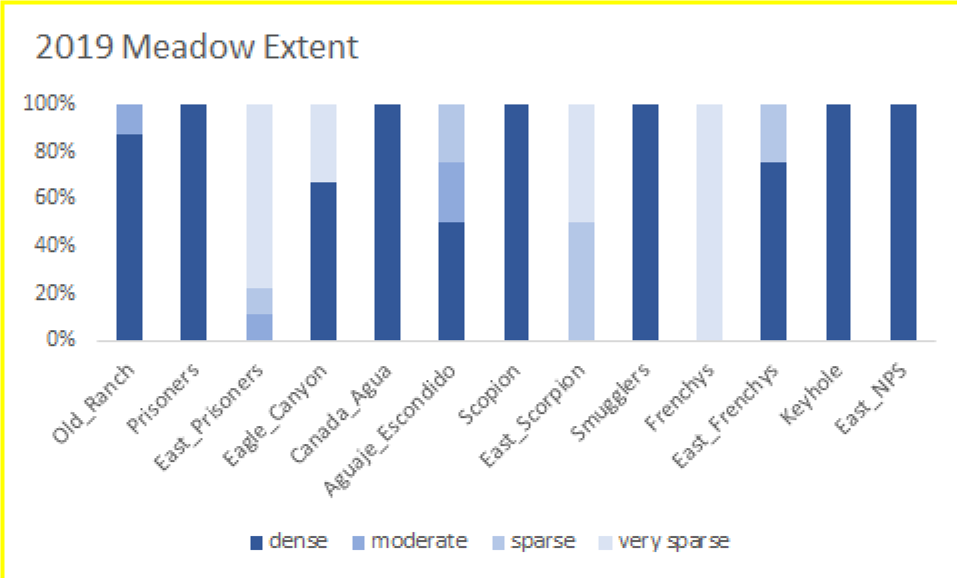


Figure 6. Eelgrass meadow extent as measured by point-intercept along core transects. Percent cover converted to density scale (Very Sparse= 0-10%, Sparse=10-40%, Moderate= 40-70%, Dense = 70-100%. Number of transects by site= 8,7,9,3,5,8,8,4,8,5,4,4,4.

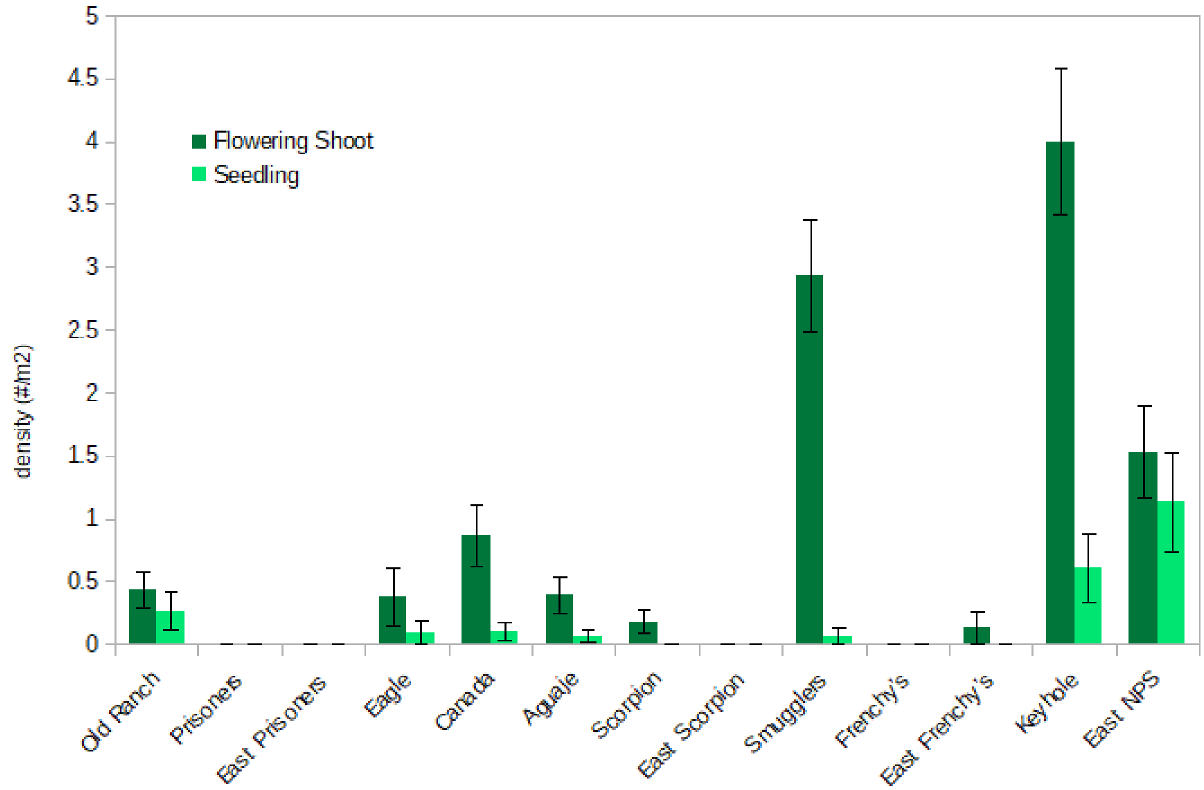


Figure 7. Density (means +/- standard error) of eelgrass flowering shoots and seedings from quadrat data.

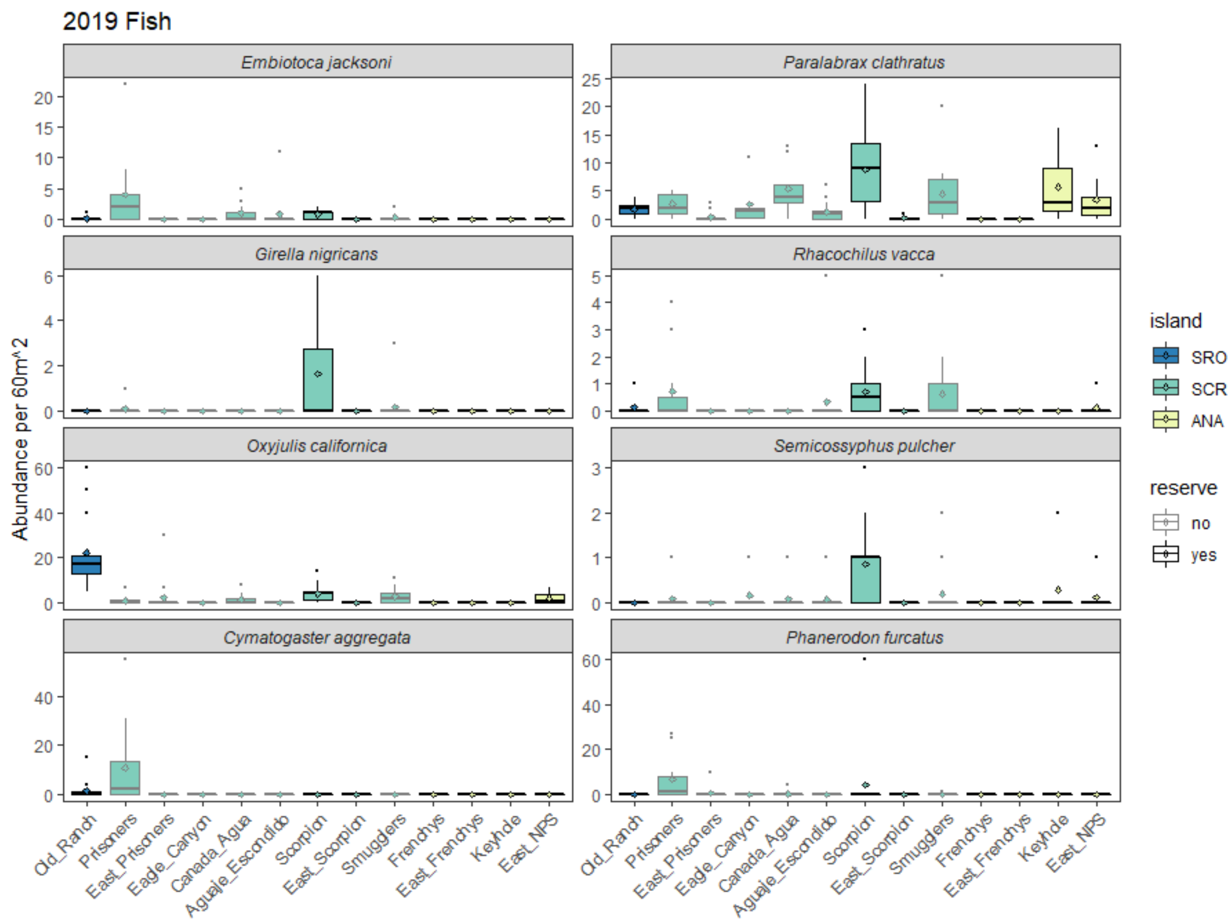


Figure 8. Fish abundance (per 60m^2) across sites for select taxa in 2019. Bars represent average value of band 60m^2 transects (core plus extra).

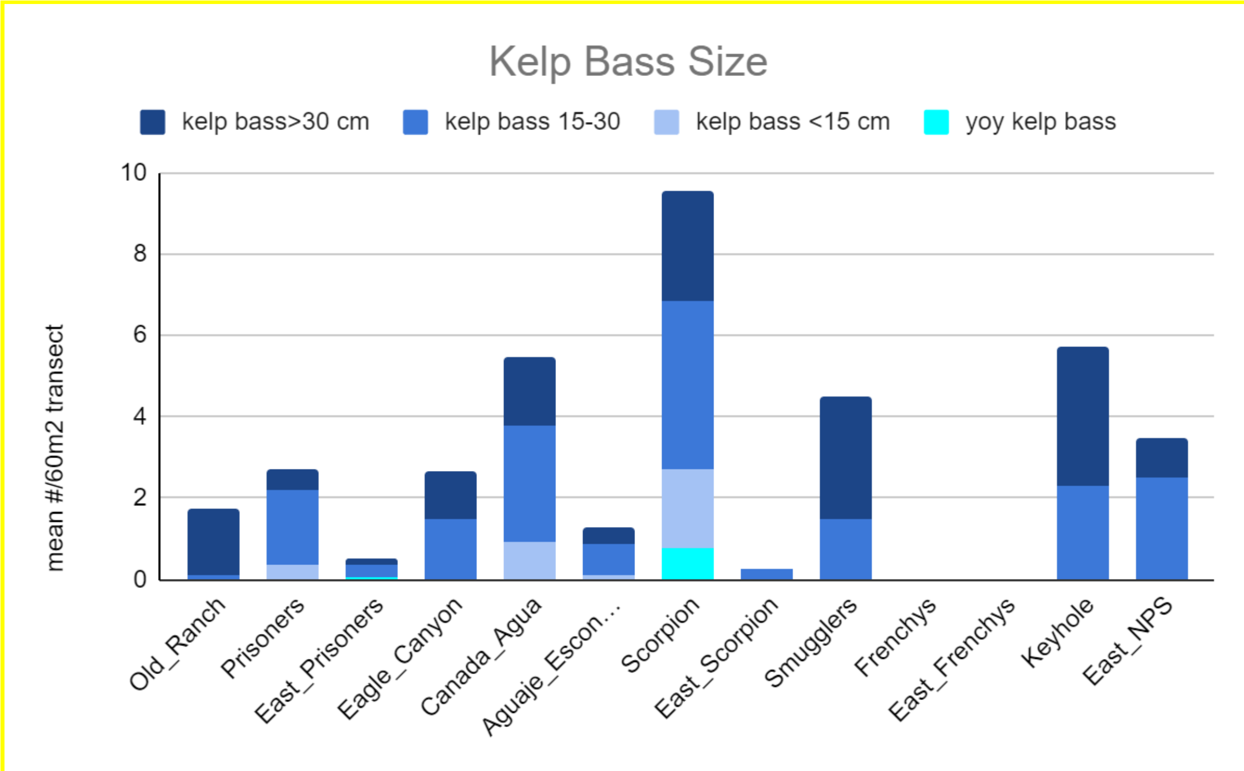


Figure 9. Density of kelp bass by four size classes at all 13 sites. Data are means of quantitative fish transects (core plus extra).

Site	Old_Ranch	Prisoners	Canada_Agua	Aguaje_Escondic	Scorpion	Smugglers	Frenchys	East_Frenchys	Keyhole	East_NPS
angel shark			0.60							1.00
barracuda				1.80	0.90					
bat ray			0.93	1.37	2.00					
black surfperch	1.00	3.00	1.96	1.03	2.00	3.00		1.47	1.10	1.27
blackeye goby							0.70			
blacksmith								1.80		
c-o turbot								1.00	0.90	0.70
fantail sole	0.70									
giant kelpfish		2.53	1.93	2.03	0.50			1.20	1.33	
giant sea bass									0.80	
giant seabass									1.60	
halfmoon			2.05	1.60		0.80		1.80	0.60	1.50
halibut							1.00		1.05	1.20
horn shark		0.50		0.60				0.95		
jack mackerel				2.85						2.60
kelp bass	3.00	3.00	3.20	3.20	3.00	2.90	2.00	2.53	3.50	3.22
leopard shark		1.25	1.80	1.28				0.55		
ocean whitefish					1.00				0.70	
opaleye		1.60	2.10	0.60	1.80	2.00		1.60	0.95	1.30
pile perch	2.00	1.80	2.50	0.85	2.00	1.53		1.20	1.65	1.03
rainbow surfperc	2.00					3.00				
rock wrasse		1.00	1.60	1.87	2.00	1.53		1.80	1.55	1.77
rubberlip seaperch			1.60							
salema		2.00								
sand dab							1.80			
sarcastic fringehead							0.00			
sargo					0.60					
senorita	3.00	1.30	1.80	1.67	3.00	4.00		1.00	3.00	3.00
sheephead			0.70	1.40	2.50	1.17		1.80	1.59	1.12
shiner surfperch	3.00	4.00	0.70	1.50	3.60					1.30
topsmelt		3.00			2.70					
tube-snout	0.80			1.00		2.40				
white surfperch		3.00	1.85	1.90	2.70					
yellowtail							2			

Figure 10. Roving Diver Fish Surveys summarized for all sites surveyed by the Average Fish Abundance Index (0-4, with 4 as the most common and seen earliest in the dive). Details are in text.

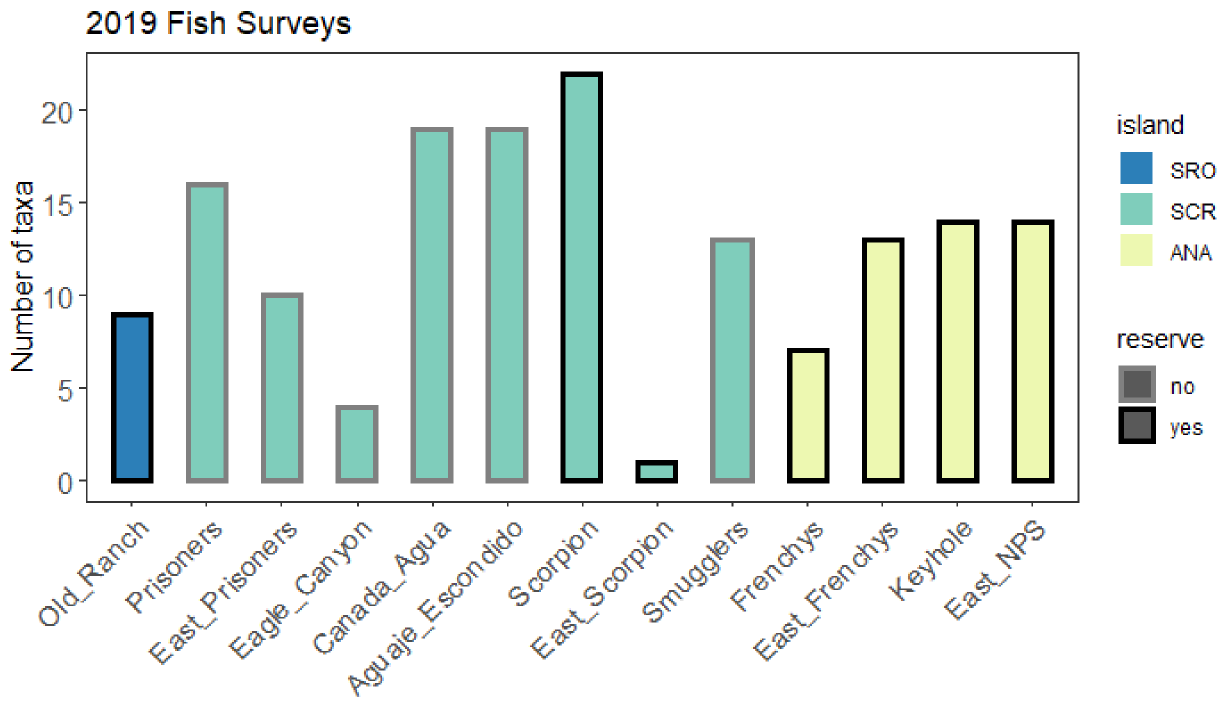


Figure 11. Total Fish Species Richness. Data are for the total number of fish taxa observed at each site (combination of quantitative transects, Roving Diver, and other observations during surveys).

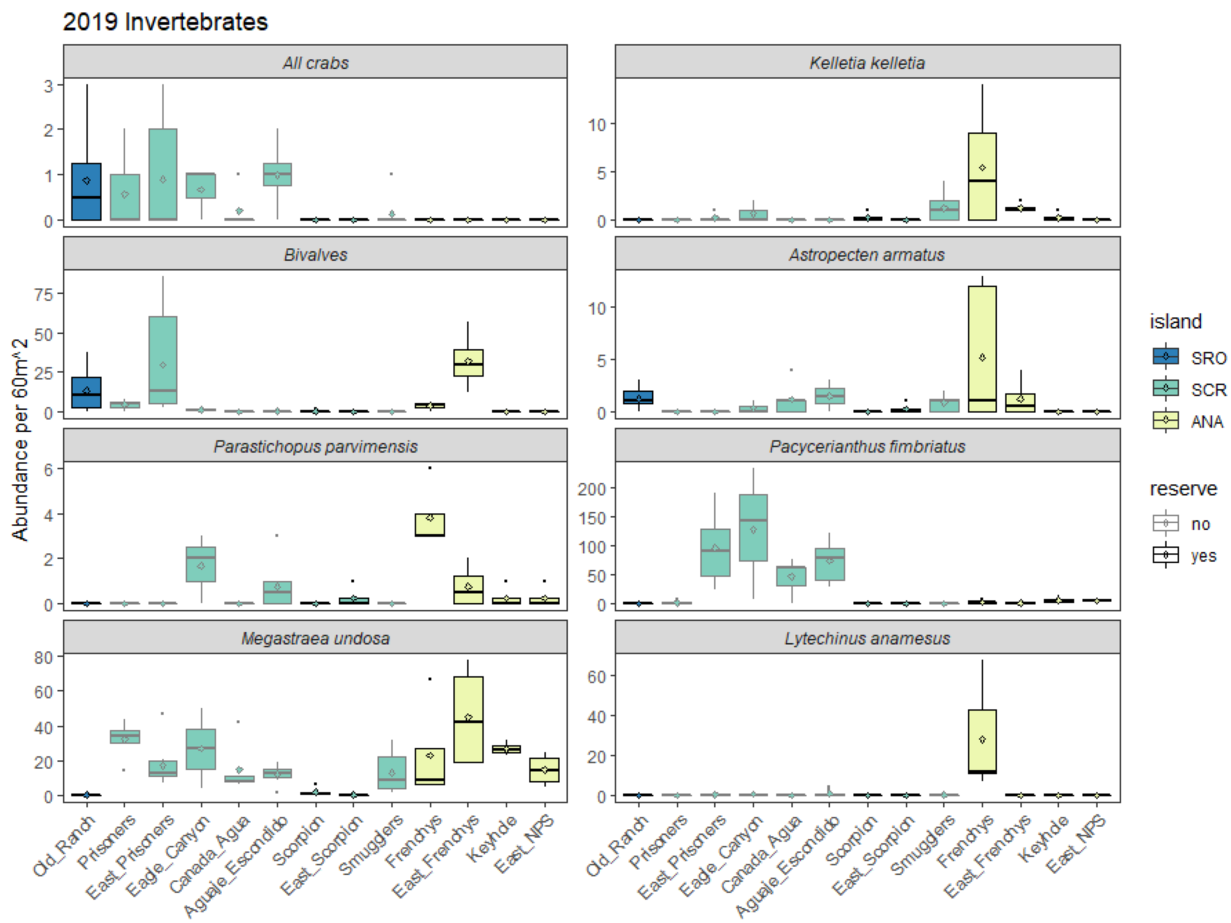


Figure 12. Invertebrate abundance (per 60m^2) across sites for select taxa in 2019. Bars represent average value of (n=3-15) band 60m^2 transects.

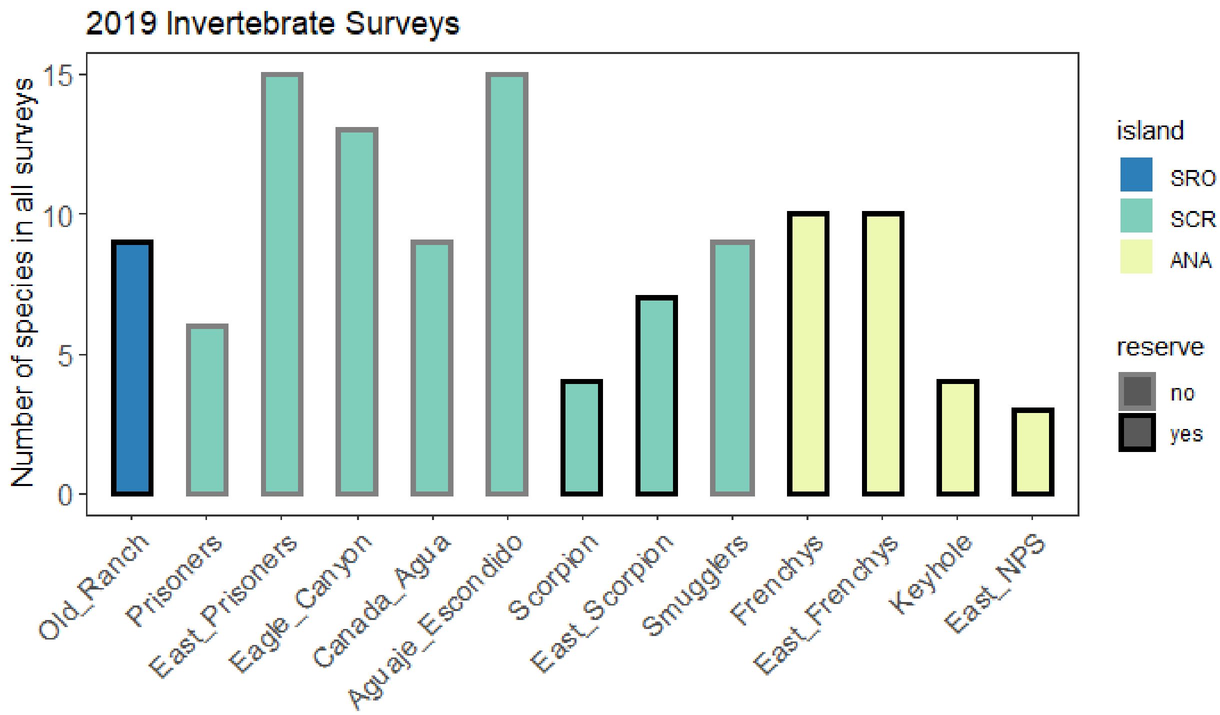


Figure 13. Total Invertebrate Species Richness. Data are for the total number of invertebrate taxa observed at each site along band transects.

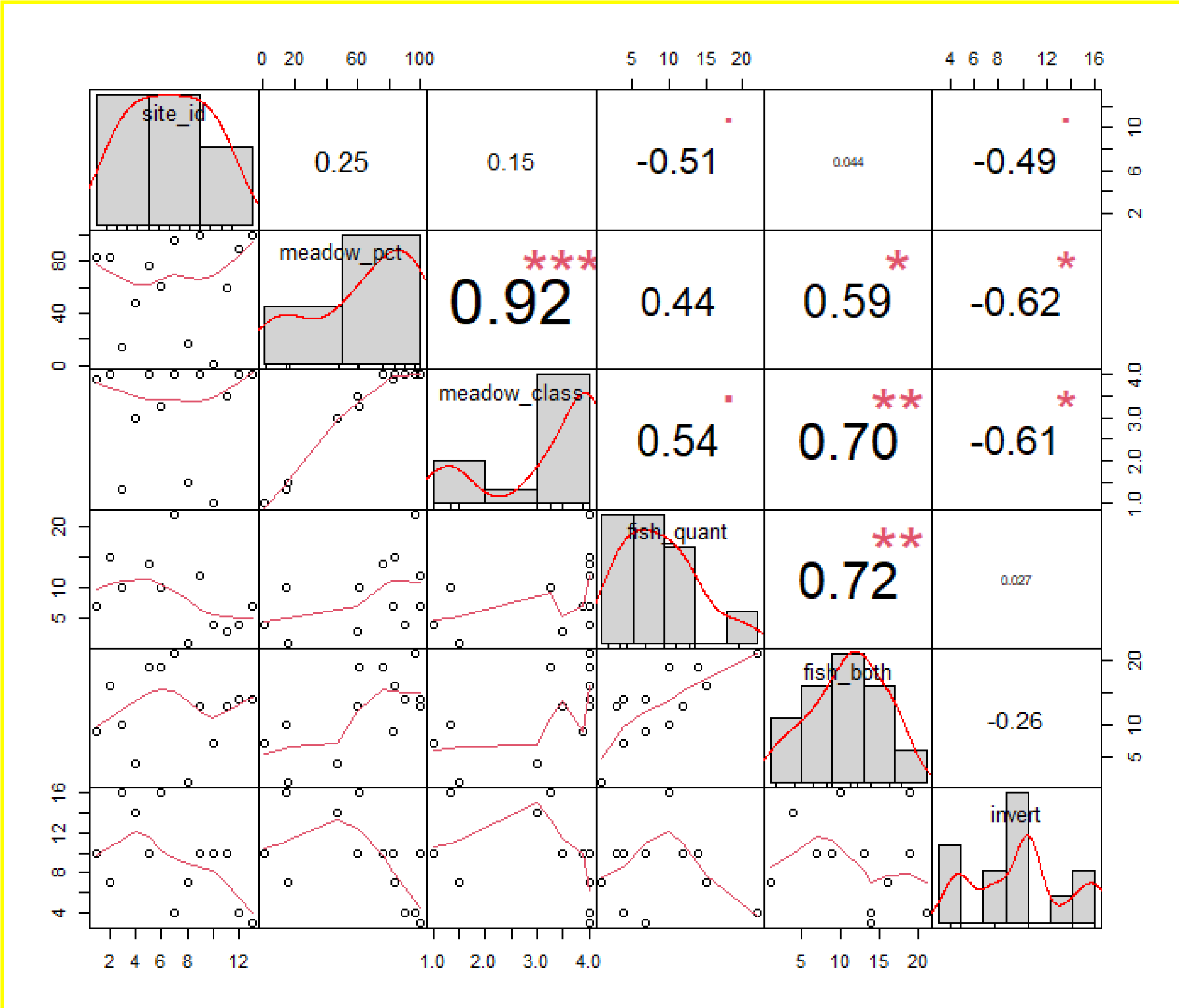


Figure 14. Correlation matrix of meadow extent, fish richness, and invertebrate richness in 2019. Spearman's rank correlation computed due to non-normal distributions and small sample sizes. ***, p<0.001; ** p<0.01; *,p<0.05;• <0.1). Red lines represent smoothing of raw data and histograms. Font size in upper panels relates to correlation strength.

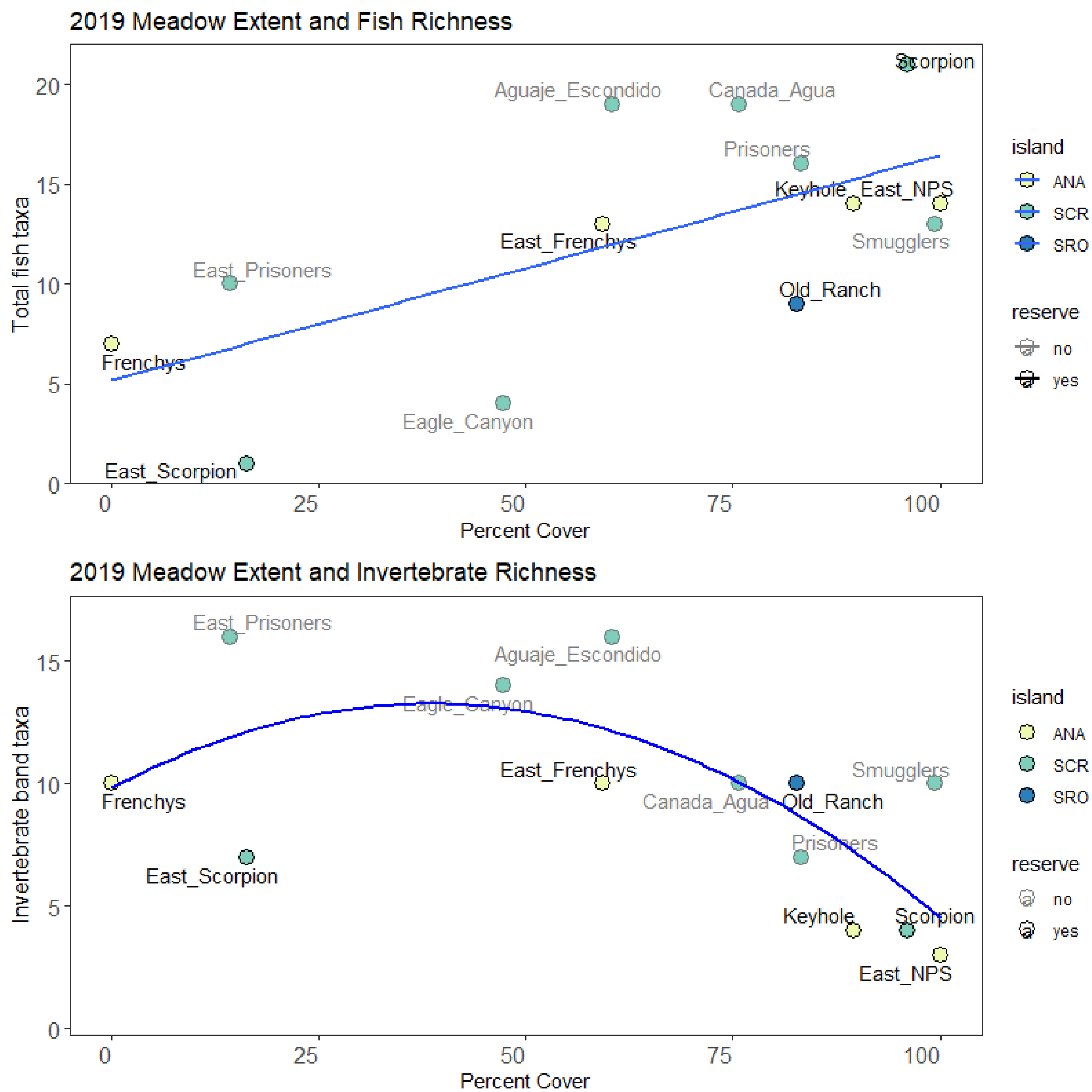


Figure 15. Species richness as a function of eelgrass meadow extent in 2019. Each data point represents averages for each site. Taxa data are total species richness, percent cover data are from point intercept data along transects. Top panel: fish species richness for band and roving diver transects. Line shows fitted linear regression (r^2=0.42, p=0.01). Bottom panel: invertebrate species richness for band transects. Line represents fitted second order polynomial regression (r^2=0.49, p=0.03), which explains more variance than a linear regression (r^2=0.26, p=0.07).

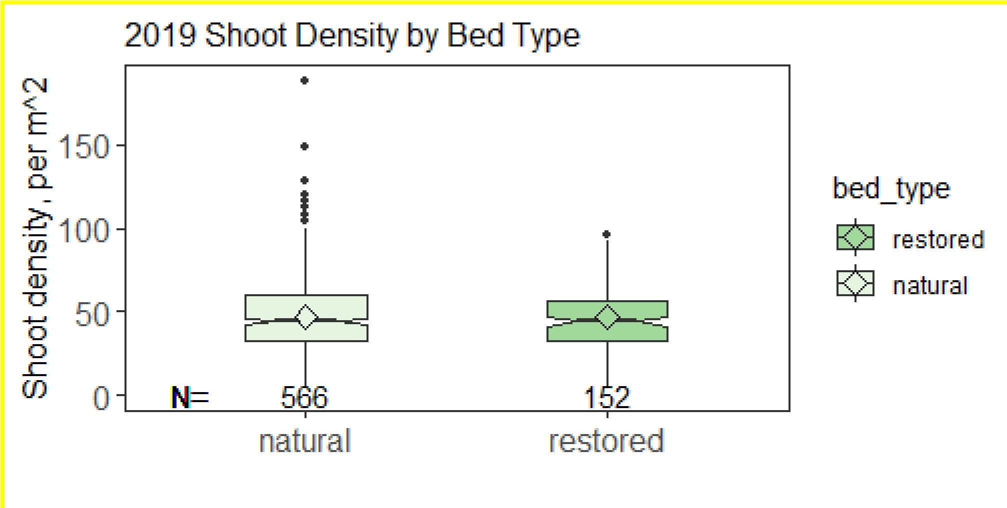


Figure 16. Comparison of shoot density in natural vs restored beds in 2019. Bed types are not significantly different based on overlap of 95% confidence interval around the median.

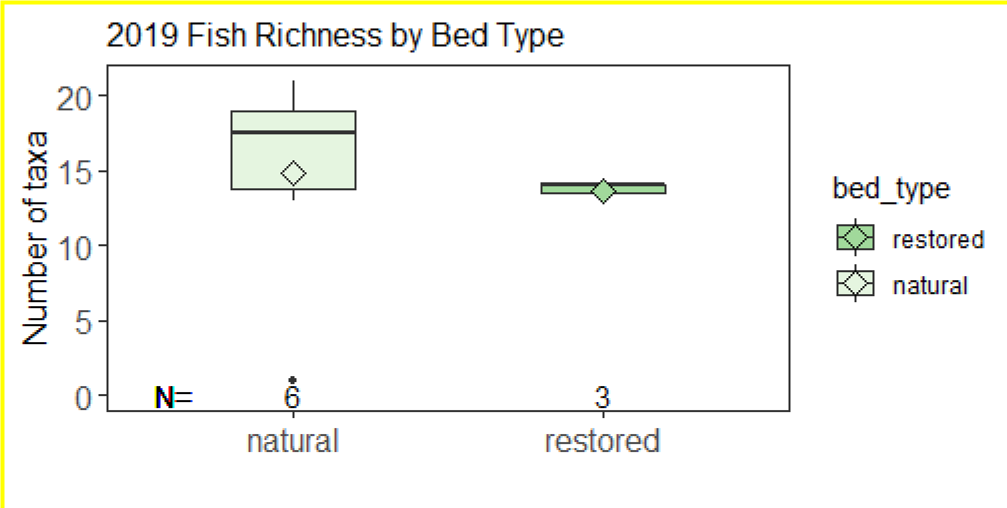


Figure 17. Comparison of fish richness in natural vs restored beds in 2019. Bed types are not significantly different (Kruskal-Wallace test, p=0.54). N is the number of sites in each category. Averages are the same, greater range for natural.

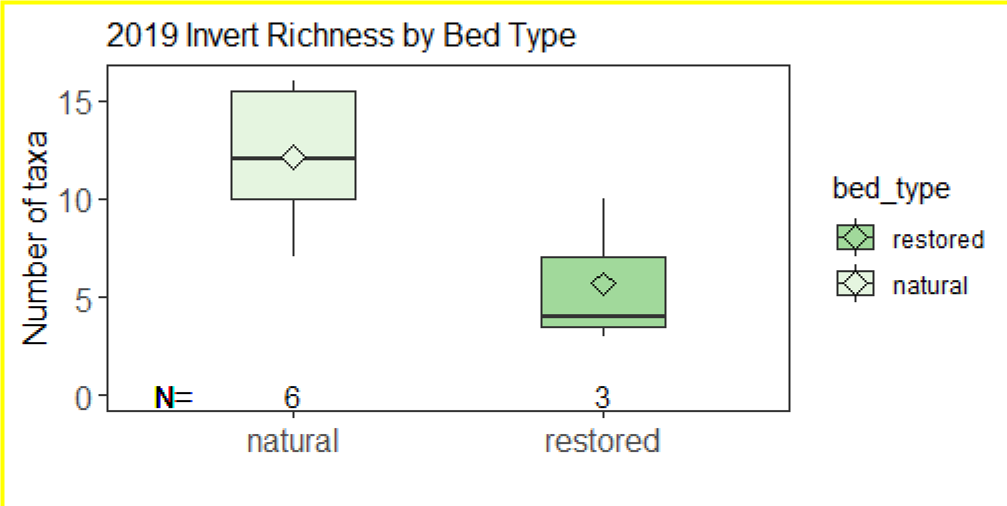


Figure 18. Comparison of invertebrate richness in natural vs restored beds in 2019. Bed types are not significantly different (Kruskal-Wallace test, p=0.40). N is the number of sites in each category.

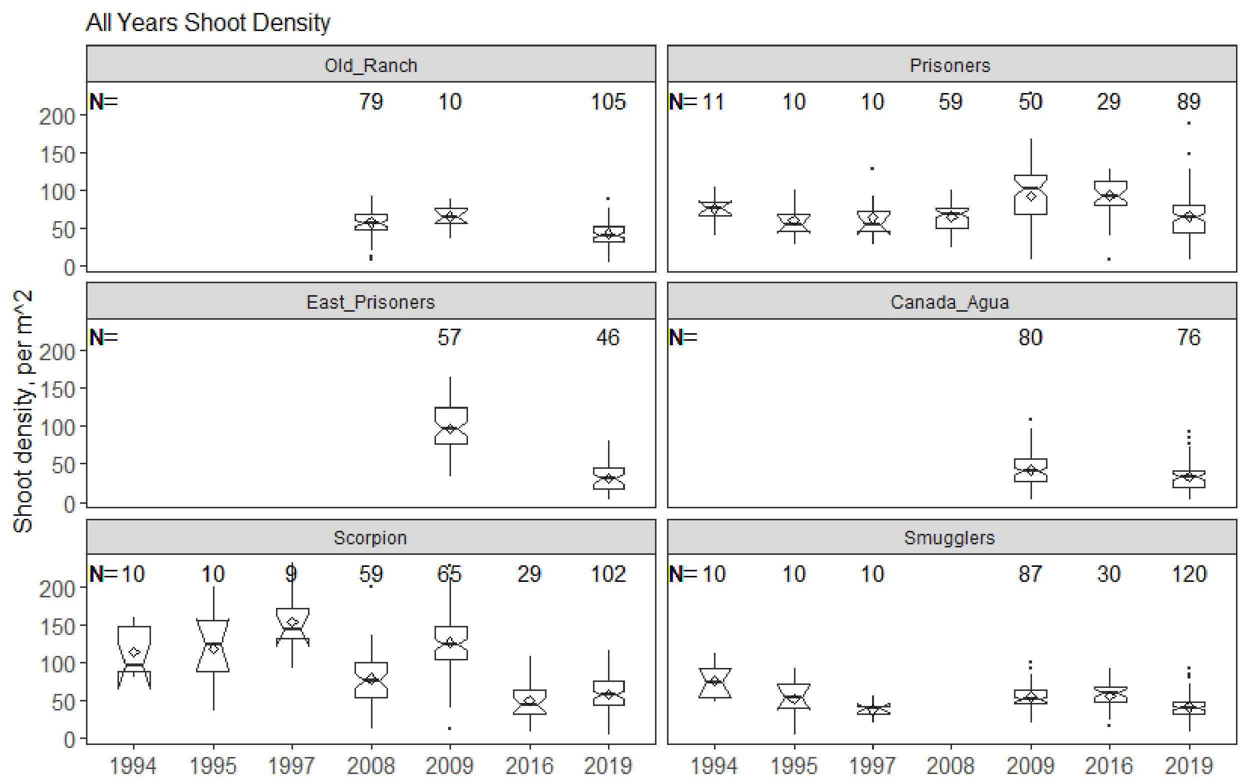


Figure 19. Boxplots of shoot density in quadrats with eelgrass present for sampled years, for select sites. N refers to the number of quadrats with eelgrass per year. For each year: box shows the interquartile range, whiskers represent the upper and lower quartiles, horizontal line represents the median, the diamond marks the mean, dots represent outliers, and notches ascribe the 95% confidence interval of the median.

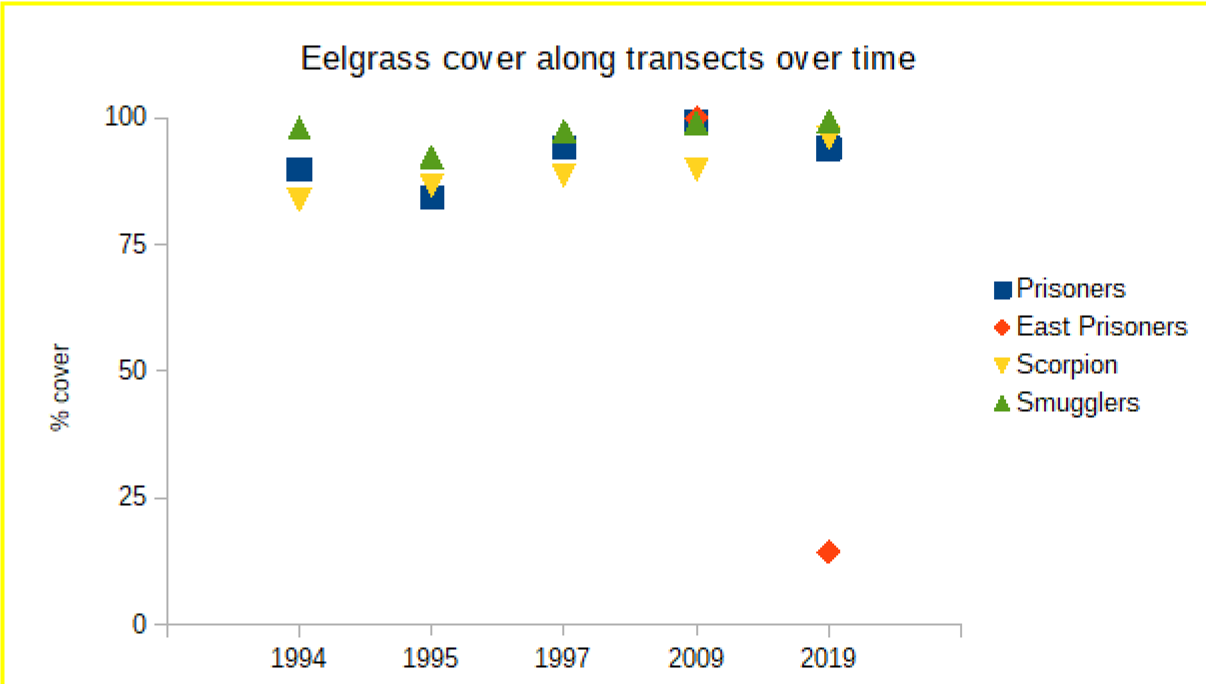


Figure 20. Eelgrass cover along transects at four Santa Cruz Island sites. East Prisoners not sampled in 1994, 1995, and 1997.

Table 1. Channel Islands Eelgrass Meadows 2019 Survey Sites

Site_name	site_id	Island	General Coordinates	Date Surveyed
Old_Ranch	1	SRO	34.96351 -119.97329	20190624
Prisoners	2	SCR	34.02090 -119.68586	20190424, 20190724
East_Prisoners	3	SCR	34.02087 -119.68201	20190424, 20190509
Eagle_Canyon	4	SCR	34.02033 -119.67372	20190509
Canada_Agua	5	SCR	34.01807 -119.66876	20190606, 20190626, 20190724
Aguaje_Escondido	6	SCR	34.01783 -119.64918	20190606, 20190626, 20190724
Scorpion	7	SCR	34.04970 -119.55496	20190514, 20190606, 20190727
East_Scorpion	8	SCR	34.04772 -119.54955	20190514
Smugglers	9	SCR	34.02076 -119.53563	20190625
Frenchys	10	ANA	34.00918 -119.41086	20190523, 20190620
East_Frenchys	11	ANA	34.00763 -119.40873	20190523, 20190620
Keyhole	12	ANA	34.00736 -119.39976	20190524, 20190620
East_NPS	13	ANA	34.00796 -119.39227	20190524, 20190626

Table 2. Channel Islands Eelgrass Meadows 2016 Survey Sites

Site_name	site_id	Island	General Coordinates	Date Surveyed
Prisoners	2	SCR	34.02090 -119.68586	20160808
Scorpion	7	SCR	34.04970 -119.55496	20160808
Smugglers	9	SCR	34.02076 -119.53563	20160808, 20160929
Yellowbanks		SCR		20160808
Frenchys	10	ANA	34.00918 -119.41086	20160624, 20160929*
East_Frenchys	11	ANA	34.00763 -119.40873	20160701, 20160929*
Keyhole	12	ANA	34.00736 -119.39976	20160920*, 20160628*
East_NPS	13	ANA	34.00796 -119.39227	20160920*, 20160628*
Cathedral Cove		ANA		20160920*

Table 4. 2019 fish transect summary data

2019 Fish Band Transects

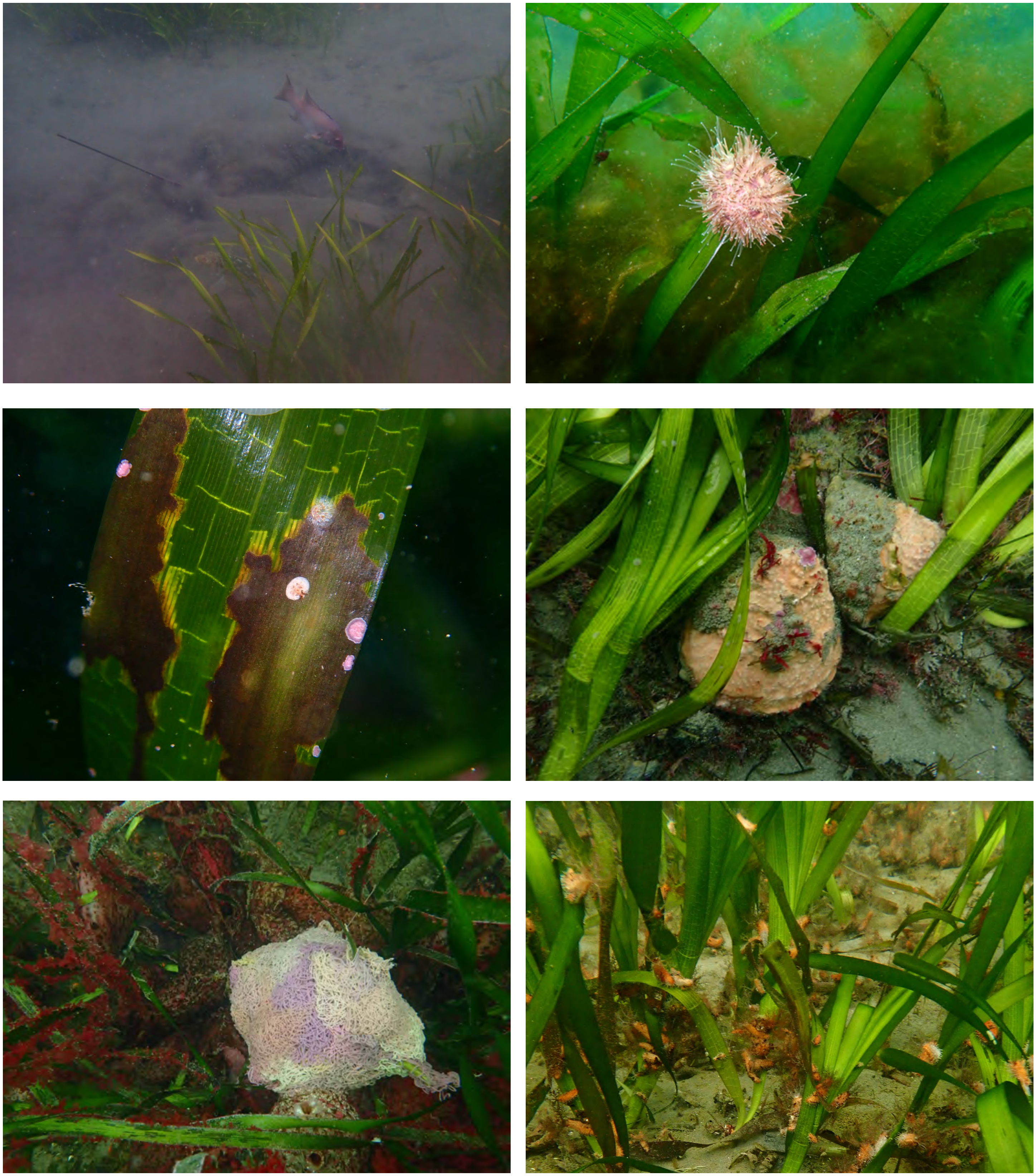
				Abundance per 60 m^2												
Scientific name	common name	Num Sites Present	Avg Abund	Old_Ranch	Prisoners	East_Prisoners	Eagle_Canyon	Canada_Agua	Aguaje_Escondid	Scopion	East_Scorpion	Smugglers	Frenchys	East_Frenchys	Keyhole	East_NPS
Paralabrax clathratus	kelpbass	11	3.2	1.7	2.7	0.4	2.7	5.5	1.3	8.8	0.3	4.5	0.0	0.0	5.7	3.5
Paralabrax clathratus YOY	kelp bass yoy	2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Oxyjulis californica	senorita	7	3.8	22.1	0.9	2.3	0.0	1.4	0.0	4.1	0.0	2.8	0.0	0.0	0.0	2.0
Oxyjulis californica YOY	senorita yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halichoeres semicinctus	rock wrasse	6	0.3	0.0	0.3	0.0	0.0	0.4	0.2	0.8	0.0	0.1	0.0	0.0	0.0	1.9
Embiotoca jacksoni	black perch	6	0.6	0.1	4.0	0.0	0.0	1.0	0.8	0.8	0.0	0.3	0.0	0.0	0.0	0.0
Embiotoca jacksoni YOY	black perch yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhacochilus vacca	pile perch	6	0.3	0.1	0.7	0.0	0.0	0.0	0.3	0.7	0.0	0.6	0.0	0.0	0.0	0.1
Rhacochilus vacca YOY	pile perch yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypsurus caryi	rainbow perch	2	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Hypsurus caryi YOY	rainbow perch yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhacochilus toxotes	rubberlip perch	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Cymatogaster aggregata	shiner perch	2	1.1	1.5	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phanerodon furcatus	white perch	5	1.0	0.0	6.1	0.6	0.0	0.3	0.0	4.3	0.0	0.1	0.0	0.0	0.0	0.0
Phanerodon furcatus	white perch yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sebastes sp. YOY	yoy rockfish UNID	1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myliobatis californica	bat ray	4	0.1	0.3	0.0	0.1	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Girella nigricans	opaleye	3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	1.6	0.0	0.2	0.0	0.0	0.0	0.0
Semicossyphus pulcher	sheephead F	7	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.6	0.0	0.2	0.0	0.0	0.3	0.1
Semicossyphus pulcher	sheephead M	2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Semicossyphus pulcher	sheephead all	8	0.2	0.0	0.1	0.0	0.2	0.1	0.1	0.9	0.0	0.2	0.0	0.0	0.3	0.1
Heterostichus rostratus	giant kelpfish	5	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0
Heterostichus rostratus	YOY giant kelpfish	6	1.6	0.0	7.5	0.4	0.0	2.8	0.3	0.0	0.0	1.0	0.0	11.7	0.0	0.0
Aulorhynchus flavidus	tubesnout	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhinogobiops nicholsii	black eye goby	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Rhinogobiops nicholsii	black eye goby yoy	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Chaenopsis alepidota	Orange-throat	3	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
Medialuna californiensis	halfmoon	4	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.7	0.0	0.0	0.0	0.0	0.1	0.1
Paralichthys californicus	halibut	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Synodus lucioceps	lizardfish	1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
flatfish unid	flatfish unid	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Trachurus symmetricus	jack mackerel	2	2.2	0.0	0.0	0.0	0.0	15.4	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0
Atherinops affinis	top smelt	3	1.4	0.0	6.4	0.0	0.0	5.8	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
Sphyraena argentea	barracuda	3	1.3	0.0	0.0	2.2	0.0	1.5	0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0
Atractoscion nobilis	white seabass	1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anisotremus davidsonii	Sargo	1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Caulolatilus princeps	ocean whitefish	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Triakis semifasciata	leopard shark	3	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scorpaena guttata	CA scorpionfish	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Heterodontus francisci	Hornshark	3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.2	0.0	0.0
Leiocottus hirundo	lavender sculpin	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Pleuronichthys coenosus	CO turbot	1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Citharichthys stigmaeus	sanddab	3	0.1	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Gymnothorax mordax	moray eel	1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neoclinus blanchardi	sarcastic fringehead	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Sebastes rastrelliger	grass rockfish	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brachyistius frenatus	kelp perch	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyperprosopon argenteum	walleye perch	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Embiotoca lateralis	striped perch	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sebastes serranoides YOY	olive rockfish yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Squatina californica	angel shark	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scorpaenichthys	cabezon	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sardinops sagax	sardines	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sebastes serranoides	olive rockfish	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sebastes paucispinis YOY	boccacio yoy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5. 2019 Invertebrate summary data.

Table. Invertebrate abundance in 2019 surveyes.

Scientific name	common name	Num Sites Present	Avg Abund	Old_Ranch	Prisoners	East_Prisoners	Eagle_Canyon	Canada_Agua	Aguaje_Escondido	Scorpion	East_Scorpion	Smugglers	Frenchys	East_Frenchys	Keyhole	East_NPS
				Abundance per 60 m^2												
Anthopluera sola	solitary anemone	1	0.002	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pacycerianthus fimbriatus	tube_anemone	11	7.236	0.1	2.0	96.1	128	47	74	0.0	0.3	0.0	2.4	1.0	5.5	5.0
Renilla koellikeri	sea_pansy	5	0.152	0.0	0.0	0.0	2.7	0.2	2.5	0.0	1.8	0.5	0.0	0.0	0.0	0.0
Phyllactis sp	sand_anemone	2	0.023	0.0	0.0	0.0	0.7	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stylatula elongata	sea_pen	6	0.073	0.0	0.0	0.0	1.0	0.2	0.6	0.0	0.3	0.4	1.2	0.0	0.0	0.0
Eudistyla sp	feather duster worm	1	0.003	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bivalves	misc_bivalves	8	1.652	13.4	2.6	29.7	1.0	0.0	0.1	0.3	0.0	0.0	3.6	32.0	0.0	0.0
Megastraea undosa	wavy_turban_snail	13	4.570	0.1	32.3	17.3	27.0	15.0	12.3	1.8	0.3	13.0	23.0	45.0	26.8	14.8
Aplysia californica	sea_hare	3	0.022	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Kelletia kelletia	kellet_whelk	7	0.186	0.0	0.0	0.2	0.7	0.0	0.0	0.3	0.0	1.3	5.4	1.3	0.3	0.0
Bula/Haminoea	bubble_snail	1	0.284	0.0	0.0	14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neverita lewisii	moon_snail	3	0.015	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Pluerobranchus sp	Pluerobranchus sp	1	0.020	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navanax inermis	Navanax inermis	4	0.063	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.3	0.0	1.0	1.0	0.0	0.0
Rixtaxis	snail	1	0.033	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Octopus sp	octopus	1	0.005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Norrisia norrisii	kelp_snail	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conus californicus	cone_snail	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crossata californica	California frog shell	1	0.003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
other_snail	other_snail	1	0.004	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loxorhynchos grandis	sheep_crab	2	0.005	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cancer sp.	cancer_crab	3	0.020	0.5	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Portunus xantusii	swimming_crab	1	0.002	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pagurus/Paguristes	hermit_crab	6	0.042	0.0	0.3	0.8	0.3	0.2	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Pugettia/Taliepus	kelp_crab	2	0.005	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heterocrypta occidentalis	elbow_crab	1	0.008	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cancer gracilis	slender_crab	1	0.005	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Panulirus interruptus	lobster	1	0.004	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Randallia ornata	globe_crab	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
unid crab	other_crab	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
all_crabs	all_crabs	7	0.087	0.9	0.6	0.9	0.7	0.2	1.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Phoronida	phoronid	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Parastichopus parvimensis	sea_cucumber	7	0.154	0.0	0.0	0.0	1.7	0.0	0.8	0.0	0.3	0.0	3.8	0.8	0.3	0.3
Astropecten armatus	sand_star	8	0.237	1.3	0.0	0.0	0.3	1.2	1.5	0.0	0.3	0.9	5.2	1.3	0.0	0.0
Pisaster sp.	giant-spined sea star	1	0.005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Dendraster excentricus	sand dollar	1	0.009	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arbacia stellata	Arbacia urchin	1	0.004	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lytechinus anamesus	white_urchin	5	0.608	0.0	0.0	0.6	0.7	0.0	0.9	0.0	0.0	0.1	28.2	0.0	0.0	0.0
Strongylocentrotus franciscanus	red_urchin	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strongylocentrotus purpuratus	purple_urchin	1	0.002	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patiria miniata	bat_star	3	0.039	1.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0
unidentified cucumber	unidentified cucumber	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Luidia foliolata	deep sand star	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pycnopodia	sunflower_star	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pachythione rubra	small red cucumber	0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Anthropogenic disturbances to eelgrass. CW from UL: Mooring anchor and chain in 2016 and 2019 (Scorpion SCR); small vessel anchor (East NPS ANA); debris from land (Scorpion SCR); fishing gear (Frenchys ANA); sunken vessel (Keyhole ANA).

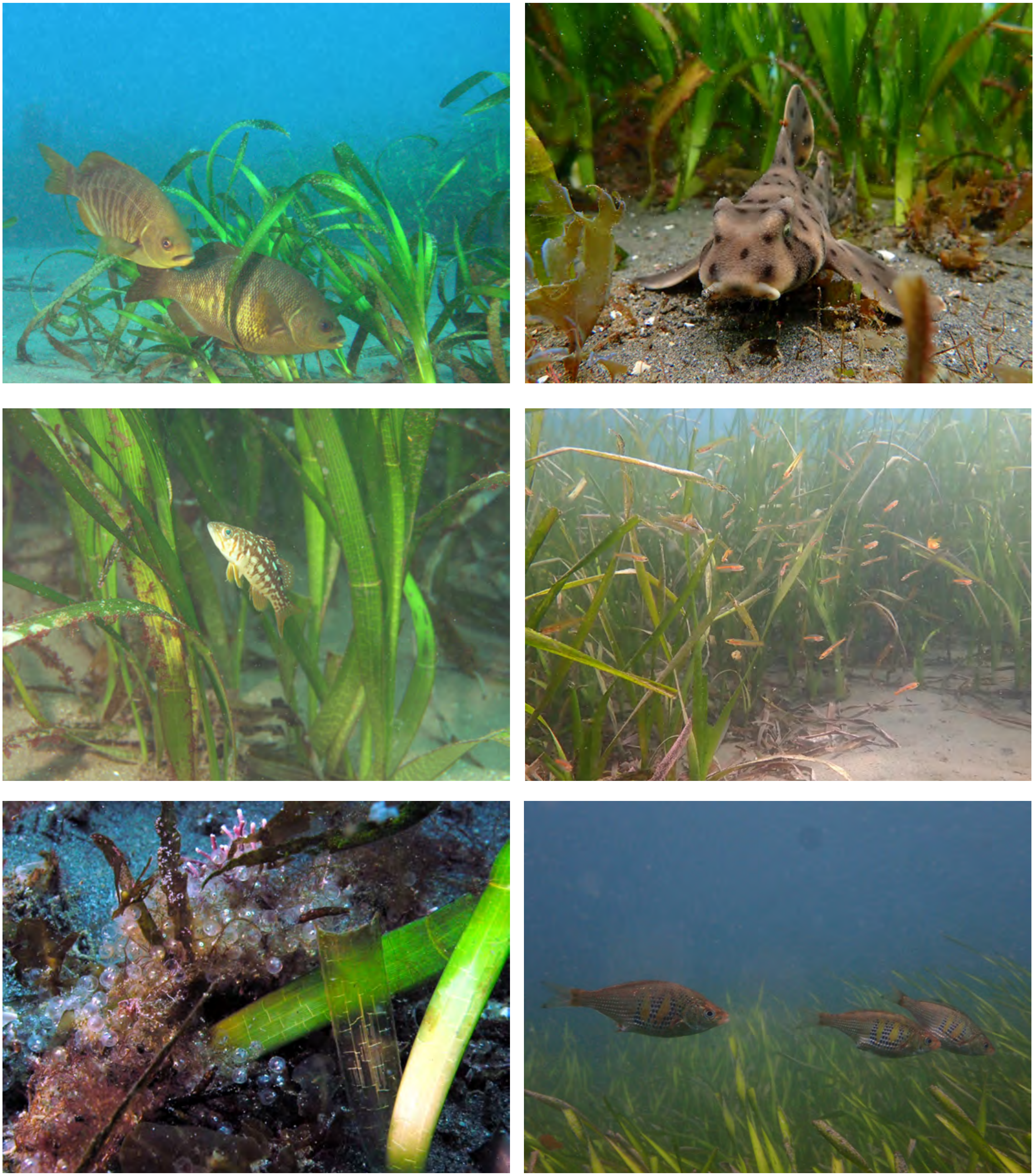


Natural disturbances to eelgrass meadows. CW from UL: Bat ray feeding pits (Scorpion SCR); urchin grazing (Eagle Canyon SCR); wavy turban snail grazing (Smugglers SCR); invertebrate mobbing (*Pachythione rubra* Old Ranch SRO); sea hare mass spawning (Aguaje Escondido SCR); disease (East Frenchys ANA).

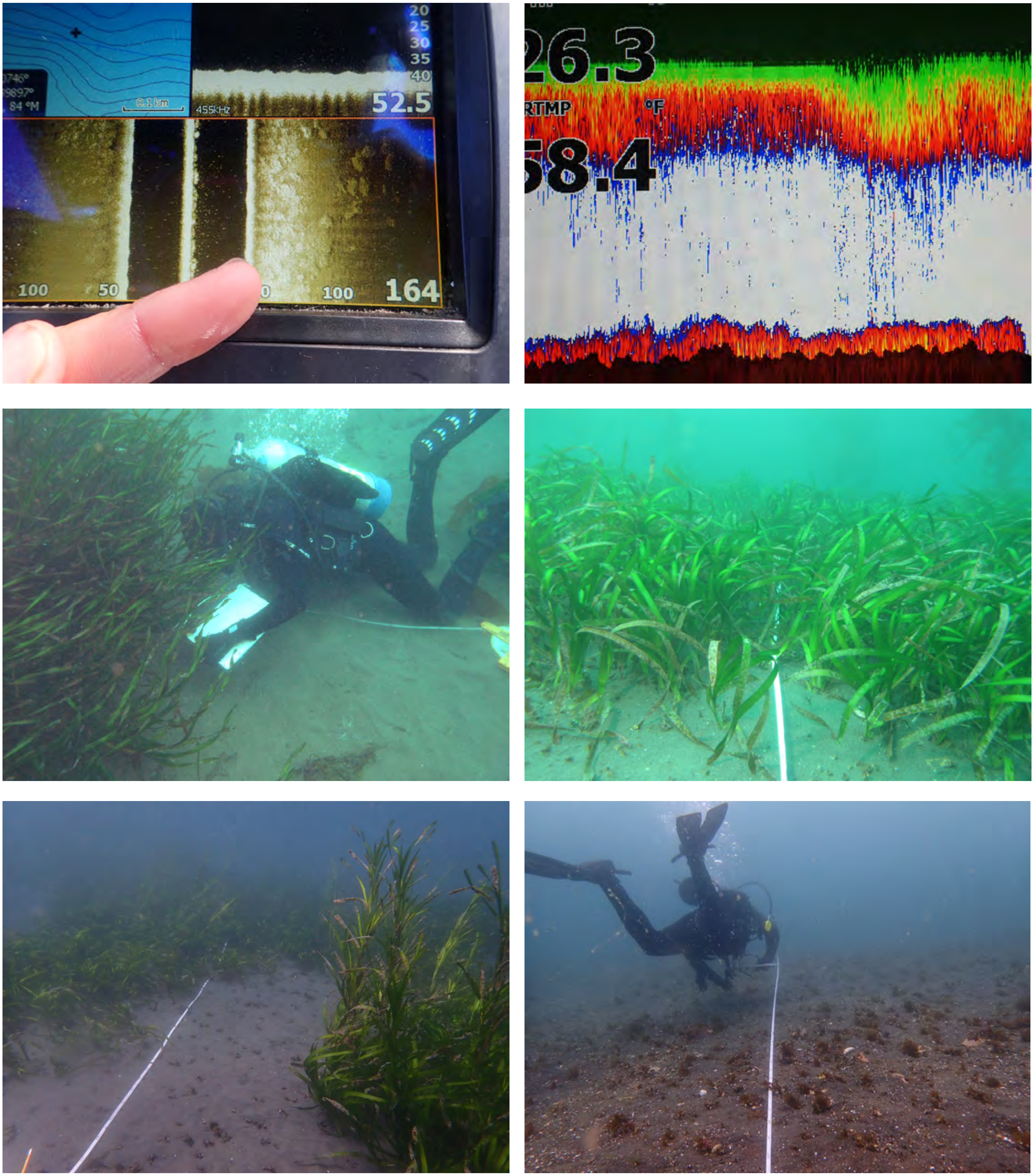
Major invertebrates found in eelgrass beds. CW from UL: Sea cucumber (Prisoners SCR); Cancer crabs (Prisoners SCR); sand star (East Frenchys ANA); lobster (Frenchys ANA); sand tube anemone (Canada Agua SCR); clam (Aguaje Escondido SCR).

Reproductive phases in *Zostera pacifica*. CW from UL: New reproductive shoots developing in late spring (Keyhole ANA; and at East Frenchys ANA); close-up of an open spathe with male flowers (Prisoners SCR); ripening seeds (Aguaje Escondido SCR); a seedling (Canada Agua SCR); senescing reproductive shoot in late July (Prisoners SCR).

Common fishes in eelgrass. CW from UL: White and pile perch (Scorpion SCR); rainbow and black perch (Smugglers SCR); sheephead (Scorpion SCR); bay pipefish (East Frenchys ANA); kelp bass (Keyhole ANA); halibut (East NPS ANA).

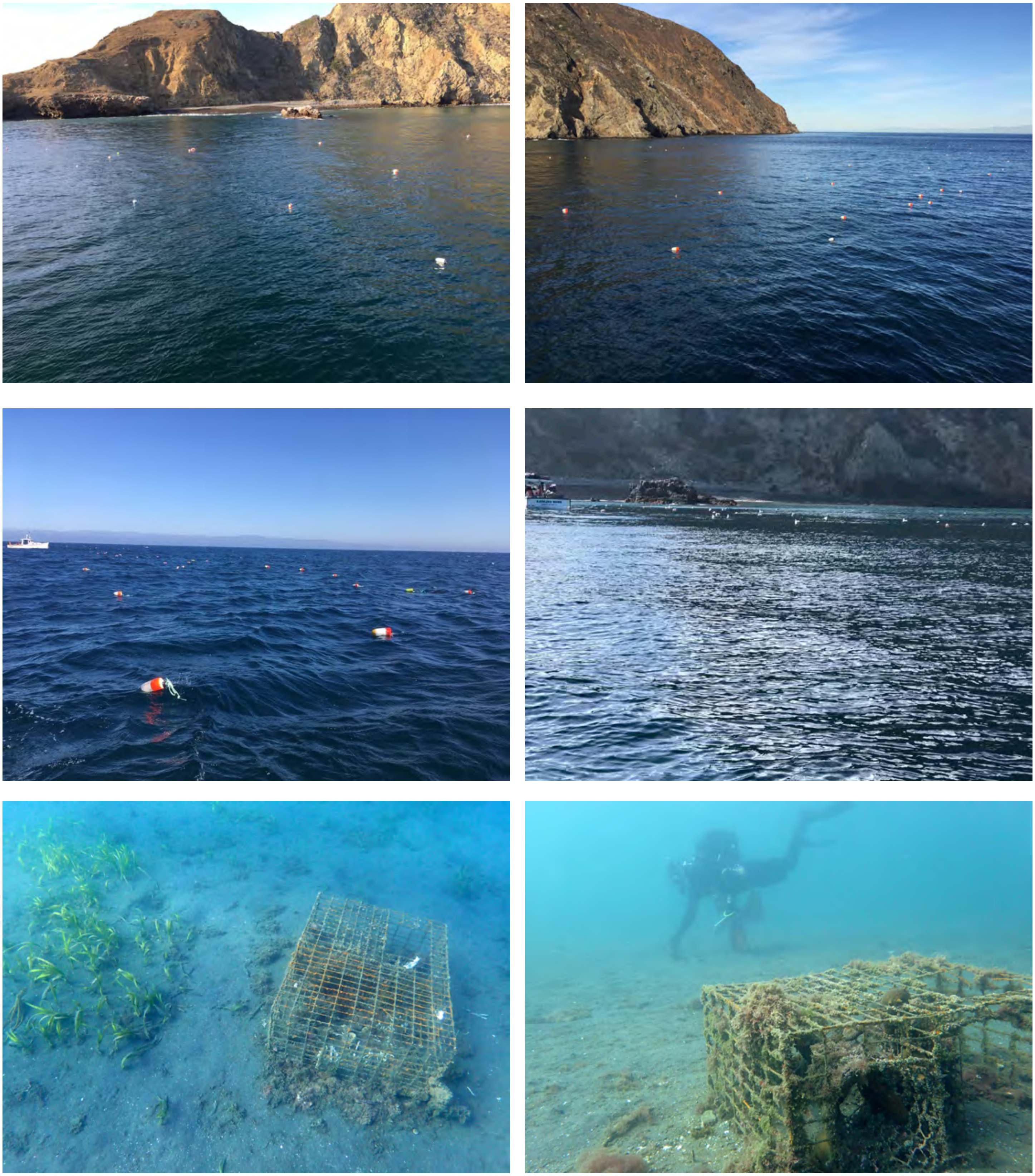


Fish reproductive use of eelgrass meadows. CW from UL: Black perch exhibiting courtship behavior; juvenile horn shark (both East Frenchys ANA); young of the year (YOY) giant kelpfish (Canada Agua SCR); gravid shiner perch (Scorpion SCR); topsmelt eggs on eelgrass (Frenchys ANA) kelp bass YOY recruit (Frenchys ANA).

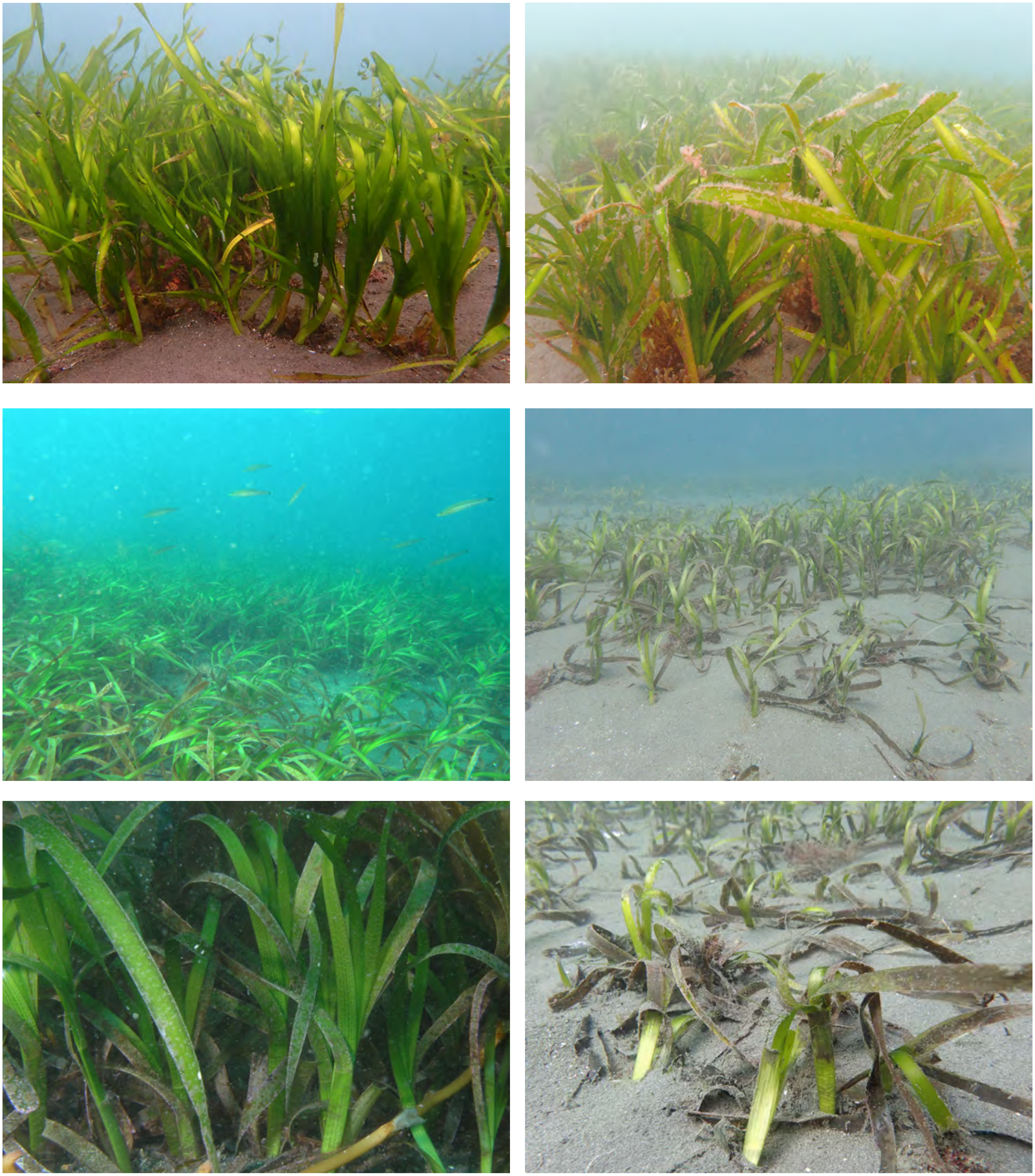


Mapping and quantifying eelgrass meadows. CW from UL: Eelgrass along Middle Anacapa imaged on ship's sounder (2016); imaged on fish finder (2019); Frenchys restoration transect within MCA (2006); and same restoration transect in 2019; control transect at East Frenchys within MPA (2019); diver mapping patch along same control transect in 2009.

Interesting observations during 2016 and 2019 surveys. CW from UL: Giant sea bass (2019 East Frenchys ANA); moray eel (2019 Prisoners SCR); sea sweet potato (2016 Prisoners SCR), pelagic red crab (2016 East Frenchys ANA); juvenile white seabass (2019 Prisoners SCR); black sea hare (2016 East Frenchys ANA, the largest of all sea slug species).



Commercial trapping at Frenchys. Top row: Lobster floats November 2016 on the MPA/MCA bounday (left) and in the MCA (right); Middle row: November 2019 on the MPA/MCA boundary, facing north (left), December 2020 looking south in to the cove along the boundary , > 2 dozen visible (right); Bottom row: abandoned trap within MPA September 2016 (left); abandoned trap on the restoration transect (diver touching marker stake) in MCA September 2016.



Physiological stress in eelgrass following warm-water events, compared to cooler years. Top row L and R: Eelgrass in late June 2019 (cooler) and late June 2016, el Nino (both East Frenchys ANA); Center and bottom rows: left, mid- September 2007 (cold) and right, 2016, el Nino (both at East Frenchys ANA).

November 30, 2023

Eric Sklar, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

Re: **<u>Decadal Management Review Marine Protected Areas Petition Process: Anacap SMCA at Anacapa Island</u>**

Dear President Sklar and Honorable Commissioners:

The undersigned organizations have decades of combined experience and interest working on Marine Protected Area ("MPA") management, research, compliance, outreach, and education efforts. We submit this letter to support the submission of an MPA petition for the Anacapa State Marine Conservation Area ("SMCA") as a part of the Decadal Management Review ("DMR") process. This petition seeks to reclassify the Anacapa SMCA as a State Marine Reserve ("SMR") or at a minimum reclassify the portion of the SMCA from shore to at least 30 meters depth to better protect eelgrass habitat.

The DMR is a momentous step in adaptive and community-based conservation. We commend the California Fish and Game Commission, California Department of Fish and Wildlife, and California Ocean Protection Council for the enormous effort undertaken to complete this first 10-year review. The MPA Network was designed to function as an ecological network to ensure the protection of California's diverse coastal ecosystems. Eelgrass meadows are one of the may habitats protected by MPAs. The eelgrass found in California and at Anacapa Island is *Zostera marina.* This subspecies of eelgrass used to be abundant at multiple sites at Anacapa island until white urchin (*Lytechinus anemesus)* populations increased and invaded the area following the 1983 El Nino. Transplantation efforts at Anacapa Island have had some success, however the shift of spiny lobster trapping to soft bottom habitat has led to a decline in the transplanted eelgrass population at Frenchy's Cove.

Anacapa Island Historic Eelgrass Cover

Eelgrass plays an important role in many marine systems like species survival, reducing coastal erosion, acting as a carbon sink, etc. Globally eelgrass populations have declined during the past 25 years through a combination of natural and anthropogenic deterioration. By 1995, only 2 small eelgrass patches were present at East Anacapa Island, and both disappeared by 1999. Past research at Anacapa Island found that there had been no sign of recruitment at Frenchy's Cove since 1991 up until the 2000s when efforts were made to reintroduce eelgrass into the area. The annual surveys conducted from 1991 to 2001 at Frenchy's Cove revealed no eelgrass seedlings, adult plants, or drift material, underlining the limited long-distance dispersal capabilities of this species.

Impacts to Anacapa SMCA Eelgrass Meadows

Follow up surveys in 2014 and 2016, after the transplantation effort in the early 2000s, found the transplanted eelgrass meadows at the Anacapa SMCA to be damaged and greatly reduced. Information gained from mariners and National Park rangers revealed that Frenchy's Cove was being fished heavily during the two months (November, December) that the brown pelican Special Closure was open. Fishing block data for the mainland showed that effort more than doubled within blocks containing fishing areas adjacent to SMRs. Notably, eelgrass continues to thrive within the Anacapa SMR, 200 meters to the east.

Before the shift in fishing efforts for spiny lobster, in 2012 the research team responsible for the transplantation in the early 2000s found additional patches 200 meters to the east of the transplant site and scattered shoots were observed at the west end of East Anacapa Island. The unintended differences in usage of the SMCA and SMR showed that eelgrass will rapidly colonize and thrive if anthropogenic disturbance (i.e., trapping) were to cease.

The impact of fishing for spiny lobster during the two months allowed is destroying the eelgrass meadows. Research shows that recruitment of new eelgrass is a long process, but it is possible when the ideal habitat is left undisturbed. Currently the SMCA allows for recreational take of spiny lobster and pelagic finfish and commercial take of spiny lobster. The Brown Pelican special closure allows for lobster traps in November and December. We ask that the SMCA be reclassified as a SMR or reclassifying the portion of the SMCA from shore to at least 30 meters depth.

Conclusion

We celebrate the success of the MPA network in a time when ocean conservation wins are more important than ever. While we rely on oceans to contribute to many of our societal needs, from food to energy, we must remain committed to protection of our shared resources, not only for future generations but also for the intrinsic value of a thriving ocean. This petition to reclassify the Anacapa SMCA as an SMR or reclassifying the portion of the SMCA from shore to at least 30 meters depth will allow Anacapa Island to recover its historic eelgrass meadow.

Thank you for your consideration of the MPA petition. If you have any questions, please contact Azsha Hudson, ahudson@environmentaldefensecenter.org.

Sincerely,

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