MARINE PROTECTED AREA MONITORING

Action Plan

California Department of Fish and Wildlife
California Ocean Protection Council





2018

Acknowledgments

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CALIFORNIA MARINE PROTECTED AREAS

OCEAN PROTECTION COUNCIL

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Executive Summary

RECOGNIZING THE IMPORTANCE OF CALIFORNIA'S DIVERSE MARINE SPECIES AND ECOSYSTEMS as vital to the state's coastal economy, public well-being, and ecological health, the California Legislature passed the Marine Life Protection Act (MLPA) in 1999. The MLPA required the state to redesign its pre-existing system of marine protected areas (MPAs) to function as a statewide network to increase its coherence and effectiveness at protecting the state's marine life, habitats, and ecosystems. The MLPA also required the adoption of a Marine Life Protection Program (now called the MPA Management Program) with six primary goals to improve the design and management of California's MPAs. An extensive public planning process for MPA design and siting was implemented across California's coast incrementally through four regional, science-based and stakeholder-driven processes, ending in December 2012 and resulting in the creation of an ecologically connected network of 124 new or redesigned MPAs and 15 special closures.

California's MPAs are adaptively managed as a network through the MPA Management Program which consists of four focal areas: 1) outreach and education, 2) enforcement and compliance, 3) research and monitoring, and 4) policy and permitting. Within the research and monitoring focal area, the California Department of Fish and Wildlife (CDFW) and California Ocean Protection Council (OPC) collaboratively direct California's MPA Monitoring Program which includes a two-phased, ecosystem-based approach. Regional baseline monitoring (Phase 1, 2007 – 2018) characterized ecological and socioeconomic conditions near the time of regional MPA implementation and improved our understanding of a variety of representative marine habitats and the associated biodiversity. CDFW and OPC are now designing and implementing statewide long-term monitoring (Phase 2, 2016 – present) to reflect current priorities and management needs.

The MPA Monitoring Action Plan (Action Plan) informs next steps for long-term MPA monitoring in California by aggregating and synthesizing work to date, as well as by incorporating novel, quantitative, and expert-informed approaches. The Action Plan prioritizes key measures, metrics, habitats, sites, species, human uses, and management questions to target for long-term monitoring to inform the evaluation of California's MPA Network. For example, the Action Plan includes select species-level, community-level, physical, chemical, and human use measures and metrics identified to advance understanding of conditions and trends across the MPA Network. MPA index monitoring sites are prioritized based on scoring MPAs against four defined criteria that evaluated various aspects of individual MPAs, including 1) MPA design features, 2) historical coastwide monitoring, 3) habitat-based connectivity modeling, and 4) local recreational fishing effort prior to MPA implementation. These index sites are recommended using a tiered approach across three bioregions to create scalable monitoring options based on available resources and capacity. The Action Plan also provides lists of species and species groups to target for long-term monitoring, and highlights examples of existing programs that can contribute to long-term monitoring in California. In addition, the Action Plan incorporates long-term monitoring approaches to inform adaptive management. Specifically, quantitative analyses focused on detecting population responses to MPAs over time, incorporating spatial differences in fishing mortality rates, informing sample design for deep-water surveys, and comparing various fish monitoring techniques used for nearshore marine ecosystems and MPAs.

The primary intended audiences of the Action Plan include existing and potential partners interested in applying for funding to conduct MPA monitoring, as well as other entities with mandates, or interests relating to California's MPA Network. This is a living document and may be updated as needed to ensure the latest understanding of MPA network performance evaluation is reflected in the priorities of the MPA Monitoring Program.

1. Introduction

1.1 California's MPA Network

Recognizing the importance of California's marine resources to the state's coastal economy, public well-being, and ecological health, the California Legislature passed the Marine Life Protection Act (MLPA, Chapter 10.5 of the California Fish and Game Code [FGC], §2850-2863) in 1999. The MLPA required the state to redesign its pre-existing system of marine protected areas (MPAs) to meet six goals (Box 1).

BOX 1: Goals of the Marine Life Protection Act (MLPA)

>> **GOAL 1:** *Protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.*

>> **GOAL 2:** *Help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.*

>> **GOAL 3:** *Improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.*

>> **GOAL 4:** *Protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.*

>> **GOAL 5:** *Ensure California s MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.*

>> **GOAL 6:** *Ensure the state s MPAs are designed and managed, to the extent possible, as a network.*

To read the full text of the MLPA, please visit
www.wildlife.ca.gov/Conservation/Marine/MPAs/MLPA

GUIDED BY THESE SIX GOALS, the MLPA was implemented incrementally across four planning regions through science-based and stakeholder-driven processes, resulting in the creation of an ecologically connected network of 124 MPAs. Implemented regionally, the new and revised MPAs went into effect in the central coast (Pigeon Point to Point Conception) in September 2007, the north central coast (Alder Creek near Point Arena to Pigeon Point) in May 2010, the south coast (Point Conception to U.S./Mexico border) in January 2012, and the north coast (California/Oregon border to Alder Creek) in December 2012. California's MPA Network (Figure 1) now spans the state's entire 1,100-mile coastline and encompasses approximately 740 square nautical miles (16% of California's jurisdictional waters). It is the largest network of MPAs in North America and one of the largest in the world.

FIGURE 1: California's MPA Network

The MPAs that comprise the Network are under several designations that reflect various management objectives (Table 1). Nine percent of state waters are no-take state marine reserves and approximately six percent of state waters are state marine conservation areas in which limited take is permitted. Special closures are not MPAs, but they do contribute to the goals of the MLPA by restricting access to waters adjacent to seabird rookeries or marine mammal haul-out sites.

TABLE 1: MPA and marine managed area (MMA) map color, classification, number of sites, percent of California state waters protected, and summary. For full definitions and a complete overview of MPA classifications, please refer to CDFW (2016).

MAP COLOR	CLASSIFICATION	NUMBER OF SITES	%	SUMMARY
Red	State Marine Reserve	49	9.0%	An MPA designation that prohibits damage or take of all marine resources (living, geologic, or cultural) including recreational and commercial take.
Purple	State Marine Conservation Area	60	6.5%	An MPA designation that may allow some recreational and/or commercial take of marine resources (restrictions vary)
Blue	State Marine Conservation Area (no-take)	10	0.6%	An MPA designation that generally prohibits the take of living, geological, and cultural marine resources, but allows potentially affected and ongoing permitted activities such as dredging and maintenance to continue.
Green	State Marine Recreational Management Area	5	0.1%	An MMA designation that limits recreational and commercial take of marine resources while allowing for legal waterfowl hunting to occur; provides subtidal protection equivalent to an MPA (restrictions vary)
Pink	Special Closure	15[1]	0.1%	An area designated by the Fish and Game Commission that prohibits access or restricts boating activities in waters adjacent to sea bird rookeries or marine mammal haul-out sites (restrictions vary)

Eight key habitats and two types of human uses (called “ecosystem features” in regional monitoring plans) were identified during Phase 1, and continue to help guide monitoring efforts: Rocky Intertidal, Kelp and Shallow Rock (0-30 m), Mid-depth Rock (30-100 m), Estuaries, Soft-bottom Intertidal and Beach, Soft-bottom Subtidal (0-100 m), Deep Ecosystems & Canyons (>100 m), Nearshore Pelagic (i.e., the water column habitat within state waters in depths >30 m), Consumptive Uses, and Non-Consumptive Uses.

1. The Commission repealed Rockport Rocks Special Closure on August 22, 2018, effective upon approval of Office of Administrative Law by January 1, 2019.

1.2 Management of the MPA Network

Management of California's MPA Network is guided by the 2016 MLPA Master Plan for MPAs (CDFW 2016) and the MPA Statewide Leadership Team Work Plan (OPC 2015). The MPA Management Program (Management Program) is a collaboration between the California Department of Fish and Wildlife[2] (CDFW) the California Fish and Game Commission[3] (Commission), the California Ocean Protection Council[4] (OPC), the MPA Statewide Leadership Team[5] (Leadership Team), California Native American Tribes, and non-governmental partners. This novel partnership-based approach is guided by "The California Collaborative Approach: Marine Protected Areas Partnership Plan[6]" (OPC 2014) and ensures that California's MPA Network is adaptively managed with active engagement across the ocean community.

MPA Management Program Focal Areas

California's MPAs are managed as a statewide network through the Management Program. The Management Program is composed of four programmatic focal areas that require active engagement to ensure the MPA Network is adaptively managed and informed by engaged partnerships (Gleason et al. 2013, CDFW 2016).

Outreach and education. Outreach and education efforts primarily focus on encouraging compliance with MPA regulations. The dissemination of MPA-based regulatory, interpretive, and educational materials is a collaborative effort with partners across the state. Collaboration with CDFW and local groups on these materials improves outreach efforts by helping to tailor messaging and delivery mechanisms to reach out to California's diverse public in a consistent, cohesive, and effective manner.

Enforcement and compliance. The success of any MPA or MPA network relies, in part, on proper enforcement of and compliance with MPA regulations (Gleason et al. 2013, CDFW 2016). The MLPA emphasizes the importance of enforcement as a primary goal of the Management Program and identifies CDFW as the primary agency responsible for MPA enforcement. CDFW occasionally receives assistance from other allied agencies such as the National Oceanographic and Atmospheric Administration (NOAA), the California Department of Parks and Recreation, the United States Coast Guard, local sheriffs, and the California Highway Patrol. In 2016, CDFW's Law Enforcement Division established a Marine Enforcement District, which includes 40 wildlife officers focused solely on enforcing marine regulations including MPAs.

Research and monitoring. The MLPA requires the MPA Network be monitored to evaluate progress toward meeting its goals, and that the results of monitoring inform adaptive management decisions. The Monitoring Program (detailed in Section 2) integrates across existing science, policy, and management needs to inform the adaptive management of the MPA Network. The Monitoring Program is carried out by multiple state partners, is scientifically rigorous, addresses the mandates of the MLPA, and informs other California coastal and ocean policy priorities.

Policy and permitting. Consistent policy and permitting is a critical component of MPA Network governance. The Management Program uses scientific data and expert knowledge to inform management recommendations to the Commission to aid in their rule-making decisions. For example, goal three of the MLPA states that the MPA Network provide study opportunities in marine ecosystems that are subject to minimal human disturbance. However, unregulated research activities have the potential to negatively impact marine environments. To address these potential adverse effects, in 2017 CDFW began utilizing an ecological framework (Saarman et al. 2018) for informing scientific collecting permitting decisions in MPAs.

2. https://www.wildlife.ca.gov/
3. http://www.fgc.ca.gov/
4. http://www.opc.ca.gov/
5. http://www.opc.ca.gov/programs-summary/marine-protected-areas/partnerships/
6. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/mpa/APPROVED_FINAL_MPA_Partnership_Plan_12022014.pdf

MPA Governance

MPA governance in California is rooted in a partnership-based approach to facilitate design, implementation, and adaptive management of the MPA Network to achieve the goals of the MLPA (CDFW 2016). The Commission is the primary regulatory decision-making authority for regulations related to California's MPAs. CDFW implements and enforces the regulations set by the Commission, and is the lead managing agency for the MPA Network. OPC is responsible for the direction of policy for California's MPAs.

By tapping into the specialized knowledge of partners at other state and federal agencies, California Native American Tribes, non-governmental organizations, academic institutions, and fishing communities, CDFW and OPC leverage existing capacity to help ensure efficient, cost-effective management of the MPA Network. In 2014, the Secretary for Natural Resources directed OPC staff to convene the Leadership Team to encourage effective communication and collaboration among these partners. The Leadership Team is a standing advisory body made up of state, federal, nonprofit, and Tribal members that ensures communication and collaboration among entities that have regulatory authority, responsibility, or interests related to California's MPA Network. By building and maintaining active partnerships, the Leadership Team works to engage a diverse range of stakeholders in the management of the MPA Network. In particular, the Leadership Team plays a critical role in helping to support the MPA Monitoring Program.

Partnership with California Native American Tribes

Both informal discussions and formal Tribal Consultation are important to the ongoing management of MPAs (CDFW 2016). As the traditional users and stewards of California's marine resources, California Native American Tribes are particularly important to the success of the Management Program. The US Government recognizes some Native American Tribes as separate and independent sovereign nations, and these federally recognized Tribes have trust relationships with the US Government and interact with it on a government-to-government basis. Non-federally recognized Tribes also play an important role in natural resource management. The State of California does not have a formal trust relationship with federally recognized or non-federally recognized Tribes. However, the state is committed to engaging in meaningful collaborations with California Native American Tribes.

Guided by the Executive Order B-10-11 established by Governor Edmund G. Brown Jr. and demonstrating California's commitment to improving collaboration and communication with Tribes, CDFW, OPC through the California Natural Resources Agency[7] (CNRA), and the Commission developed and adopted formal Tribal Consultation policies to enable California Native American Tribes to provide meaningful input for natural resource management.

7. http://resources.ca.gov/

2. MPA Monitoring Program

SCIENTIFICALLY SOUND MPA MONITORING is a critical component of the adaptive management process required by the MLPA (CDFW 2016). The state and its partners have designed a scientifically rigorous and robust Monitoring Program. The Monitoring Program draws from best available science regarding MPA performance evaluation and uses best practices in science, policy, and management, recognizing the uniqueness of California's marine environment (CDFW 2016).

The Monitoring Program consists of a two-phase approach. Phase 1, which was completed in early 2018, focused on regional baseline monitoring and established a "snapshot" of ecological and socioeconomic conditions near the time of MPA implementation. Phase 2 is focused on statewide long-term monitoring to track changes in selected performance metrics inside and outside MPAs over time. Underpinning both phases are three core elements necessary for generating meaningful monitoring results: science, communication, and evaluation (Figure 2).

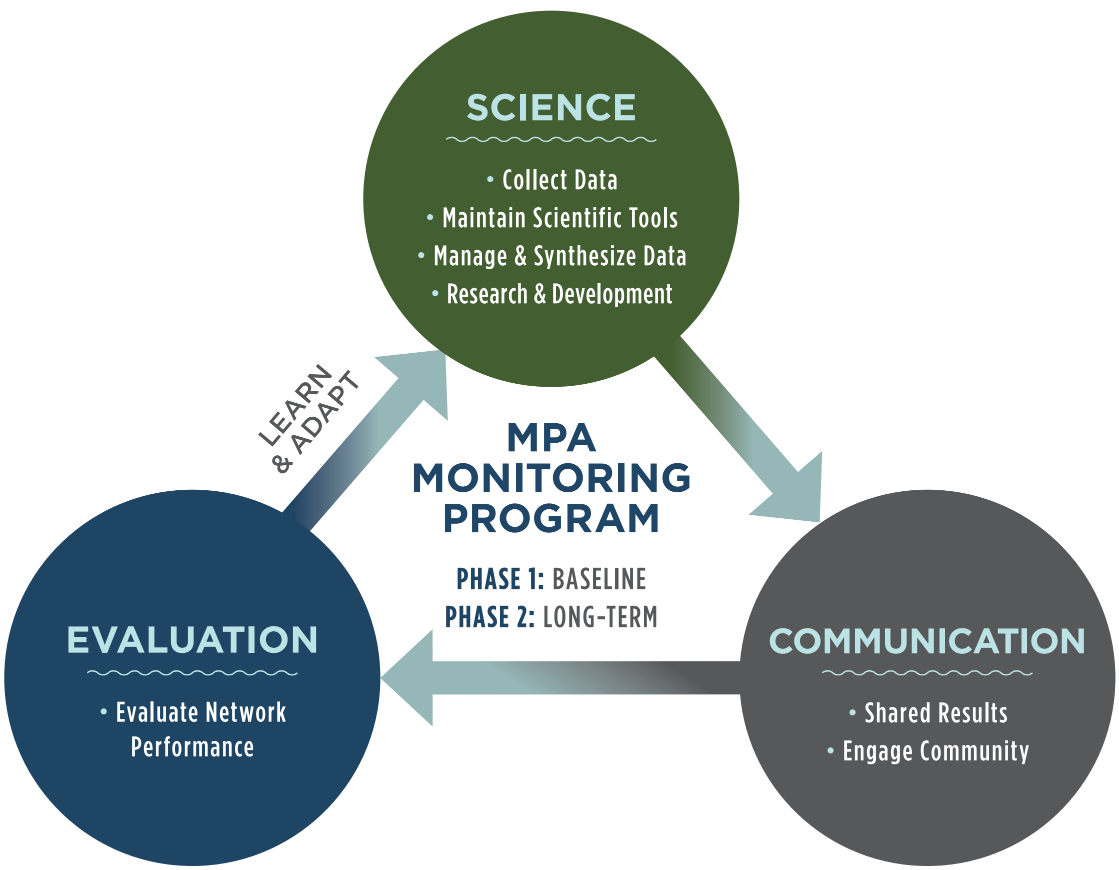


FIGURE 2: Science, communication, and evaluation elements that help inform adaptive management of California's MPA Monitoring Program.

2.1 Phase 1: Regional Baseline Monitoring

Regional baseline monitoring established a comprehensive snapshot of ecological and socioeconomic conditions at or near the time of MPA implementation in each of four planning regions across California's coast (Table 2). Baseline monitoring projects were guided by regional priorities funded in each region through a competitive peer review process, and covered eight habitats and two human uses, guided by recommendations from the MLPA Science Advisory Team (SAT) during the MPA design and siting process (CDFW 2008, MLPA SAT 2008, 2009, 2011, White et al. 2013):

- Rocky Intertidal
- Kelp and Shallow Rock (0-30 m)
- Mid-depth Rock (30-100 m)
- Soft-bottom Intertidal and Beach
- Soft-bottom Subtidal (0-100 m)
- Deep Ecosystems and Canyons (>100 m)
- Nearshore Pelagic (i.e., the water column within state waters 0-3 nm)
- Estuaries
- Consumptive Human Use
- Non-consumptive Human Use

TABLE 2: MPA baseline monitoring regions, number of projects, data collection period, analysis and sharing information period, and year of the initial regional 5-year management review.

COASTAL REGION	NUMBER OF PROJECTS	DATA COLLECTION PERIOD	ANALYZE, SYNTHESIZE, & SHARE INFORMATION	5-YEAR MANAGEMENT REVIEW
CENTRAL *(Pigeon Pt. to Pt. Conception)*	5	2007 - 2010	2010 - 2013	2013
NORTH CENTRAL *(Alder Creek to Pigeon Pt.)*	11	2010 - 2012	2012 - 2016	2016
SOUTH *(Pt. Conception to US/Mexico Border)*	10	2011 - 2013	2013 - 2017	2017
NORTH *(California/Oregon border to Alder Creek)*	11	2013 - 2016	2016 - 2018	2018

Data and results are found in raw data packages and individual technical reports for each funded project, as well as in summary "State of the Region" reports (Table 3). Baseline products informed an initial 5-year management review of regional MPA implementation, and provide a benchmark against which future changes can be measured. All baseline monitoring data and reports can be accessed at **https://data.cnra.ca.gov.**

TABLE 3: MPA baseline products by coastal region.

COASTAL REGION	PRODUCT
NORTH	Baseline Monitoring Projects[8] State of the Region Report[9] CDFW's Management Review[10]
NORTH CENTRAL	Baseline Monitoring Projects[11] State of the Region Report[12] CDFW's Management Review[13]
CENTRAL	Baseline Monitoring Projects[14] State of the California Central Coast Report[15] CDFW's Management Review[16]
SOUTH	Baseline Monitoring Projects[17] State of the California South Coast Report[18] CDFW's Management Review[19]

8. https://caseagrant.ucsd.edu/news/north-coast-marine-protected-areas-project-summaries
9. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=151828&inline
10. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=155713&inline
11. https://caseagrant.ucsd.edu/news/north-central-coast-marine-protected-areas-project-summaries
12. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=133100&inline
13. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=133098&inline
14. https://caseagrant.ucsd.edu/news/central-coast-marine-protected-areas-project-summaries
15. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=133101&inline
16. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=80499&inline
17. https://caseagrant.ucsd.edu/news/south-coast-mpa-baseline-program
18. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=144357&inline
19. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=144356&inline

2.2 Phase 2: Statewide Long-Term Monitoring

Statewide long-term monitoring focuses on gathering the required information necessary to assess MPA Network performance. Major components supported or identified to date include:

- Maintaining or expanding the geographic scope of data collection in selected key habitats and on human uses,
- Maintaining the capacity of CDFW to collect data through scientific equipment upgrades,
- Supporting the development of an Open Data Platform[20] (ODP), a comprehensive, publicly accessible information management system hosted by CNRA and connected to existing data platforms, and
- Conducting integrated analyses across sites, regions, and scientific disciplines to inform adaptive management.

This document informs next steps for long-term monitoring. It does this by aggregating and synthesizing work from the MPA design and siting process, baseline monitoring projects, and additional scientific study in California on MPAs over the past decade, as well as incorporating novel, quantitative, and expert informed approaches. ***This Action Plan prioritizes metrics, habitats, sites, species, and human uses for long-term monitoring to inform the evaluation of the MPA Network.*** The primary intended audiences include existing and potential partners interested in applying for funding to conduct MPA monitoring, as well as other entities with mandates, or interests relating to California's MPA Network. This is a living document and may be updated as needed to ensure the latest understanding of MPA Network performance evaluation is reflected in the priorities of the Monitoring Program.

Funding for Long-Term Monitoring

A variety of funding sources, disbursement mechanisms, and administrative processes have been identified to ensure the successful implementation of the Monitoring Program. Currently, the Monitoring Program receives a $2.5 million annual General Fund appropriation into the Secretary for Natural Resources budget that is designated for MPA monitoring. This amount is supplemented with other types of funds when available, but these monies are not available every year and the amount available for the Monitoring Program fluctuates annually. OPC's Once-Through Cooling (OTC) Interim Mitigation Program identifies research to determine the degree to which the MPA Network is mitigating OTC impacts as one of the designated uses for those funds[21]. The OTC Program will sunset in 2029. Payments to the program will decrease each year as power plants come into compliance with the policy or shut down. A general portfolio of potential funding disbursement mechanisms has been identified that will inform and enable state investments to strategically target maximum cost-effectiveness, transparency, and efficiency across the breadth of activities within the Monitoring Program (Appendix A). The MPA Management Program's adaptive management process includes a decadal management review, the first of which is anticipated in 2022 (marking 10 years since statewide MPA Network implementation in 2012; CDFW 2016). Some key elements of the process, specific to funding the Monitoring Program prior to the first review in 2022, are discussed below.

CURRENT TIMELINE

November 2018
Open call for proposals released

January 2019
Scientific peer review of submitted proposals

February 2019
Recommend proposals brought to OPC

March – May 2019
Approved project agreements executed

April 2019 – 2021
Data collection and analyses

December 2022
Ten-year management review brought to Commission

20. https://data.cnra.ca.gov/
21. Dawson C.L., Worden S., Whiteman L. 2016. Once-Through Cooling Mitigation Program Policy and Science Framework Linking California's Marine Protected Area Network to OTC Impacts. http://www.opc.ca.gov/webmaster/_media_library/2016/10/FINALScience_PolicyFramework_LinkingMPAstoOTCmitigation_8.30.16.pdf

RESEARCH CONSORTIUMS

The MPA Network spans more than 1,100 miles along California's coastline, excluding San Francisco Bay. Research programs are often clustered around academic institutions, and many focus on conducting monitoring studies within their local geographic region (see monitoring dashboard[22] for more information). Few monitoring programs have a statewide focus and fewer still work at broader scales. The Monitoring Program supports consortiums of principal investigators (PIs), often from multiple institutions or organizations, to conduct some elements of the Monitoring Program. Administratively, a single lead-PI and their associated institution/organization submits a single proposal during open call periods that identifies their geographically distributed co-PIs as sub-awardees. If a proposal is successful, the lead-PI will be awarded funds and they are responsible for using their institution's accounting practices to disburse funds to their co-PIs. In practice to date, most of the consortium awards have been organized around habitat types along the coast, e.g., Rocky Intertidal, Kelp and Shallow Rock (0-30 m), Mid-depth Rock (30-100 m). This prevents the state from absorbing the administrative burden of awarding monitoring projects on a regional basis, which significantly increases the number of overall awards being administered and allows for a more efficient leveraging of existing resources. Another major advantage of this approach is collaborators can share training resources and equipment across the state, when feasible, to increase efficiency and keep costs as low as possible.

OPEN CALL COMPETITIVE PROCESS

The state will, in most cases, release Requests for Qualifications (RFQs) soliciting proposal bids for monitoring projects. An RFQ lays out a highly specific project plan and is appropriate for many of the key habitat types that already have very clearly defined consensus approaches to monitoring the key metrics (see section 2.3). Long-term monitoring RFQs and submissions will undergo full scientific peer review. Successful applicants will enter into an agreement with the state and will be funded in arrears by reimbursement. Reimbursements will require ongoing written progress updates and a percentage of the total award (usually 10%) will be held back and released upon the submittal of all the required deliverables delineated in the agreement. The RFQ process will last a total of 12-14 weeks plus time for agreement execution. Steps include an open call period (4-6 weeks), peer review (4 weeks), applicant revisions based on reviewer comments (1-2 weeks), and final state review and decisions on recommended projects to fund (2 weeks). Although most open calls will likely be for new RFQs, other funding mechanisms identified in Appendix A can be deployed at any time as appropriate. For instance, specific questions regarding key habitats without clearly defined consensus approaches may be considered through Expressions of Interest (EOI).

Incorporating Existing Approaches

The Monitoring Program utilizes a partnership-based approach to leverage existing capacity. This approach has established a foundation for generating novel scientific information, tools, and strategies through partnerships with academic institutions, local, state, Tribal and federal governments, citizen science, other organizations, fishermen, and others across the state and beyond (CDFW 2016). For example, CDFW, OPC, and the Commission collaborated with over 60 organizations to conduct comprehensive baseline monitoring across all four coastal planning regions from 2007– 2018. Moving forward, the Monitoring Program will continue to identify opportunities to align monitoring approaches to leverage resources, capacity, and expertise.

To enhance our understanding of the magnitude of ocean monitoring and research along California's coastline, an interactive dashboard was developed to explore who is monitoring what and where. The dashboard is the result of information collected from a survey conducted following baseline monitoring in each of the four planning regions and represents a key step in planning for long-term monitoring. Survey participants included government agencies, non-government organizations, and academics involved in conducting or managing monitoring efforts.

22. http://oceanspaces.org

In 2018, 134 entities were actively monitoring and researching at 8,228 sites off California's coast. Some of these entities have long-term monitoring sites that may help fill data gaps and address data collection limitations related to the Monitoring Program. It should be noted that not all the projects described in the survey are on-going or monitoring the selected sites, metrics, and indicators identified by the Monitoring Program.

EXAMPLES OF IMPORTANT EXISTING PROGRAMS

The programs below have been in existence for often over a decade and are contributing data to statewide long-term monitoring. Though not a comprehensive list, the following programs include extended time series or novel monitoring of under-sampled metrics (e.g., human use metrics) that can contribute to long-term MPA monitoring in California.

- **Multi-Agency Rocky Intertidal Network (MARINe)**
  Established in the 1980s, MARINe[23] is a partnership of agencies, universities, and private research groups working together to collect data in rocky intertidal habitats. Surveys by MARINe partners follow standardized protocols and occur throughout the year at over 200 sites ranging from Southeast Alaska to Mexico, with more than 187 in California. With over 20-30 years of data at some California sites, long-term data will be invaluable to assessing MPA effectiveness, performance, and network connectivity.

- **Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)**
  Established in 1999, PISCO[24] is a long-term, ecosystem-based scientific monitoring program involving marine scientists at four universities along the U.S. West Coast. The monitoring program was designed to enhance understanding of the California Current Large Marine Ecosystem (CCLME), with research focusing on physical oceanographic conditions of the coastal ocean (5-10 km from shore and less than 25 m deep), as well as the ecology of kelp forests and rocky shorelines. PISCO's broad-scale research, monitoring, data management, training, and outreach will continue to improve the understanding of how MPAs and surrounding areas respond to long-term protections.

- **National Science Foundation (NSF) Long-Term Ecological Research (LTER)**
  In 1980, to address ecological questions that cannot be resolved with short-term observations or experiments, NSF established the LTER program.[25] This program has designated specific sites to represent major ecosystem types or natural biomes, with two in southern California. The Santa Barbara Coastal LTER[26] project was established in 2000 and investigates the relative importance of land and ocean processes in structuring giant kelp forest ecosystems in the Santa Barbara Channel. The California Current Ecosystem LTER[27] project was established in 2004, and focuses on the oceanographic mechanisms leading to changes and dynamics of the pelagic ecosystem. Both sites have the potential to contribute greatly to our understanding of long-term change because of spatial protection.

- **California Cooperative Oceanic Fisheries Investigations (CalCOFI)**
  Established in 1949 to study ecological aspects of the sardine population crash, CalCOFI[28] is a partnership between CDFW, NOAA, and Scripps Institution of Oceanography that today focuses on the study of the marine environment off the coast of California through data collection on a wide array of marine indicators. CalCOFI conducts four seasonal oceanographic cruises a year to collect hydrographic and biological data in waters out to 300 nautical miles (nm) at various set stations from San Diego to Point Arena that are designed to improve the overall understanding of the fluctuations and long-term changes of the CCLME through continuous investigation.

23. https://www.eeb.ucsc.edu/pacificrockyintertidal/index.html
24. http://www.piscoweb.org/
25. https://lternet.edu/
26. http://sbc.lternet.edu/
27. http://cce.lternet.edu/
28. http://calcofi.org/

- **Integrated Ocean Observing System (IOOS)**
  Created in 2001, IOOS[29] is a national-regional partnership intended to integrate ocean observing systems to enable NOAA and partners to provide new tools and forecasts to improve safety, enhance the economy, and protect the environment through improved ecosystem and climate understanding. California waters are divided into two IOOS regions, the Southern California Coastal Ocean Observing System (SCCOOS) and the Central and Northern California Ocean Observing System (CeNCOOS). Created in 2002, SCCOOS[30] is a regional component of the IOOS that works with local, state, and federal agencies to provide scientific data and information to inform decision making and to understand the changing Southern California coastal ocean conditions. SCCOOS activities include marine operations, coastal hazards, climate variability and change, and ecosystems, fisheries, and water quality in waters from Point Conception south to the Mexico border. Since 2004, CeNCOOS[31] has been regional partner with IOOS to develop long-term environmental conditions monitoring (e.g., water quality, productivity, and connectivity) to support MPA management in waters from the California/Oregon border south to Point Conception. CeNCOOS activities include scientific and technical expertise in ocean surface circulation measurements, shore stations that measure biological conditions, atmospheric and oceanographic forecasting, ocean acidification monitoring, seafloor mapping, and data serving.

- **U.S. National Park Service Kelp Forest Monitoring (KFMP)**
  Channel Islands National Park established the Kelp Forest Monitoring Program[32] (KFMP) in 1982 to collect baseline data on the Park's kelp forest ecosystems. The protocol was formally adopted in 1987 and two formal reviews and revisions of monitoring protocol have occurred since. This is now one of the longest continuous datasets on the nearshore ecosystem in California and provides baseline data prior to the 2003 MPA establishment at the Northern Channel Islands to compare against for context. Each year, KFMP divers collect size and abundance data for algae, invertebrates, and fish along permanent transects. Currently 33 sites are surveyed annually, including 15 sites within the Northern Channel Islands MPAs and their associated reference sites. Information from the KFMP program has been used alongside PISCO data to detect changes in size and density of fishes, invertebrates, and algae in response to MPAs.

- **Citizen Science Programs**
  The capacity for citizen science to play a role in MPA monitoring is increasing, as multiple programs improve and standardize their sampling methods to meet traditional scientific standards. Citizen science can take many forms, from casual observations of marine life onshore to organized surveys of offshore reefs. Though citizen science is not a substitute for academic research, when suitable, citizen science has the potential to generate large amounts of reliable, cost-effective data while simultaneously creating more informed and invested communities.

  - **Reef Check California (RCCA)**
    Since 2005, RCCA[33] has conducted a statewide program that monitors and reports on subtidal rocky reefs throughout California. Trained volunteer SCUBA divers conduct surveys of fish, algae, and invertebrate species and document underwater topography. RCCA has established high expectations for volunteer entry, including extensive training requirements and a hierarchy of survey skills that develop over time through continued participation in the program. Due to the rigorous training requirements, RCCA has shown its data collection standards to be on par with those collected by academic and agency scientists, and as such received funding to collect data as part of regional baseline monitoring projects.

29. https://ioos.noaa.gov/about/about-us/
30. https://ioos.noaa.gov/regions/sccoos/
31. https://ioos.noaa.gov/regions/cencoos/
32. https://science.nature.nps.gov/im/units/medn/monitor/kelpforest.cfm
33. http://www.reefcheck.org/california/ca-overview

- **California Collaborative Fisheries Research Program (CCFRP)**
  CCFRP[34] is a partnership of researchers and local fishing communities interested in fisheries sustainability. Established in 2007 as part of baseline monitoring on California's central coast, the program uses local charter boats to take volunteer anglers out to conduct fishery-independent, hook-and-line, catch and release surveys of offshore rocky reefs inside and outside MPAs. Volunteer anglers participate in research cruises under the oversight of scientists who are on hand to help with measurements, tagging, and fish identification. The program has now expanded statewide. Researchers attribute the success of this program to its collaborative nature, which helps to create an open and collaborative dialogue between scientists and recreational fishermen.

- **Long-term Monitoring Program and Experiential Training for Students (LiMPETS)**
  Created in 2002, LiMPETS[35] is a youth-based citizen science program that works primarily with middle and high school students to collect data from more than 60 sites across California's coast. Volunteers are taught to identify, count, and measure marine species in rocky intertidal and sandy beach habitat. Participation in the LiMPETS program help increase students' understanding of California's coastal ecology while also providing publicly accessible, long-term data.

- **MPA Watch**
  MPA Watch[36], established in 2010, monitors both consumptive and non-consumptive human use of coastal resources. The program is overseen by ten different organizations, which collectively train and support volunteers to collect data on how coastal usage is changing as a result of MPA implementation. All volunteers utilize standardized data collection and reporting methods, which helps to increase the scientific rigor of the program. MPA Watch began collaboration with the State in 2013.

While established long-term monitoring programs will be of vital importance in tracking the MPA Network's progress towards meeting the goals of the MLPA, additional programs may also play important roles.

- **Mid-depth (30-100 m) and deep rocky reefs (>100 m) visual surveys**
  Mid-depth and deep rocky reefs comprise more than half of the rocky reef habitat within California's jurisdictional waters (0-3 nm from shore and around offshore islands and rocks). CDFW has performed extensive surveys inside and outside of MPAs using a remotely operated vehicle (ROV) since 2004. Recently, CDFW collaborated with Marine Applied Research and Exploration[37] (MARE) to survey 148 locations in a three-year, statewide effort revisiting historic baseline monitoring sites and adding many new locations. Synthesis of this data set with fine scale seafloor mapping products, through the use of spatial models, has demonstrated ability to quantify fish and invertebrates across these reef systems. Ongoing development of these techniques and refinement of sampling methodology will provide the ability to detect change in these important ecosystems. A series of workshops to explore the full range of sampling methods used in this habitat were held in 2017. The workshop focused on using expert input to develop consensus recommendations on metrics, sites, and indicators which will be used to inform (along with other emerging analyses), long-term monitoring in this habitat (Appendix E).

- **Seabird surveys**
  While seabirds are generally highly migratory, during breeding and nesting season, many species are central place foragers requiring frequent returns to their nests for roosting or feeding young throughout the day. This behavior dictates a more limited foraging range that could

34. https://www.mlml.calstate.edu/ccfrp/
35. http://limpets.org/
36. http://www.mpawatch.org/
37. https://www.maregroup.org/

benefit from nearby MPAs providing reduced competition with humans for prey resources. Continued monitoring of seabirds and their utilization of special closures and MPAs may potentially provide an indirect approach to study nearshore fish and invertebrate recruitment at spatial scales relevant to MPA establishment (McChesney & Robinette 2013, Robinette et al. 2015, Golightly et al. 2017, Robinette et al. 2018).

INCORPORATING TRADITIONAL ECOLOGICAL KNOWLEDGE

Another important component of long-term monitoring is the incorporation of Traditional Ecological Knowledge (TEK). Since time immemorial, California Native American Tribes have stewarded and utilized marine and coastal resources in the region. The foundation of their management is a collective storehouse of knowledge about the natural world, acquired through direct experience and contact with the environment, and gained through many generations of learning passed down by elders about practical, as well as, spiritual practices (Anderson 2005). This knowledge, which is the product of keen observation, patience, experimentation, and long-term relationships with the resources, today is commonly called TEK (Anderson 2005).

While no single definition of TEK is universally accepted, it has been described as “a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” (Berkes 1999). Traditional Knowledge (TK) and Indigenous Traditional Knowledge (ITK) encompasses TEK, science, and other relevant information from Tribes. Many California Native American Tribes continue to regularly harvest marine resources within their ancestral territories and maintain relationships with the coast for ongoing customary uses.

The Monitoring Program is committed to learning from and collaborating formally with California Native American Tribes on ways to integrate TEK into the long-term monitoring of MPAs. One of the baseline monitoring projects for the North Coast MPAs, *Informing the North Coast MPA Baseline: Traditional Ecological Knowledge of Keystone Marine Species and Ecosystems*, provided recommendations (Box 2) on management and policy that could act as a springboard for conversation.

BOX 2: North Coast Keystone Species

The North Coast TEK baseline project identified five keystone species of cultural importance to several North Coast Tribes including abalone, clams, mussels, seaweed, and smelt. These species are represented as key indicators for long-term monitoring on the North Coast, and species from other regions could be added once identified and discussed with respective Tribal nations.

2.3 Selection of Key Measures and Metrics, Sites, and Species

The MLPA Master Plan for MPAs directed the development of evaluation questions to help guide monitoring and adaptive management. Informed by existing science and policy, this broad list of evaluation questions (Appendix B) represent the key elements regarding the design, performance, and functioning of the MPA Network in relation to the goals of the MLPA. In order to provide a contextual framework for the key measures and metrics, sites, and species identified in this section, a sub-set of these evaluation questions are shown below as examples:

- **GOAL 1:** Do indicator species inside of MPAs differ in size, numbers, and biomass relative to reference sites?
- **GOAL 2:** Do California Monitoring Program indicator species, including those of economic importance, experience positive population level benefits (e.g. increase in abundance, larger size, increased reproductive output, increased stock size) in response to MPA implementation?
- **GOAL 3:** How are the frequency of non-consumptive use, knowledge, attitudes, and perceptions regarding the MPAs changing over time?
- **GOAL 4:** Have endangered species and culturally significant species benefited from the presence of California's MPAs?
- **GOAL 5:** How has the level of compliance changed over time since the MPAs were first implemented and what factors influence variation in compliance within and among MPAs?
- **GOAL 6:** How do other stressors impact the performance of MPAs over time (e.g., water quality, oil spills, desalination plants, ocean acidification, sea level rise)?

Inquiry into the additional evaluation questions listed in Appendix B by Monitoring Program partners is encouraged. It is important to note that the overarching questions listed above in many cases will provide insights into the other evaluation questions listed in Appendix B.

The priorities selected below are meant to guide the Monitoring Program. The Action Plan purposefully does not address the types of data collection methods or analytical approaches that should be used to evaluate the performance of California's MPA Network because methods and analytical approaches are rapidly evolving. This approach will help ensure our scientific partners have the ability, in collaboration with the state through the proposal solicitation process, to use their expertise to select the most effective and efficient procedures. The Monitoring Program will continue to incorporate opportunities to explore emerging methods and analytical approaches through proposal solicitations focused on pilot or research and design studies as appropriate.

Key Performance Measures and Metrics

To meet California's adaptive management objectives (CDFW 2016), a prioritized list of key measures and metrics have been selected to advance understanding of conditions and trends across the MPA Network as well as inform network evaluation[38]. Decades of MPA performance studies from around the world indicate that these ecological, physical, chemical, human use, and enforcement measures and metrics are the most important for evaluating and interpreting MPA performance (e.g., Claudet et al. 2008, Lester & Halpern 2008, Cinner et al. 2009, Caselle et al. 2015, Cinner et al. 2016, Giakoumi et al. 2017).

Species-level
- Abundance
- Density/cover
- Size/age frequency
- Biomass

Community-level
- Functional diversity--tracking the population dynamics of those species and organismal traits that influence ecosystem functioning
- Stability

Physical
- Temperature
- Depth
- Substrate *(e.g., rock or sediment size, type, and rugosity)*
- Wave exposure

Chemical[39]
- pH
- Total alkalinity
- Dissolved oxygen

Human Use[40]
- **Commercial Passenger Fishing Vessel**
  - Annual license renewal and vessel registration
  - Port of departure
  - Number of anglers
  - Target species
  - Trip length
  - Fishing location
  - Average price paid per angler
  - Number and pounds of fish caught by species
  - Number of crew on trip
  - Effort and catch per unit effort (CPUE)
  - Annual operating costs
  - Number of crew employed
- **Commercial Fisheries**
  - Annual license and vessel renewal
  - Number of fishermen making landings
  - Landings: catch, price, and revenue by species
  - Gear type
  - Landings port location
  - CPUE
  - Harvest location
  - Annual operating costs
  - Number of crew employed
- **Recreational Fisheries**
  - License purchases
  - Catch amount
  - Catch location
  - Catch effort
  - Type of gear/mode
- **Coastal Recreation and Tourism**
  - Location of residence
  - Demographic information *(i.e. age, gender, education, etc. See Appendix D for further detail)*
  - Income
  - Employment status
  - Frequency and type of visit
  - Location of visit
  - Type of activities
  - Trip expenditures
- **Enforcement (location specific)**
  - Patrol hours
  - Citations
  - Warnings
  - Cal TIPs received related to potential MPA violations[41]

38. Proposal solicitations will contain additional details on priorities.
39. Note total maximum daily load (TMDL) and other water quality parameters are addressed in complementary monitoring programs lead by the State and Regional Water Quality Control Boards
40. Appendix D contains a detailed plan for human use monitoring and proposal solicitations will contain additional details on priorities. It is important to note, existing data collection efforts like landing receipts, logbooks, report cards, and citizen science monitoring provide much of the required data to track key human use trends. Additional monitoring will be required and included in the Monitoring Program.
41. CalTIP (Californians Turn In Poachers and Polluters) is a confidential secret witness program that encourages the public to provide CDFW with factual information leading to the arrest of poachers and polluters. 1-888-334-CalTIP (888-334-2258).

The common approach to MPA performance evaluation is to compare the responses of these metrics inside and outside MPAs over time to distinguish responses to MPA protection from natural temporal variation (Lester et al. 2009, Fox et al. 2014, Caselle et al. 2015, Soykan & Lewison 2015). ***State-funded long-term monitoring projects will compare changes in the above performance measures inside and outside MPAs over time.*** Some projects may not measure all the key measures and metrics but where feasible, it will be important to measure as many of the key measures and metrics as possible at priority sites and their associated reference sites.

Index Site Selection

BIOREGIONS FOR LONG-TERM MONITORING

This Action Plan identifies three bioregions for long-term monitoring: the north coast (California/Oregon border to San Francisco Bay, including the Farallon Islands), the central coast (San Francisco Bay to Point Conception), and the south coast (Point Conception to the U.S./Mexico border, including the Channel Islands) (Figure 3). It is important to note these bioregions are not the same as the four historical MLPA planning regions and subsequent baseline monitoring regions. The four MLPA planning regions were identified in order to allow for a design approach that could reasonably take into account the unique character of different regions in developing the statewide network of MPAs (CDFW 2016), while the three bioregions in the Action Plan are in large part designated based on data collected during baseline monitoring that identified clusters of similar biota, ecological communities, and key habitats.

TIERED APPROACH

The MPA Network consists of 124 MPAs that span the state's entire 1,100-mile coastline including offshore islands, from the U.S./Mexico border to the California/Oregon border. It is both logistically and financially infeasible to monitor all marine species at all MPAs and their associated reference sites. This Action Plan prioritizes long-term MPA monitoring sites by identifying tiers: required (Tier I), secondary (Tier II), and tertiary (Tier III). These monitoring priority tiers, which are based on best available science, will enable efficient data collection by researchers while still allowing for a broad evaluation of network performance by CDFW. A key advantage of the tiered priority groupings is providing managers and partners a discrete list of index sites to inform the performance evaluation of the MPA Network. State-funded long-term monitoring projects should prioritize the Tier I index sites that align with monitoring project methods. Tier I sites should provide the ability to infer observed conditions to the broader evaluation of Network performance. When feasible, projects are encouraged to monitor sites from Tier II and Tier III lists (Appendix F). Sites not identified in Tier I still play a critical role in the functioning of the Network.

The MLPA requires the MPA Network include a variety of marine habitats and communities to be represented and replicated across a range of depths and environmental conditions (FGC §2857(c)). Habitat type, complexity, and depth are all known to be important drivers of community structure (Allen et al. 2006, Love et al. 2009, Schiel & Foster 2015, Starr et al. 2015, Fulton et al. 2016). Subsequent analyses indicate that most of the habitats targeted by the MPA design and siting process were successful in achieving representation and replication targets (Young & Carr 2015). MPA index sites were prioritized based on scoring each of the 102 coastal and island MPAs against four defined criteria that evaluated different aspects of individual MPAs ensuring a good representation of multiple habitats in the selected sites. The four criteria used to determine site selection are based on the best readily available science, and serve as a starting point for determining whether the Network is meeting the six goals of the MLPA. However, within each of the criteria there are limitations that are noted.

Only one of the four quantitative methods, MPA design features, could be applied to the 22 estuarine MPAs. Therefore, to assign estuarine MPAs into one of three tiers, they were separated from coastal MPAs and only evaluated on their ability to meet the SAT recommended MPA design features. See Appendix F for tiered list of estuary index sites.

The scoring approach for each quantitative method are summarized below, with detailed methodology located in Appendix F.

CRITERIA 1: MPA Design Features

During the MPA design and siting process, the MLPA SAT provided regional stakeholders with MPA science design guidelines, such as MPA size, level of protection, and habitat representation within MPAs. SAT guidelines also included identifying co-locating MPAs with existing water quality protection (e.g., Areas of Special Biological Significance (ASBS)) and areas that had historical protection as priorities. **MPAs that meet SAT guidelines are expected to realize more significant conservation benefits, and therefore should be prioritized for long-term monitoring.** All MPAs were scored against SAT guidelines as follows:

- **MPA size.** MPA size points = 2 if an MPA met the SAT recommended size of 18 square statute miles (sm^2) or larger; MPA size points = 1 if an MPA met the SAT recommended minimum area of 9 sm^2; MPA size points = 0 if an MPA was smaller than the SAT recommended minimum area of 9 sm^2.
- **Threshold of habitat representation and replication within an MPA.** MPAs received 1 point for each of 12 key habitats that met minimum size guidelines for representation/replication, and 0 points for key habitats that did not meet minimum size guidelines. See Appendix F, Table F1 for SAT-recommended minimum size guidelines by habitat.
- **Level of protection (LOP) within an MPA.** LOP points = Habitat threshold points * LOP multiplier. See Appendix F, Table F2 for LOP multiplier values by habitat.
- **MPA Overlap with Areas of Special Biological Significance.** MPAs were assigned a point value from 0 to 1 representing percent overlap with ASBS, e.g. if ASBS overlapped with 72% of the MPA area, point value = 0.72.
- **MPA Overlap with historically protected area.** MPAs were assigned a point value from 0 to 1 representing percent overlap with historically protected area, e.g. if historically protected area overlapped with 64% of the MPA, point value = 0.64. This point value was added to a second term representing protection, assigned 1 if the historical MPA prohibited all take and 0 if the historical MPA allowed take. The two terms were then summed for a final historical MPA points score.

Design scores were calculated as follows:

Total Design Score = MPA size + habitat threshold + LOP + ASBS + Historical MPA points

A key design metric outlined by the SAT during the MLPA planning process, spacing of MPAs, was not included in this criteria. There was uncertainty on how to properly score spacing guidelines for MPAs, and was therefore not included in the design score. However, the connectivity modeling done through the Regional Oceanographic Modeling System (ROMS, criteria 3) model helps to fill in this gap.

CRITERIA 2: MPA Historical Monitoring

Responses of targeted fished species to MPA implementation can occur on the order of years to decades, and community responses tend to occur over longer time scales (Babcock et al. 2010, Caselle et al. 2015, Starr et al. 2015). Moreover, change in and of itself is not sufficient evidence of an MPA effect. The ability to compare MPA trends to both control (no MPA regulations yet other fishing regulations apply) reference sites and to periods where protection was absent is more informative. Hence historical monitoring efforts that uniformly and consistently conducted monitoring statewide prior to and following MPA implementation will allow for a more objective evaluation of MPA effects using 'before-after' and 'control-impact' (BACI) analyses. BACI design allows for controlling for the effects of temporal and spatial variation (e.g., recruitment variability in time, habitat variability in space), and coupled dynamics inside and outside MPAs (i.e., larval connectivity and adult spillover) (White et al. 2011).

For more informative and successful network evaluation, it is essential to prioritize MPAs with the longest possible time series of available data to allow for statistically robust BACI analyses - in other words, a greater understanding of change over time.

The following three ecosystem features and associated monitoring programs were assessed for historical monitoring:

- Rocky intertidal monitoring: MARINe biodiversity and fixed plot surveys
- Nearshore (0-30 m) subtidal kelp forest monitoring: PISCO and RCCA scuba surveys
- Mid-depth (30-100 m) ROV monitoring: CDFW/MARE

In order to offer an unbiased assessment of the statewide monitoring we used very specific criteria in order to include monitoring as part of "historical monitoring." Specifically, the monitoring had to occur consistently throughout the state both before and after MPA implementation. There are a multitude of programs that offer long-term monitoring data (see section 2.2 "Examples of Important Existing Programs"), but were ultimately not included due to either temporal or spatial limitations. The approach to only include historical monitoring consistently conducted statewide limited the analysis to only rocky substrate programs. However, data collected by spatially limited survey programs such as the National Park Service's KFMP at the Northern Channel Islands will be integrated in future analyses.

All non-estuarine MPAs were scored for level of historical monitoring according to the following rule: for each of the five monitoring programs, MPAs received a single point for an annual survey replicate conducted since the beginning of the monitoring program. As an example, Point Lobos SMR has been surveyed for biodiversity by MARINe in 2001, 2005, 2014, and 2017, so receives a point value of 4. These individual survey points for all five monitoring programs are then summed for an MPA to create an initial score. To account for the importance of monitoring multiple habitats over time, initial scores were multiplied by a "monitoring multiplier" that ranged from 0 to 3 representing the number of habitats, of the three listed above, that were monitored over the date range considered.

Historical monitoring scores were calculated as follows:

Total Historical Monitoring Score = (rocky intertidal biodiversity + rocky intertidal fixed plot + PISCO kelp forest monitoring + RCCA kelp forest monitoring + mid-depth ROV) * monitoring multiplier

CRITERIA 3: Habitat Based Connectivity

The spatial connectivity among sites through larval dispersal within the MPA Network was examined for key habitats excluding estuaries. This was accomplished using a set of outputs from the ROMS model coupled to a coastwide habitat model. ROMS is a four dimensional (space over time) general circulation model that is widely used by the scientific community for simulating currents and tracking particle movement throughout the CCLME. Connectivity is modeled by tracking the simulated movement of passive particles released into the ROMS-derived nearshore ocean circulation patterns through time.

The nearshore habitat model was applied to ROMS to "convert" particles into simulated larvae. The key simulation was done using a 30-60 day pelagic larval duration (PLD) period. PLDs represent the dispersal period for larvae and 30 to 60 days is a PLD representative for most non-algal species (algae have propagules like spores as a dispersal stage) along the California coast. Habitat extent (e.g. area of rock in a location) was used in two ways: (1) as proxy for number of larvae produced for species associated with a particular habitat in a source location, and (2) as a target for species associated with a particular habitat in a sink location. Hence, the coupled model tracks the larval production (source) from a given location to a settlement location (sink) within the modeling domain (U.S. West Coast). Sites were ranked based on their level of larval connectivity to areas both inside and outside MPAs. Areas that are highly connected (both sources and sinks) across habitats were prioritized.

Summed source and sink numbers served as connectivity scores for individual MPA sites. The scores represent an individual MPA's level of connection to the entire California coastline. Sites that were significant sources and/or sinks received higher scores than areas that were less connected. It is important to note that the ROMS output can be considered a measure of connectivity among cells (locations) but should not be considered an estimate of one cell's contribution of larvae (propagules) to other cells. This is because cells in ROMS grids are only characterized by oceanographic factors. To estimate the level of larval contribution, propagule production for donor cell, and amount of suitable habitat for receiving cells, high resolution habitat information must be incorporated as a sub-model. For detailed information on ROMS methodology, habitat sub-model integration, and results, see Appendix F.

CRITERIA 4: High Resolution Mapping of Recreational Fishing Effort

Recovery trajectories of fished populations following MPA implementation are highly dependent on the level of fishing mortality (F) to which those populations were subjected prior to protection (Micheli et al. 2004, White et al. 2013, Casselle et al. 2015, Starr et al. 2015, White et al. 2016). In other words, more pronounced ecological change should be expected inside MPAs where F was once high, and these sites should be prioritized for long-term monitoring. However, many populations lack direct estimates of F. For these populations, fishing effort can provide a reasonable proxy for F.

To attribute fishing effort at a spatial scale appropriate for determining influence on MPAs, data collected by CDFW's California Recreational Fisheries Survey (CRFS) was used to calculate a relative index of fishing pressure by standardizing the sampled historical fishing effort (angler boat trips) over time and at sites, excluding estuaries, statewide. The analysis focused on recreational fishing trips targeting common nearshore rocky reef dwelling species (Appendix F). While there are many other types of target species and fishing modes, including commercial fisheries, the recreational private and rental boat support mapping at the high spatial resolution needed for this analysis. It presents an index of historical recreational bottom fishing pressure on MPAs prior to implementation, independent of fishing pressure from other modes of fishing. Results suggested that relative recreational fishing effort was concentrated in coastal areas surrounding major ports and surrounding island areas closest to these ports. Relative index numbers served as comparative fishing effort scores calculated within one-minute-by-one-minute areas (blocks) which were then summarized as maximum values for individual MPAs. For detailed information on methods, see Appendix F.

INTEGRATING QUANTITATIVE METHODS

For each of the four criteria listed above, a rank-order list of MPAs within each bioregion was generated based on final scores (Appendix F, Table F3). The four

individual rank-order values were then averaged to generate a final integrated rank-order value. MPAs were sorted into tiers based on these values, with cutoffs for each tier varying by bioregion to ensure equal representation of the bioregion's MPAs within each of the three tiers (Table 4). For example, the 34 north coast MPAs were sorted so that 11 MPAs fell into Tier I, 11 MPAs fell into Tier II, and 12 MPAs fell into Tier III (Appendix F, Table F3).

These rankings do not reflect the relative importance of a given MPA to the Network, but rather how well an MPA meets the specific quantitative criteria previously outlined.

Tier I MPAs received the highest integrated rank-order values. They meet many of the design criteria needed for effective protection, are well connected components of the MPA network, and may have long time series of monitoring data and/or have experienced high historical fishing effort, which make these MPAs good candidates for detecting the potential effects of protection over time. Many of the MPAs on the Tier I index site list are state marine reserves, which were designated during the design process to be the backbone of the network (CDFW 2016), thus providing "an improved marine life reserve component consistent with the guidelines for the preferred siting alternative" (FGC §2853(c)(1)).

Tier II MPAs received the second-highest integrated rank-order values. Many of these MPAs ranked high in one or two of the quantitative methods and may be considered valuable index sites for more specific research questions. Tier II MPAs can be considered for long-term monitoring when funding permits, when an MPA cluster is split between tiers, or to help answer more regionally focused questions.

Tier III MPAs received the lowest integrated rank-order values. While valuable to the Network's integrity, many of these MPAs are limited for monitoring purposes at this time due to features such as smaller size, fewer representative habitats, are difficult to access, have limited or no long-term monitoring data, or have more allowable take within their boundaries. Tier III MPAs are recommended for long-term monitoring only to answer very specific or localized research questions.

TABLE 4: Recommended MPA tiers within each bioregion (MPAs listed north to south). Abbreviations: SMR = state marine reserve, SMCA = state marine conservation area, SMRMA = state marine recreational management area.

TIER I	TIER II	TIER III
NORTH COAST		
Reading Rock SMCA	Point St. George Reef Offshore SMCA	Pyramid Point SMCA
Reading Rock SMR	South Cape Mendocino SMR	Samoa SMCA
Sea Lion Gulch SMR	Big Flat SMCA	Mattole Canyon SMR
Ten Mile SMR	Double Cone Rock SMCA	Ten Mile Beach SMCA
MacKerricher SMCA	Point Cabrillo SMR	Russian Gulch SMCA
Saunders Reef SMCA	Point Arena SMR	Van Damme SMCA
Stewarts Point SMR	Point Reyes SMCA	Point Arena SMCA
Salt Point SMCA	Duxbury Reef SMCA	Sea Lion Cove SMCA
Bodega Head SMR	North Farallon Islands SMR	Del Mar Landing SMR
Bodega Head SMCA	Southeast Farallon Island SMR	Stewarts Point SMCA
Point Reyes SMR	Southeast Farallon Island SMCA	Gerstle Cove SMR
		Russian River SMCA
CENTRAL COAST		
Montara SMR	Pillar Point SMCA	Portuguese Ledge SMCA
Año Nuevo SMR	Natural Bridges SMR	Edward F. Ricketts SMCA
Greyhound Rock SMCA	Soquel Canyon SMCA	Lovers Point - Julia Platt SMR
Carmel Bay SMCA	Pacific Grove Marine Gardens SMCA	Carmel Pinnacles SMR
Point Lobos SMR	Asilomar SMR	Point Lobos SMCA
Piedras Blancas SMR	Point Sur SMR	Point Sur SMCA
Point Buchon SMR	Big Creek SMR	Big Creek SMCA
Point Buchon SMCA	Cambria SMCA	Piedras Blancas SMCA
Vandenberg SMR		White Rock SMCA
SOUTH COAST		
Point Conception SMR	South Point SMR	Kashtayit SMCA
Campus Point SMCA	Gull Island SMR	Naples SMCA
Harris Point SMR	Begg Rock SMR	Richardson Rock SMR
Carrington Point SMR	Santa Barbara Island SMR	Judith Rock SMR
Scorpion SMR	Point Vicente SMCA	Skunk Point SMR
Anacapa Island SMCA	Abalone Cove SMCA	Painted Cave SMCA
Anacapa Island SMR	Arrow Point to Lion Head Point SMCA	Footprint SMR
Point Dume SMCA	Long Point SMR	Blue Cavern Offshore SMCA
Point Dume SMR	Crystal Cove SMCA	Casino Point SMCA
Blue Cavern Onshore SMCA	Laguna Beach SMCA	Lover's Cove SMCA
Laguna Beach SMR	San Diego-Scripps Coastal SMCA	Farnsworth Onshore SMCA
Dana Point SMCA	Matlahuayl SMR	Farnsworth Offshore SMCA
Swami's SMCA	South La Jolla SMCA	Cat Harbor SMCA
South La Jolla SMR	Cabrillo SMR	Tijuana River Mouth SMCA

Although soft-bottom habitat makes up the majority (85%) of substrate along California's coast, MPA size and spacing design guidelines largely influenced designs which focused around the patchy distributions of limited rocky substrate (Saarman et al. 2013). *Because rocky substrate is associated with a higher density of fished species (Bond et al. 1999, Stephens et al. 2006), presence of highly productive kelp forests (Carr & Reed 2015, Schiel & Foster 2015), and significant human use (CDFW CRFS database 2005-present, CPFV logbook data), these areas are a primary focus for monitoring.* Tables 5 and 6 provide area and linear extent of habitats within each MPA.

Prioritized sites in all Tiers include a variety of habitat types.

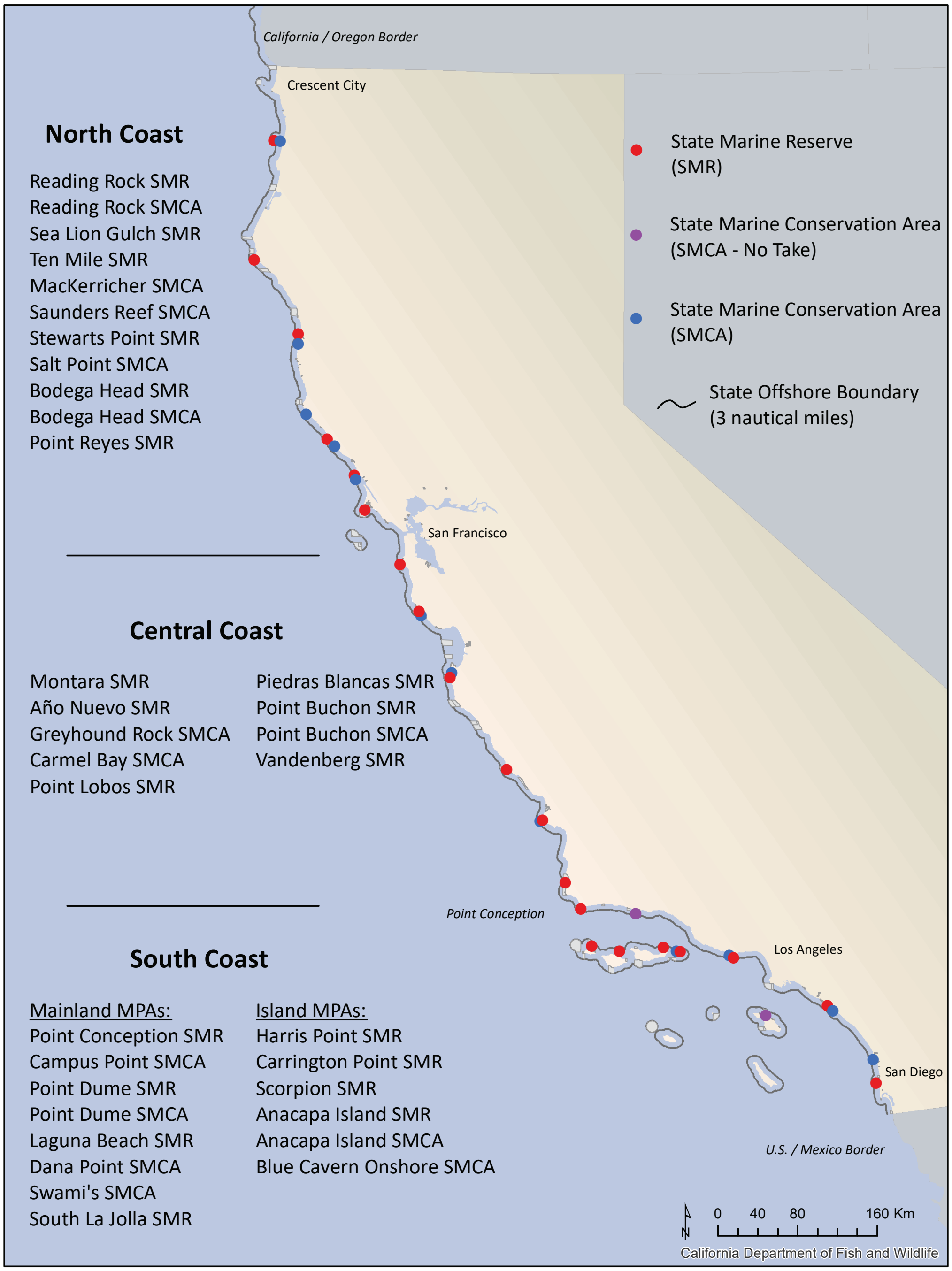


FIGURE 3: Tier I MPA sites by Marine Protected Area Monitoring Action Plan sampling bioregion.

TABLE 5: Soft bottom habitats - Area or linear extent of coastline and percentage of available habitats within each bioregion - Tier I MPA sites. Abbreviations: SMR = state marine reserve, SMCA = state marine conservation area, SMRMA = state marine recreational management area.

MPA	BIOREGION	TOTAL AREA (mi²)	BEACHES (linear mi)	SOFT SUBSTRATE 0-30m (linear mi)	SOFT SUBSTRATE 30-100m (area mi²)	SOFT SUBSTRATE 100-3000m (area mi²)	ESTUARY (area mi²)	EELGRASS (area mi²)	COASTAL MARSH (area mi²)
READING ROCK SMCA	NORTH	11.96	2.96	2.82	3.77	0.00	0.00	0.00	0.00
READING ROCK SMR		9.60	0.00	0.00	9.43	0.00	0.00	0.00	0.00
SEA LION GULCH SMR		10.42	2.42	2.01	3.86	1.09	0.00	0.00	0.00
TEN MILE SMR		11.95	2.63	2.00	8.13	0.46	0.00	0.00	0.01
MACKERRICHER SMCA		2.48	4.40	0.00	0.06	0.00	0.00	0.00	0.01
SAUNDERS REEF SMCA		9.36	1.83	0.19	5.25	0.00	0.00	0.00	0.00
STEWARTS POINT SMR		24.06	0.89	0.18	21.89	0.00	0.00	0.00	0.00
SALT POINT SMCA		1.84	0.59	0.36	0.37	0.00	0.00	0.00	0.00
BODEGA HEAD SMR		9.34	1.32	0.26	5.38	0.00	0.00	0.00	0.00
BODEGA HEAD SMCA		12.31	0.00	0.00	6.31	0.00	0.00	0.00	0.00
POINT REYES SMR		9.55	8.38	2.07	1.20	0.00	0.00	0.00	0.00
MONTARA SMR	CENTRAL	11.81	2.14	0.95	7.75	0.00	0.00	0.00	0.01
AÑO NUEVO SMR		11.15	10.46	3.34	1.63	0.00	0.00	0.00	0.05
GREYHOUND ROCK SMCA		12.00	2.79	0.70	8.61	0.00	0.00	0.00	0.00
CARMEL BAY SMCA		2.20	3.09	1.58	0.36	0.07	0.02	0.00	0.02
POINT LOBOS SMR		5.50	2.10	1.36	2.05	0.33	0.00	0.00	0.01
PIEDRAS BLANCAS SMR		10.44	5.48	4.43	2.25	0.00	0.01	0.00	0.06
POINT BUCHON SMR		6.68	1.46	0.73	4.56	0.00	0.00	0.00	0.00
POINT BUCHON SMCA		12.19	0.00	0.00	8.11	3.02	0.00	0.00	0.00
VANDENBERG SMR		32.91	13.33	12.82	10.11	0.00	0.04	0.00	0.09
POINT CONCEPTION SMR	SOUTH	22.52	2.73	1.83	15.79	3.26	0.00	0.00	0.01
CAMPUS POINT SMCA		10.56	3.02	1.21	7.08	1.48	0.01	0.00	0.01
HARRIS POINT SMR		25.40	2.71	5.60	15.93	2.54	0.00	0.00	0.00
CARRINGTON POINT SMR		12.78	0.82	3.32	3.82	0.00	0.00	0.00	0.00
SCORPION SMR		9.64	0.89	2.28	4.88	0.18	0.00	0.01	0.00
ANACAPA ISLAND SMCA		7.30	0.19	1.74	6.21	0.18	0.00	0.00	0.00
ANACAPA ISLAND SMR		11.55	1.12	2.59	7.25	0.78	0.00	0.00	0.00
POINT DUME SMCA		15.92	4.09	3.14	5.95	7.18	0.00	0.00	0.00
POINT DUME SMR		7.53	2.77	1.81	1.07	4.30	0.00	0.00	0.00
BLUE CAVERN ONSHORE SMCA		2.61	1.66	1.89	0.79	1.43	0.00	0.00	0.00
LAGUNA BEACH SMR		6.72	3.48	3.65	2.82	1.79	0.00	0.00	0.00
DANA POINT SMCA		3.47	3.60	1.90	0.79	0.00	0.00	0.00	0.00
SWAMI'S SMCA		12.71	3.77	1.29	3.85	5.52	0.00	0.00	0.00
SOUTH LA JOLLA SMR		5.04	2.33	0.07	0.85	0.00	0.00	0.00	0.00
NORTH BIOREGION TOTAL		1618.90	391.45	227.31	820.08	75.93	60.84	13.31	136.88
CENTRAL BIOREGION TOTAL		1317.84	272.90	231.37	602.63	158.19	7.02	1.94	45.02
SOUTH BIOREGION TOTAL		2350.87	441.29	362.57	672.08	392.73	43.30	19.64	60.78

*All miles are statute.

TABLE 6: Rocky habitats - Area or linear extent of coastline and percentage of available habitats within each bioregion - Tier I MPA sites. Abbreviations: SMR = state marine reserve, SMCA = state marine conservation area, SMRMA = state marine recreational management area.

MPA	BIOREGION	TOTAL AREA (mi^2)	ROCKY INTERTIDAL (linear mi)	KELP (linear mi)	HARD SUBSTRATE 0-30m (linear mi)	HARD SUBSTRATE 30-100m (area mi^2)	HARD SUBSTRATE 100-3000m (area mi^2)
READING ROCK SMCA	NORTH	11.96	0.22	0.00	0.08	0.00	0.00
READING ROCK SMR	NORTH	9.60	0.00	0.00	0.00	0.16	0.00
SEA LION GULCH SMR	NORTH	10.42	2.32	0.19	0.56	2.86	0.12
TEN MILE SMR	NORTH	11.95	6.77	2.43	1.10	0.50	0.00
MACKERRICHER SMCA	NORTH	2.48	3.91	2.23	0.00	0.05	0.00
SAUNDERS REEF SMCA	NORTH	9.36	4.29	1.11	2.52	1.65	0.00
STEWARTS POINT SMR	NORTH	24.06	4.57	3.00	3.03	0.88	0.00
SALT POINT SMCA	NORTH	1.84	4.03	3.84	2.46	0.54	0.00
BODEGA HEAD SMR	NORTH	9.34	2.74	0.00	2.27	1.85	0.00
BODEGA HEAD SMCA	NORTH	12.31	0.29	0.00	1.33	5.11	0.00
POINT REYES SMR	NORTH	9.55	5.37	0.00	1.49	0.09	0.00
MONTARA SMR	CENTRAL	11.81	3.45	0.55	2.73	0.72	0.00
AÑO NUEVO SMR	CENTRAL	11.15	6.86	0.24	1.83	0.79	0.00
GREYHOUND ROCK SMCA	CENTRAL	12.00	3.39	0.08	2.38	0.03	0.00
CARMEL BAY SMCA	CENTRAL	2.20	2.66	2.57	1.15	0.12	0.02
POINT LOBOS SMR	CENTRAL	5.50	13.70	4.61	3.91	1.38	0.02
PIEDRAS BLANCAS SMR	CENTRAL	10.44	6.09	4.18	2.10	0.54	0.00
POINT BUCHON SMR	CENTRAL	6.68	2.71	1.85	2.59	0.47	0.00
POINT BUCHON SMCA	CENTRAL	12.19	0.00	0.00	0.00	0.32	0.04
VANDENBERG SMR	CENTRAL	32.91	10.21	0.63	1.45	0.08	0.00
POINT CONCEPTION SMR	SOUTH	22.52	3.13	1.29	1.84	0.32	0.10
CAMPUS POINT SMCA	SOUTH	10.56	1.37	1.62	1.85	0.04	0.00
HARRIS POINT SMR	SOUTH	25.40	8.18	2.30	1.96	2.40	0.25
CARRINGTON POINT SMR	SOUTH	12.78	5.35	1.24	1.97	0.27	0.00
SCORPION SMR	SOUTH	9.64	4.07	0.05	0.69	0.33	0.01
ANACAPA ISLAND SMCA	SOUTH	7.30	3.50	0.00	0.54	0.03	0.00
ANACAPA ISLAND SMR	SOUTH	11.55	6.50	0.65	0.65	0.10	0.00
POINT DUME SMCA	SOUTH	15.92	0.44	0.85	1.05	0.00	0.00
POINT DUME SMR	SOUTH	7.53	1.54	0.57	0.47	0.00	0.89
BLUE CAVERN ONSHORE SMCA	SOUTH	2.61	1.68	1.40	0.88	0.01	0.00
LAGUNA BEACH SMR	SOUTH	6.72	2.48	0.00	1.13	0.00	0.00
DANA POINT SMCA	SOUTH	3.47	2.06	0.80	1.67	0.00	0.00
SWAMI'S SMCA	SOUTH	12.71	1.20	1.44	1.43	0.02	0.04
SOUTH LA JOLLA SMR	SOUTH	5.04	1.45	0.72	1.95	0.50	0.00
NORTH BIOREGION TOTAL		1618.90	301.58	104.23	114.65	79.24	0.76
CENTRAL BIOREGION TOTAL		1317.84	238.83	151.07	95.97	46.60	29.98
SOUTH BIOREGION TOTAL		2350.87	280.71	253.51	191.62	47.79	6.05

*All miles are statute

REFERENCE SITE CRITERIA

Comparison of ecological metrics between MPA index sites and reference sites outside of MPAs, or inside/outside comparison, has been well established as a method of assessing the progress of MPAs toward conservation goals (Paddack & Estes 2000, Gell & Roberts 2003, Lester & Halpern 2008, Lester et al. 2009). However, differences between MPA sites and sites outside of MPAs unrelated to protection status (e.g. habitat quality, physical oceanographic conditions) are also identified as common confounding factors when assessing the effects of protection (Charton & Ruzafa 1999, Charton et al. 2000). Therefore, effective MPA monitoring requires informed selection of reference sites outside of MPAs so that inside/outside comparison is meaningful.

For long-term monitoring, selection of reference sites will be the responsibility of individual PIs. Although this Action Plan does not mandate monitoring at specific reference sites, the state requires that reference sites be selected, and data be provided, that supports compatibility with the corresponding MPA index sites they are being compared to. Compatibility is based on the following criteria:

Biotic Factors

- **Ecological conditions at the time of MPA implementation:** Detection of ecological divergence between MPA and reference sites requires similar initial conditions at both sites (Starr et al. 2015). Key metrics to consider include functional biodiversity, species composition, species density and biomass, and size frequency distributions.

Human Uses

- **Fishing pressure at time of MPA implementation:** Responses of fished populations to MPA implementation are highly dependent on the level of fishing pressure to which those populations were exposed before being protected (Micheli et al. 2004, Kaplan et al. in prep, Yamane et al. in prep). Key metrics to consider include: local fishing mortality (F) for targeted species, if available; historical fishing effort; and/or regional proxies for fishing effort (e.g., distance from port).
- **Non-consumptive human use:** While generally less significant than fishing, non-consumptive human use (e.g,. boating, tidepooling, scuba diving) affects marine ecosystems. Examples of deleterious effects associated with non-consumptive use include trampling, accidental take, and habitat alteration (Tratalos & Austin 2001, Davenport & Davenport 2006, Lloret et al. 2008). Key metrics to consider include: type and level of non-consumptive use (e.g. from MPA Watch beach surveys), water quality, and frequency of boat anchoring.

Abiotic Factors

- **Geography:** Biogeographic boundaries play an important role in driving marine community structure, and California's coastline encompasses several distinct marine ecoregions. It is therefore crucial to group index sites and reference sites at the correct geographic scale (Hamilton et al. 2010). Furthermore, a reference site adjacent or proximate to an MPA may be ecologically connected to that MPA through larval dispersal or spillover of adult organisms, potentially confounding inside/outside comparison (Moffitt et al. 2013). Key metrics to consider include: presence of biogeographic barriers and distance between MPA and reference sites.

- **Habitat features:** Habitat/microhabitat type, quality, and availability are critical drivers of marine species distribution and community composition, in some cases more influential than the presence or absence of protection (Lindholm et al. 2004, Oliver et al. 2010, Starr et al. 2015, Fulton et al. 2016). Key metrics to consider include: depth, percent rock, rugosity, habitat complexity, macroalgal cover, and distribution of habitat types.

- **Geology:** Seafloor sediment and benthic communities both play important roles in driving marine community structure (Snelgrove 1997). Key metrics to consider include: underlying rock type (e.g., shale, granite), grain size, benthic community structure, and proximity to major geologic features such as submarine canyons.

- **Physical and chemical oceanography:** Physical and chemical oceanographic conditions have significant impacts on marine communities. For example, by driving patterns of larval dispersal or influencing nutrient availability in an ecosystem (Menge et al. 1997, Ruzicka et al. 2012, Nickols et al. 2013). Key metrics to consider include: primary productivity/nutrient availability, wave exposure (including direction, extent, and intensity), and variability and spatial distribution of relevant dynamics and processes, such as upwelling, fronts, river plumes, ocean acidification, and hypoxia.

State-funded long-term monitoring projects will be required to justify reference site(s), based on the above criteria and using quantitative methods whenever possible. Qualitative comparisons are acceptable in situations where data are limited and potential reference sites are logistically difficult to access. Quantitative methods to address this question include: statistical comparison of habitat metrics (e.g., rock rugosity), habitat suitability modeling (Young et al. 2010), covariate analysis with matching models (Ahmadia et al. 2015), oceanographic observations, and oceanographic circulation models such as the ROMS (Moore et al. 2011).

BOX 3: Examining oceanographic and biogeographical conditions across MPAs and reference sites on the north coast.

Along the California coast, marine ecosystems exist in a highly energetic and variable oceanographic environment that shapes the dynamics of populations and communities (Checkley and Barth, 2009, Bjorkstedt et al. 2017). Understanding how ocean conditions vary over space and time is therefore essential for interpreting ecological responses to spatial management. A diverse suite of ocean observations can be synthesized to characterize historical conditions and spatial context to inform adaptive management strategies for the MPA Network that account for changing ocean conditions due to climate change.

For example, analysis based on oceanographic data for MPAs and reference sites along the north coast of California suggests that in most cases, MPA-reference pairs share similar oceanographic influences across seasons, while also highlighting factors that may contribute to MPA-reference site differences as the ecosystem changes over time (Robinson et al, in prep). Successful development of oceanographic context for the north coast and its application, drawing on observation systems (e.g., CeNCOOS and NANOOS), might serve as a template for a statewide synthesis in support of broader, long-term monitoring, evaluation, and adaptive management of California's MPA Network.

Indicator Species Selection

California's MPA Network was implemented, in part, to help conserve ecologically and economically important marine species, as well as to protect the structure and function of marine ecosystems. To that end, this Action Plan provides lists of species and species groups to target for long-term monitoring at MPA and reference sites (Tables 7-10). These lists of fishes, invertebrates, algae, and birds were compiled using the following sources (in the tables, "Y" indicates that the species is listed in the corresponding source, "N" indicates that it is not).

MPA Regional Monitoring Plans.
These plans were developed during MPA baseline monitoring and include regionally-focused lists of ecologically and economically important marine species. Plans and associated species lists were developed for each of the four coastal planning regions in which the MLPA was implemented (north, north central, central, and south). However, it is important to note that long-term MPA monitoring will take place in three broader-scale bioregions, or clusters of similar biota, ecological communities, and key habitats, as discussed in section 2.3 above.

Deepwater MPA Monitoring Workshop.
This 2017 workshop convened experts from across the state to discuss monitoring of deep marine ecosystems (>100 m depth) in California's MPAs. The species list developed at this workshop and included in Action Plan Appendix E represents these experts' best understanding of which species and species groups should be targeted for monitoring in deep ecosystems in order to meaningfully assess MPA performance.

Marine Life Management Act.
The Marine Life Management Act (MLMA) Master Plan (CDFW 2018) identifies 36 species of finfish and invertebrates, which are the targets of 45 distinct fisheries, as priority species for fishery management. These species represent the majority of commercial landings value in California as well as species of particular recreational importance.

Special Status Species.
For the purposes of this Action Plan, "species of special status" is any fish, invertebrate, algae, plant, or bird native to California that is identified in one of the four MPA regional monitoring plans, deepwater MPA monitoring workshop recommendations, or MLMA Master Plan, and currently satisfies one or more of the following criteria:

- Is listed as threatened or endangered under the Federal Endangered Species Act[42]
- Is listed as threatened or endangered under the California Endangered Species Act[43]
- Is identified as a species of concern[44] by the National Marine Fisheries Service. These species are not currently listed under an Endangered Species Act, but are identified as species to take proactive measures to address conservation needs in hopes of preventing the need to protect them under an Endangered Species Act
- Listed as overfished by the Pacific Fishery Management Council[45]
- Considered by CDFW to be a Species of Special Concern[46]. Currently experiencing a fishing moratorium, meaning this species was once targeted for commercial and/or recreational harvest, but now all direct take is prohibited

42. https://www.fws.gov/endangered/
43. http://www.dfg.ca.gov/wildlife/nongame/t_e_spp/
44. https://www.fws.gov/endangered/
45. https://www.pcouncil.org/
46. https://www.wildlife.ca.gov/Conservation/SSC

TABLE 7: Indicator fish species.

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans				DEEPWATER WORKSHOP	MLMA SPECIES
		NORTH	NORTH CENTRAL	CENTRAL	SOUTH		
ANCHOVY, NORTHERN	*Engraulis mordax*	N	N	Y	N	N	N
BASS, BARRED SAND	*Paralabrax nebulifer*	N	N	N	Y	Y	Y
BASS, GIANT SEA [1]	*Stereolepis gigas*	N	N	N	Y	Y	N
BASS, KELP	*Paralabrax clathratus*	N	N	N	Y	N	Y
BASS, SPOTTED SAND	*Paralabrax maculatofasciatus*	N	N	N	Y	N	Y
BLACKSMITH	*Chromis punctipinnis*	N	N	N	Y	N	N
CABEZON	*Scorpaenichthys marmoratus*	Y	Y	Y	Y	N	N
CROAKER	Sciaenidae	N	N	N	Y	N	N
CROAKER, WHITE SEABASS	*Atractoscion nobilis*	N	N	N	Y	N	Y
FLATFISH	Multiple spp.	Y	Y	Y	Y	Y	N
FLATFISH, CALIFORNIA HALIBUT	*Paralichthys californicus*	N	Y	Y	Y	N	Y
FLATFISH, DIAMOND TURBOT	*Pleuronichthys guttulatus*	N	N	Y	N	N	N
FLATFISH, DOVER SOLE	*Microstomus pacificus*	N	N	Y	N	N	N
FLATFISH, ENGLISH SOLE	*Parophrys vetulus*	N	N	Y	N	N	N
FLATFISH, PACIFIC HALIBUT	*Hippoglossus stenolepis*	Y	N	N	N	N	N
FLATFISH, PACIFIC SANDDAB	*Citharichthys sordidus*	N	N	Y	N	N	N
FLATFISH, PETRALE SOLE	*Eopsetta jordani*	N	N	Y	N	N	N
FLATFISH, STARRY FLOUNDER	*Platichthys stellatus*	Y	Y	Y	N	Y	N
GOBY	Gobiidae	N	N	Y	Y	N	N
GOBY, BLACKEYE	*Rhinogobiops nicholsii*	N	N	Y	N	N	N
GREENLING, KELP	*Hexagrammos decagrammus*	Y	Y	Y	N	N	N
GREENLING, PAINTED	*Oxylebius pictus*	N	Y	Y	N	N	N
GUITARFISH, SHOVELNOSE	*Rhinobatos productus*	N	N	N	Y	N	N
HAGFISH, PACIFIC	*Eptatretus stoutii*	N	N	Y	Y	N	Y
HERRING, PACIFIC	*Clupea pallasii*	Y	N	N	N	N	Y
LINGCOD	*Ophiodon elongatus*	Y	Y	Y	Y	Y	N
OCEAN WHITEFISH	*Caulolatilus princeps*	N	N	N	Y	Y	Y
PERCH	Embiotocidae	Y	Y	Y	Y	N	N
PERCH, BLACK	*Embiotoca jacksoni*	N	N	Y	N	N	N
PERCH, PILE	*Rhacochilus vacca*	N	N	Y	N	N	N
PERCH, SHINER	*Cymatogaster aggregata*	N	Y	Y	N	N	Y
PERCH, STRIPED SEA	*Embiotoca lateralis*	Y	Y	Y	N	N	N
PRICKLEBACK, MONKEYFACE	*Cebidichthys violaceus*	N	Y	Y	N	N	N
PRICKLEBACK, ROCK	*Xiphister mucosus*	N	Y	N	N	N	N
RATFISH, SPOTTED	*Hydrolagus colliei*	N	N	Y	N	Y	N
RAY, BAT	*Myliobatis californicus*	N	Y	Y	Y	N	N
ROCKFISH	*Sebastes* spp.	Y	Y	Y	Y	Y	N
ROCKFISH, AURORA	*Sebastes aurora*	N	N	N	N	Y	N
ROCKFISH, BANK	*Sebastes rufus*	N	N	Y	Y	N	N
ROCKFISH, BLACK	*Sebastes melanops*	Y	Y	Y	N	N	N
ROCKFISH, BLACK-AND-YELLOW	*Sebastes chrysomelas*	Y	Y	Y	N	N	N

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans				DEEPWATER WORKSHOP	MLMA SPECIES
		NORTH	NORTH CENTRAL	CENTRAL	SOUTH		
ROCKFISH, BLUE	*Sebastes mystinus*	Y	Y	Y	Y	N	N
ROCKFISH, BOCACCIO [2]	*Sebastes paucispinis*	N	Y	Y	Y	Y	N
ROCKFISH, BROWN	*Sebastes auriculatus*	Y	Y	N	N	Y	N
ROCKFISH, CANARY	*Sebastes pinniger*	Y	Y	Y	N	Y	N
ROCKFISH, CHINA	*Sebastes nebulosus*	N	Y	Y	N	N	N
ROCKFISH, COPPER	*Sebastes caurinus*	Y	Y	Y	N	Y	N
ROCKFISH, COWCOD [2, 3]	*Sebastes levis*	N	N	Y	Y	Y	N
ROCKFISH, DWARF	*Sebastes* spp.	Y	Y	Y	Y	Y	N
ROCKFISH, GOPHER	*Sebastes carnatus*	N	Y	Y	N	Y	N
ROCKFISH, GREENSPOTTED	*Sebastes chlorostictus*	N	N	N	N	Y	N
ROCKFISH, GREENSTRIPED	*Sebastes elongatus*	Y	N	N	N	Y	N
ROCKFISH, KELP	*Sebastes atrovirens*	Y	Y	Y	Y	N	N
ROCKFISH, OLIVE	*Sebastes serranoides*	N	N	N	Y	N	N
ROCKFISH, QUILLBACK	*Sebastes maliger*	N	N	N	N	Y	N
ROCKFISH, ROSY	*Sebastes rosaceus*	N	N	Y	N	N	N
ROCKFISH, SHORTBELLY	*Sebastes jordani*	Y	Y	Y	Y	N	N
ROCKFISH, SPLITNOSE	*Sebastes diploproa*	N	N	N	N	Y	N
ROCKFISH, VERMILION	*Sebastes miniatus*	Y	Y	Y	Y	Y	N
ROCKFISH, WIDOW	*Sebastes entomelas*	Y	Y	Y	Y	Y	N
ROCKFISH, YELLOWEYE [3]	*Sebastes ruberrimus*	Y	Y	Y	N	Y	N
ROCKFISH, YELLOWTAIL	*Sebastes flavidus*	Y	Y	Y	N	N	N
SABLEFISH	*Anoplopoma fimbria*	Y	N	Y	Y	Y	N
SALMONIDS	*Oncorhynchus* spp.	Y	N	Y	N	N	N
SARDINE, PACIFIC	*Sardinops sagax*	N	N	Y	N	N	N
SCORPIONFISH, CALIFORNIA	*Scorpaena guttata*	N	N	N	Y	Y	N
SCULPIN	Cottidae	Y	N	Y	N	N	N
SEÑORITA	*Oxyjulis californica*	N	N	Y	Y	N	N
SHARK, LEOPARD	*Triakis semifasciata*	Y	Y	Y	Y	N	N
SHARK, PACIFIC ANGEL	*Squatina californica*	N	N	N	Y	Y	Y
SHEEPHEAD, CALIFORNIA	*Semicossyphus pulcher*	N	N	N	Y	Y	Y
SILVERSIDE, CALIFORNIA GRUNION	*Leuresthes tenuis*	N	N	Y	Y	N	N
SILVERSIDE, JACKSMELT	*Atherinopsis californiensis*	N	N	N	Y	N	Y
SILVERSIDE, TOPSMELT	*Atherinops affinis*	Y	N	Y	Y	N	N
SKATE, CALIFORNIA	*Raja inornata*	N	N	Y	N	N	N
SKATE, LONGNOSE	*Raja rhina*	N	N	Y	N	Y	N
SMELT, NIGHT	*Spirinchus starksi*	N	N	Y	N	N	Y
SMELT, SURF	*Hypomesus pretiosus*	Y	Y	Y	N	N	N
STICKLEBACK, THREESPINE	*Gasterosteus aculeatus*	Y	N	N	N	N	N
THORNYHEAD	*Sebastolobus* spp.	Y	N	Y	N	N	N
TUBESNOUT	*Aulorhynchus flavidus*	N	N	Y	N	N	N
YOUNG-OF-YEAR	Multiple spp.	Y	Y	Y	Y	N	N

1. Special status: Fishing moratorium (no direct commercial or recreational fishing allowed)
2. Special status: Identified as a species of concern by the National Marine Fisheries Service
3. Special status: Listed as overfished by the Pacific Fishery Management Council, as of 8/24/2018

TABLE 8: Indicator invertebrate species.

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans: NORTH	NORTH CENTRAL	CENTRAL	SOUTH	DEEPWATER WORKSHOP	MLMA SPECIES
ABALONE	Haliotidae	N	N	N	Y	N	N
ABALONE, BLACK [1,2]	*Haliotis cracherodii*	N	Y	Y	Y	N	N
ABALONE, RED [2]	*Haliotis rufescens*	Y	Y	Y	N	N	Y
AMPHIPOD, GAMMARID	Gammaridae	N	N	Y	N	N	N
ANEMONE, FISH-EATING	*Urticina piscivora*	N	N	Y	N	N	N
ANEMONE, LARGE SOLITARY	Multiple spp.	N	N	N	N	Y	N
ANEMONE, PLUMOSE	*Metridium* spp.	Y	Y	Y	Y	Y	N
BARNACLE	*Balanus spp. Chthamalus fissus/dalli*	Y	N	Y	Y	N	N
BARNACLE, ACORN	*Balanus glandula*	N	N	Y	N	N	N
BARNACLE, GOOSENECK	*Pollicipes polymerus*	N	N	Y	N	N	N
BARNACLE, PINK VOLCANO	*Tetraclita rubescens*	N	N	Y	N	N	N
BARNACLE, THATCHED	*Semibalanus cariosus*	N	N	Y	N	N	N
CLAM	Multiple spp.	Y	N	N	N	N	N
CLAM, BEAN	*Donax gouldii*	N	N	N	Y	N	N
CLAM, GEODUCK	*Panopea generosa*	Y	Y	Y	N	N	Y
CLAM, PACIFIC GAPER	*Tresus nuttallii*	Y	Y	Y	Y	N	N
CLAM, PACIFIC LITTLENECK	*Leukoma staminea*	Y	Y	Y	Y	N	N
CLAM, PACIFIC RAZOR	*Siliqua patula*	Y	Y	N	N	N	N
CLAM, PISMO	*Tivela stultorum*	N	N	N	Y	N	Y
CLAM, WASHINGTON	*Saxidomus nuttalli*	N	N	N	Y	N	N
CORAL, BLACK	*Antipathes* spp.	N	N	Y	N	N	N
CORAL, LOPHELIA	Lophelia	N	N	N	N	Y	N
CORAL, MUSHROOM SOFT	*Anthomastus ritteri*	Y	N	N	N	N	N
CORAL, SOFT	Octocorallia	N	N	Y	N	N	N
CRAB, BROWN BOX	*Lopholithodes foraminatus*	N	Y	Y	N	Y	N
CRAB, DUNGENESS	*Metacarcinus magister*	Y	Y	Y	N	N	Y
CRAB, GALATHEID (SQUAT LOBSTER)	*Munida quadrispina*	N	N	Y	N	N	N
CRAB, ROCK	*Cancer* spp. *Metacarcinus* spp.	Y	Y	Y	Y	Y	N
CRAB, SAND	*Emerita* spp.	Y	Y	Y	Y	N	N
CRAB, SHEEP	*Loxorhynchus grandis*	N	Y	Y	N	Y	N
CRAB, YELLOW SHORE	*Hemigrapsus oregonensis*	Y	N	N	N	N	N
CRINOID	Crinoidea	N	N	Y	N	Y	N
GORGONIAN, SHORT RED	*Muricea* spp.	Y	N	N	N	N	N
HYDROCORAL [2]	*Stylasterina* spp.	N	Y	Y	Y	N	N
ISOPOD, EELGRASS	*Pentidotea resecata*	N	N	Y	N	N	N
LIMPET, GIANT KEYHOLE	*Megathura crenulata*	N	N	N	Y	N	N
LIMPET, OWL	*Lottia gigantea*	N	Y	Y	Y	N	N
LOBSTER, CALIFORNIA SPINY	*Panulirus interruptus*	N	N	N	Y	N	Y
MUSSEL	*Mytilus* spp.	Y	Y	Y	Y	N	N

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans				DEEPWATER WORKSHOP	MLMA SPECIES
		NORTH	NORTH CENTRAL	CENTRAL	SOUTH		
OCTOPUS, RED	*Octopus rubescens*	Y	N	N	N	N	N
OYSTER, OLYMPIA	*Octopus rubescens*	Y	Y	Y	N	N	N
PRAWN, RIDGEBACK	*Sicyonia ingentis*	N	N	N	Y	Y	Y
PRAWN, SPOT	*Pandalus platyceros*	N	N	Y	Y	N	Y
SAND DOLLAR	*Dendraster excentricus*	N	Y	Y	N	N	N
SEA CUCUMBER, CALIFORNIA	*Parastichopus californicus*	Y	N	Y	Y	Y	Y
SEA CUCUMBER, WARTY	*Parastichopus parvimensis*	N	N	N	N	Y	Y
SEA PEN	Multiple spp.	Y	N	Y	N	N	N
SEA WHIP	Multiple spp.	Y	N	Y	N	N	N
SHRIMP, BAY GHOST	*Neotrypaea californiensis*	N	Y	Y	Y	N	N
SHRIMP, MUD	*Upogebia pugettensis*	N	Y	Y	Y	N	N
SNAIL, EMARGINATE DOG WINKLE	*Nucella emarginata*	N	N	Y	N	N	N
SNAIL, TURBAN	*Tegula* spp.	Y	N	Y	Y	N	N
SNAIL, WAVY TURBAN	*Megastraea undosa*	N	N	N	Y	N	N
SPONGE	*Porifera* spp.	N	N	Y	N	Y	N
SQUID, MARKET	*Doryteuthis opalescens*	N	N	Y	Y	N	Y
STAR	Multiple spp.	Y	Y	Y	Y	Y	N
STAR, BASKET	Multiple spp.	Y	N	Y	N	N	N
STAR, BAT	*Patiria miniata*	Y	N	Y	N	N	N
STAR, BRITTLE	Ophiuroidea	N	N	Y	Y	Y	N
STAR, DEEP SAND	*Thrissacanthias penicillatus*	N	N	Y	N	N	N
STAR, OCHRE SEA	*Pisaster ochraceus*	Y	Y	Y	Y	N	N
STAR, RED SEA	*Mediaster aequalis*	N	N	Y	N	N	N
STAR, SAND	*Luidia foliolata*	N	N	Y	N	N	N
STAR, SUNFLOWER SEA	*Pycnopodia helianthoides*	Y	Y	Y	Y	N	N
TUNICATE, COMPOUND	Multiple spp.	N	Y	N	N	N	N
URCHIN, FRAGILE PINK SEA	*Strongylocentrotus fragilis*	N	N	Y	N	N	N
URCHIN, PURPLE SEA	*Strongylocentrotus purpuratus*	Y	Y	Y	Y	N	N
URCHIN, RED SEA	*Mesocentrotus franciscanus*	Y	Y	Y	Y	N	Y
URCHIN, WHITE SEA	*Lytechinus pictus*	N	N	N	N	Y	N
WHELK, KELLET'S	*Kelletia kelletii*	N	N	N	Y	N	Y
WORM, FAT INNKEEPER	*Urechis caupo*	N	Y	Y	N	N	N
WRACK ASSOCIATED INVERTEBRATES	Multiple spp.	Y	N	Y	Y	N	N

1. Special status: Listed as federally endangered under the Federal Endangered Species Act
2. Special status: Fishing moratorium (no direct commercial or recreational fishing allowed)

TABLE 9: Indicator algae and plant species.

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans				DEEPWATER WORKSHOP	MLMA SPECIES
		NORTH	NORTH CENTRAL	CENTRAL	SOUTH		
ALGAE, CORALLINE	*Corallina* spp.	Y	N	Y	Y	N	N
ALGAE, ENCRUSTING NON-CORALLINE	Multiple spp.	Y	N	N	Y	N	N
ALGAE, FOLIOSE RED	Multiple spp.	Y	Y	N	Y	N	N
ALGAE, GOLDEN ROCKWEED	*Silvetia compressa*	N	N	Y	N	N	N
ALGAE, RED	Multiple spp.	Y	N	Y	N	N	N
ALGAE, ROCKWEED	*Fucaceae* spp.	Y	Y	Y	Y	N	N
ALGAE, SEA LETTUCE	*Ulva* spp.	Y	Y	Y	N	N	N
ALGAE, SUB CANOPY	Multiple spp.	Y	Y	N	Y	N	N
ALGAE, TURF	Multiple spp.	Y	Y	Y	Y	N	N
BEACH WRACK	Multiple spp.	Y	N	Y	Y	N	N
EELGRASS	*Zostera marina*	Y	Y	Y	Y	N	N
KELP, BROAD-RIBBED	*Pleurophycus gardneri*	N	N	Y	N	N	N
KELP, BULL	*Nereocystis luetkeana*	Y	Y	Y	N	N	N
KELP, ELK	*Pelagophycus porra*	N	N	N	Y	N	N
KELP, FEATHER BOA	*Egregia menziesii*	Y	Y	N	Y	N	N
KELP, GIANT	*Macrocystis pyrifera*	N	Y	Y	Y	N	N
KELP, KOMBU	*Laminaria setchellii*	N	N	Y	N	N	N
KELP, SEA PALM	*Postelsia palmaeformis*	Y	N	Y	N	N	N
KELP, SOUTHERN SEA PALM	*Eisenia arborea*	N	N	Y	N	N	N
KELP, STALKED	*Pterygophora californica*	Y	N	Y	N	N	N
PICKLEWEED	*Salicornia* spp.	Y	Y	N	Y	N	N
SURFGRASS	*Phyllospadix* spp.	Y	Y	Y	Y	N	N

TABLE 10: Indicator bird species.

COMMON NAME	SCIENTIFIC NAME	Regional Monitoring Plans				DEEPWATER WORKSHOP	MLMA SPECIES
		NORTH	NORTH CENTRAL	CENTRAL	SOUTH		
AUKLET, CASSIN'S	*Ptychoramphus aleuticus*	N	Y	N	Y	N	N
BIRD, PISCIVOROUS	Multiple spp.	Y	Y	Y	Y	N	N
BIRD, PREDATORY	Multiple spp.	Y	Y	N	N	N	N
BIRD, SHORE	Multiple spp.	Y	Y	Y	Y	N	N
CORMORANT, BRANDT'S	*Phalacrocorax penicillatus*	Y	Y	Y	Y	N	N
CORMORANT, PELAGIC	*Phalacrocorax pelagicus*	Y	Y	Y	Y	N	N
GUILLEMOT, PIGEON	*Cepphus columba*	Y	Y	Y	Y	N	N
MURRE, COMMON	*Uria aalge*	Y	Y	N	N	N	N
OYSTERCATCHER, BLACK	*Haematopus bachmani*	N	Y	Y	N	N	N
PELICAN, BROWN	*Pelecanus occidentalis*	N	N	N	Y	N	N
PLOVER, WESTERN SNOWY [1, 2]	*Charadrius nivosus nivosus*	N	N	Y	N	N	N
SHEARWATER, SOOTY	*Puffinus griseus*	N	N	N	Y	N	N
SURFBIRD	*Calidris virgata*	N	N	Y	N	N	N
TERN, CALIFORNIA LEAST [3, 4]	*Sterna antillarum browni*	N	N	N	Y	N	N
TURNSTONE, BLACK	*Arenaria melanocephala*	N	N	Y	N	N	N
WATERFOWL (DABBLING AND DIVING DUCKS)	Multiple spp.	N	N	Y	N	N	N

1. Special status: Listed as federally threatened under the Federal Endangered Species Act
2. Special status: CDFW Species of Special Concern
3. Special status: Listed as federally endangered under the Federal Endangered Species Act
4. Special status: Listed as state endangered under the California Endangered Species Act

OTHER SPECIES OF SPECIAL INTEREST

Although the primary goal of this Action Plan is to outline a long-term MPA monitoring strategy that will directly address the goals of the MLPA, the state is also working to integrate MPAs into other resource management efforts, such as climate change adaptation and invasive species programs. To that end, the following species of special interest should be targeted for long-term monitoring inside and outside MPAs when feasible.

Invasive Species

The impact of aquatic invasive species is not widely understood, especially related to MPAs. Available management options vary depending on characteristics of both the impacted site and the invasive species, and are generally limited to either control or eradication of invaders (Anderson 2007, Williams & Grosholz 2008). The Monitoring Program will work to identify opportunities to link MPAs and marine invasive species management, both internally and with other agencies responsible for managing invasive species, such as the California State Lands Commission (SLC) and California Coastal Commission. In addition, CDFW's Office of Spill Prevention and Response Marine Invasive Species Program[47] (MISP) conducts biological monitoring in coastal and estuarine waters to determine the level of invasion by non-native species and works to coordinate with the SLC. The Monitoring Program will work to integrate MPA considerations into future biological monitoring by MISP and help to detect new introductions that may impact MPAs.

Climate Change Species Indicators

Species that may act as good indicators for studying the effects of climate change should be considered when developing monitoring priorities. Although the MLPA does not require consideration of climate change in MPA management, the Monitoring Program recognizes that climate change is affecting oceanographic conditions along the California coast, including within MPAs. Research is continually emerging regarding the effects of climate change stressors, such as ocean acidification and hypoxia, and shifts in upwelling and temperature regimes on marine species (Bruno et al. 2018). The Monitoring Program is building partnerships with groups that have aligned and complementary expertise and missions regarding the impacts of climate change on indicator species and the MPA Network.

47. https://www.wildlife.ca.gov/Conservation/Invasives

Monitoring In Other Habitat Types

At this time, the Monitoring Program focuses sampling on shallower (<100 m depth) hard substrate along the open coast. However, that does not preclude sampling in the other habitat types, despite some challenges. Sandy beaches are highly dynamic and heavily affected by land-based factors (Dugan & Hubbard 2016). Due to the lower density of emergent benthic species in soft-bottom habitats, robust sampling of these environments to track change over time can be costly. However, emerging methods are making sampling more cost efficient.

The water surrounding deeper canyons and pelagic environments are highly dynamic and many non-benthic populations that use these areas are highly mobile (Block et al. 2011, Zwolinski et al. 2012, Bograd et al. 2016). Ecosystems deeper than 100 m have also traditionally presented significant challenges to monitor in both logistics and cost (for more information on monitoring deep ecosystems, see Appendix E). In addition, the increasing effectiveness of remote sensing and ocean circulation models will be key factors in interpreting the results of monitoring for all habitat types, as physical and chemical oceanographic factors within the CCLME are primary drivers of the structure and function of marine communities (McGowan et al. 2003, Menge et al. 2003, Broitman & Kinlan 2006, Blanchette et al. 2016, Lindegren et al. 2018).

At the land and ocean interface, estuaries are highly productive ecosystems that support important habitats (e.g., eelgrass, salt marshes, tidal mudflats) and provide critical refugia and nursery functions for a wide variety of species including those of economic value (Beck et al. 2001, Sheaves et al. 2015). Estuaries are sensitive habitats, and their natural function and associated area of wetlands have decreased significantly with increased coastal development (Allen et al. 2006, Cloern et al. 2016). The estuaries in California range widely from brackish lagoons that breach every several years to river mouth estuaries and oceanic-dominated embayments (Cloern et al. 2016). California's estuaries are generally highly modified, particularly in southern California, and each has a unique suite of stressors and marine, freshwater, and geomorphological conditions (Allen et al. 2006, Hughes et al. 2015, Cloern et al. 2016, Shaughnessy et al. 2017, Toft et al. 2018). A recent review of existing monitoring in California's 22 estuarine MPAs identified core indicators regularly monitored statewide, including 1) eelgrass areal coverage, 2) clams abundance, 3) marine/shorebird abundance, 4) marine mammal abundance, 5) dissolved oxygen, and 6) pH (Hughes 2017, Appendix C). Hughes (2017) also prioritized additional indicators for long-term MPA monitoring in estuaries across the state, including additional vegetation types (e.g., salt marshes) and macroalgae (e.g., *Ulva* and *Gracilaria* spp.), salinity, nutrients (e.g., nitrate, ammonium, and phosphate), invasive species, Olympia oysters (*Ostrea lurida*), and standardized beach seining for fish communities.

There are numerous existing long-term estuarine monitoring programs in California[48]. For example, San Francisco Bay monitoring efforts represent among the world's longest observational programs in an estuary and serve as a model system to better understand how ecosystems between land and ocean are structured, function, and change over time (Cloern & Jassby 2012, Raimonet & Cloern 2016, Cloern et al. 2017). Another example is NOAA's National Estuarine Research Reserve System-wide Monitoring Program which generates systematic water quality and weather monitoring data for 29 estuaries across the United States, including three in California (San Francisco Bay, Elkhorn Slough, and Tijuana River)[49]. However, many estuarine monitoring programs outside of San Francisco Bay are generally limited in duration, to particular estuaries, or to certain indicators (Hughes 2017). For example, existing long-term monitoring efforts in California take place at specific sites (e.g., Malibu Lagoon, Ballona Wetlands, Santa Clara River estuary), for relevant metrics in larger estuaries (e.g., Morro, Humboldt, San Diego, Tomales Bays), and regionally (e.g., across the southern California bight led by the Southern California Coastal Water Research Project[50]). These types of well-planned and robust monitoring sites and efforts can address questions related to MPA performance in areas that overlap with the MPA Network. However, monitoring

48. California Estuary Portal: https://mywaterquality.ca.gov/eco_health/estuaries/index.html.
49. NOAA National Estuarine Research Reserves: https://coast.noaa.gov/nerrs/research/.
50. Southern California Coastal Water Research Project regional monitoring: http://www.sccwrp.org/ResearchAreas/RegionalMonitoring.aspx.

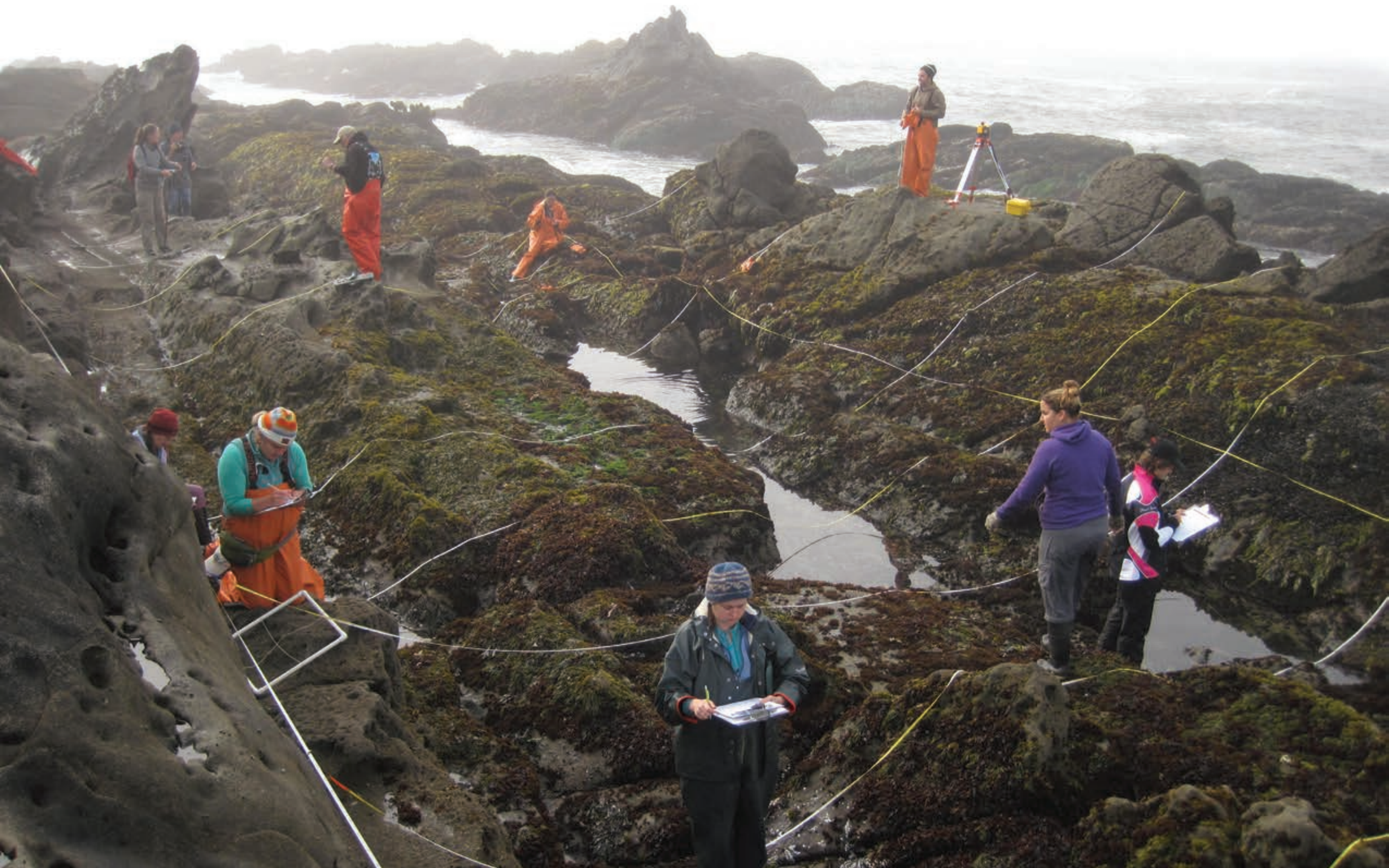
estuarine reference sites is challenging due to the unavailability of a similar site or because monitoring is focused on site based questions only. There is a need to further standardize metrics and develop coordinated, cost-effective, and repeatable methods across California estuaries to track key indicator species and habitats over time. For example, other wetland-associated assessment tools may be potentially adapted to certain estuarine habitats to expedite monitoring across the state (e.g., California Rapid Assessment Method[51]). The Monitoring Program will continue to track these efforts to determine the best approach to estuarine long-term monitoring within the MPA Network. See Appendix C for more information on estuarine MPA monitoring site recommendations.

While MPAs encompass some nearshore pelagic habitat within state waters (i.e., the water column overlying the continental shelf at depths greater than 30 m), monitoring specifically focused on the effects of protection of this habitat is difficult to implement. Many pelagic species are highly transient and may not spend significant amounts of time within MPA boundaries. However, pelagic species could be indicators of food web dynamics and shifts in ecological and physical factors in nearshore pelagic habitat within MPAs. These species will continue to be monitored within fisheries management context and their abundance and stock structure can be reported along with species monitored specifically within this plan.

51. California Rapid Assessment Method: https://www.cramwetlands.org/.

3. Approaches For Network Performance Evaluations

ADAPTIVE MANAGEMENT, as defined by the MLPA, is a process that facilitates learning from program actions and helps evaluate whether the MPA Network is making progress toward achieving the six goals of the MLPA (FGC §2852[a]; see Glossary for the full definition of adaptive management). California has set a 10-year MPA management review cycle as a mechanism to gather sufficient information for evaluating network efficacy and to inform the adaptive management process (CDFW 2016). Beginning in 2017, CDFW and researchers at University of California, Davis (UC Davis) co-mentored three postdoctoral researchers on MPA specific research projects intended to help inform long-term monitoring and the adaptive management process, including better understanding expectations of changes in highly dynamic temperate ecosystems such as the CCLME. Such expectations can inform adaptive management because they enable testing of species responses to MPA implementation, which provide updates in knowledge or management strategies. Quantitative analyses focused on examining the ability to detect population responses to MPAs over time, including incorporating spatial differences in fishing mortality rates. Analyses also focused on informing sample design for deepwater surveys and comparisons of various fish monitoring techniques being used for nearshore marine ecosystems and MPAs.



ANALYSIS 1: Projecting Changes And Their Statistical Detectability Following MPA Implementation

Modeled projections, or future estimates, of the timing and magnitude of marine life population responses to MPAs can inform adaptive management. This approach serves as a comparison between actual observations in the field and models of population responses to MPAs for evaluation of MPA performance at ecologically relevant time frames. Here we use two of the species level metrics mentioned in Section 2.3: abundance (which is the same as density here) and biomass. Globally, there are many reported levels of increase in these metrics with the implementation of MPAs (Lester et al. 2009). The increase in abundance and biomass are likely due to the effects of MPA protection on the age and size structure of the targeted species. Once an MPA is implemented, the expected response is that a population "fills in" over time with a greater proportion of older, larger individuals as a population approaches its stable age distribution after fishing mortality ceases (Baskett & Barnett 2015). This is essentially the first detectable effect of an MPA, and other longer-term potential effects (e.g., increased recruitment, changes in community structure) depend on this filling in effect (Baskett & Barnett 2015). Expected responses in abundance and biomass may be predicted from a species' life history and historical fishing rates (White et al. 2013). For example, Figure 4 demonstrates the filling in mechanism for blue rockfish (*Sebastes mystinus*), an abundant and important recreational and commercial species in California, where the age distribution moves from left to right, from red to gray over time.

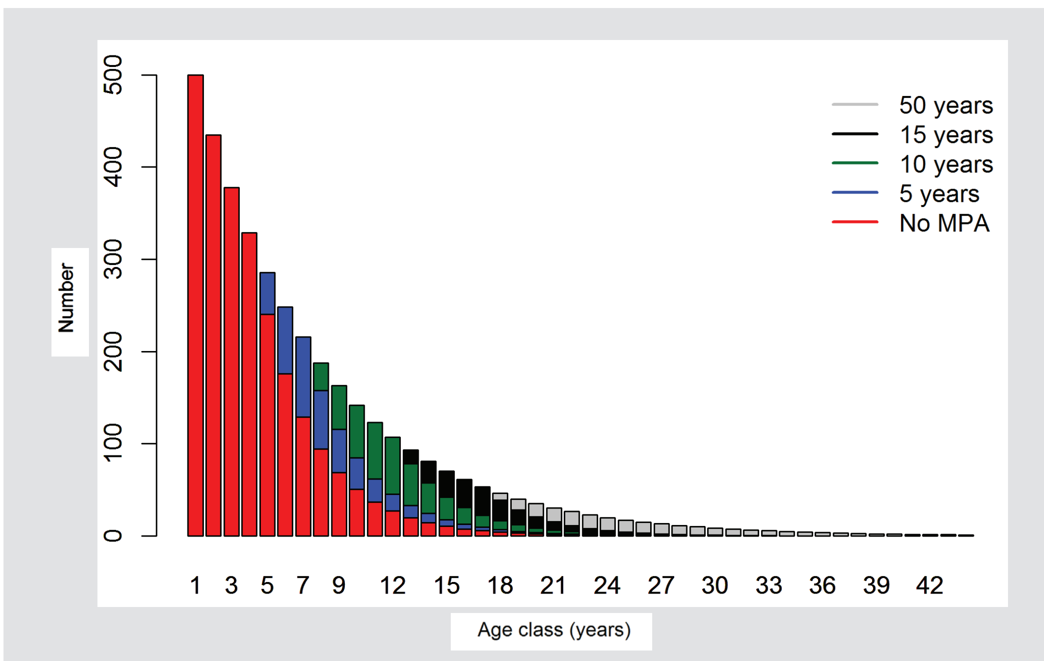


FIGURE 4: Number of individual blue rockfish *(Sebastes mystinus)* per age class increases in an MPA over time as compared to no MPA (fished state, red). Results shown for 5, 10, 15, and 50 years since MPA implementation, demonstrating the "filling-in" effect that occurs in an MPA for a previously harvested population. (This figure shows preliminary analyses by the UC Davis/CDFW postdoctoral researchers. Manuscripts detailing methodology and results are in preparation.)

The filling in and associated increase in abundance and biomass responses occur rapidly at first and then level off over time. The expected time frame to level off depends on the inverse of the natural mortality rate, which is a measure of the lifespan of the species. Thus, longer lived species take more time to observe population level responses to MPAs compared to short-lived species. The final population response to MPA implementation in terms of the change in the ratio of total abundance is dependent on the ratio of the fishing mortality rate (F) to the natural mortality rate (M) and will be proportional to (M+F)/M. In other words, the final expected gain in species abundance due to implementing an MPA depends on how heavily the population was fished before the MPA was put in place relative to the species natural mortality rate. The expected saturation level for the eventual abundance relative to its pre-MPA value is the ratio of the total pre-MPA mortality, fishing (F) plus natural mortality, to the post-MPA mortality, natural mortality M (i.e., ending abundance = (M+F)/M * starting abundance; White et al 2013). The relative biomass increase is always greater than the relative abundance increase because biomass also includes weight and age increases as individuals survive to be larger and older (Figure 5; Kaplan et al in prep.). Variable recruitment will lead to variation around this expected average (lighter colored "clouds" surrounding each line in Figure 5). Initially, this uncertainty can make an MPA effect difficult to detect (i.e., where the clouds of variability overlap).

However, as the potential MPA response increases through time, the clouds become more separated, and we can be more confident in deciding whether the MPA is working as expected. Statistical analysis of simulations of expected trajectories with and without an MPA, illustrated in Figure 5, can project the detectability of response over time (Kaplan et al in prep.).

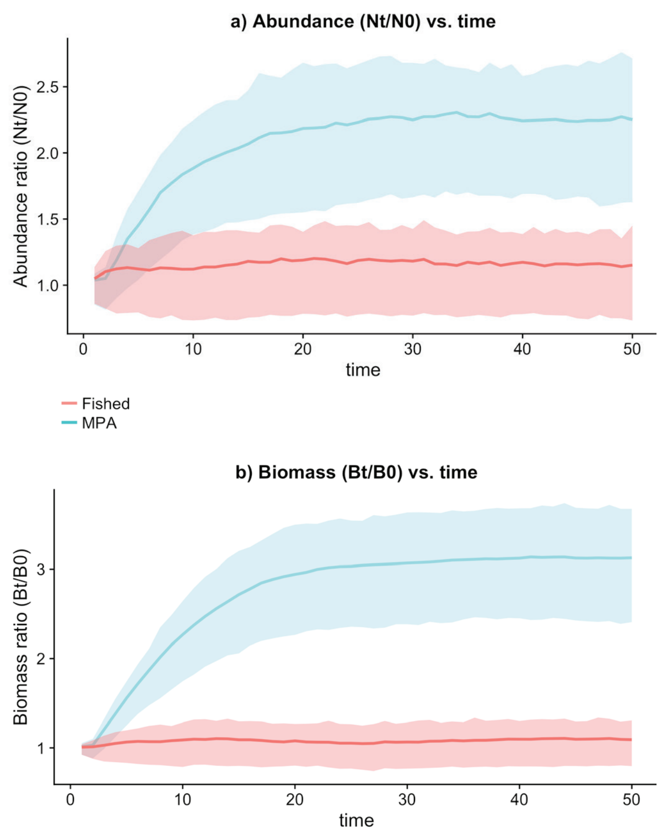


FIGURE 5: Blue rockfish population response projection with variable recruitment. Population projection in abundance (a) and biomass (b), relative to the initial value at MPA establishment, within an MPA (blue) and without an MPA (red). Nt=measure of abundance in each size class over time. N0=initial abundance at time of MPA implementation. Bt=measure of change in biomass over time. B0=population biomass at time of MPA implementation. Note difference in y-axis values. (This figure shows preliminary analyses by the UC Davis/CDFW postdoctoral researchers. Manuscripts detailing methodology and results are in preparation.)

ANALYSIS 2: Incorporating Spatial Differences in Fishing Mortality to Project Population Responses to MPAs

Because abundance and biomass responses depend directly on the fishing mortality rate prior to MPA implementation, measuring local fishing mortality is crucial for accurate predictions against which to compare monitoring data. In addition, as noted above, measuring local fishing mortality can identify target locations for monitoring prioritization. For example, coupling a monitoring site with an area recognized to have a relatively high local fishing mortality rate could result in a more detectable expected increase in abundance and biomass inside an MPA.

Fishing mortality rates for an individual species vary over space (Ralston & O'Farrell 2008). For example, Nickols et al. (in review) estimated local fishing mortality rates for blue rockfish in central California and found that it varied over tens of kilometers (Figure 6). In this example, the higher pre-MPA fishing mortality (F = 0.29) in Vandenberg SMR compared to White Rock SMCA (F = 0.10) means that responses will be more detectable in the Vandenberg SMR. In addition, the lack of significant fishing mortality at Big Creek means that this location is unlikely to provide short-term detectable responses to MPA establishment (Figure 6). A method for estimating local per-species fishing mortality is to apply a population model that accounts for the changes in fish size before and after fishing (Figure 6; White et al. 2016). The UC Davis/CDFW postdoctoral researchers evaluated the performance of this method across species and sampling protocols to inform monitoring efforts and index site selection (Yamane, et al in prep.).

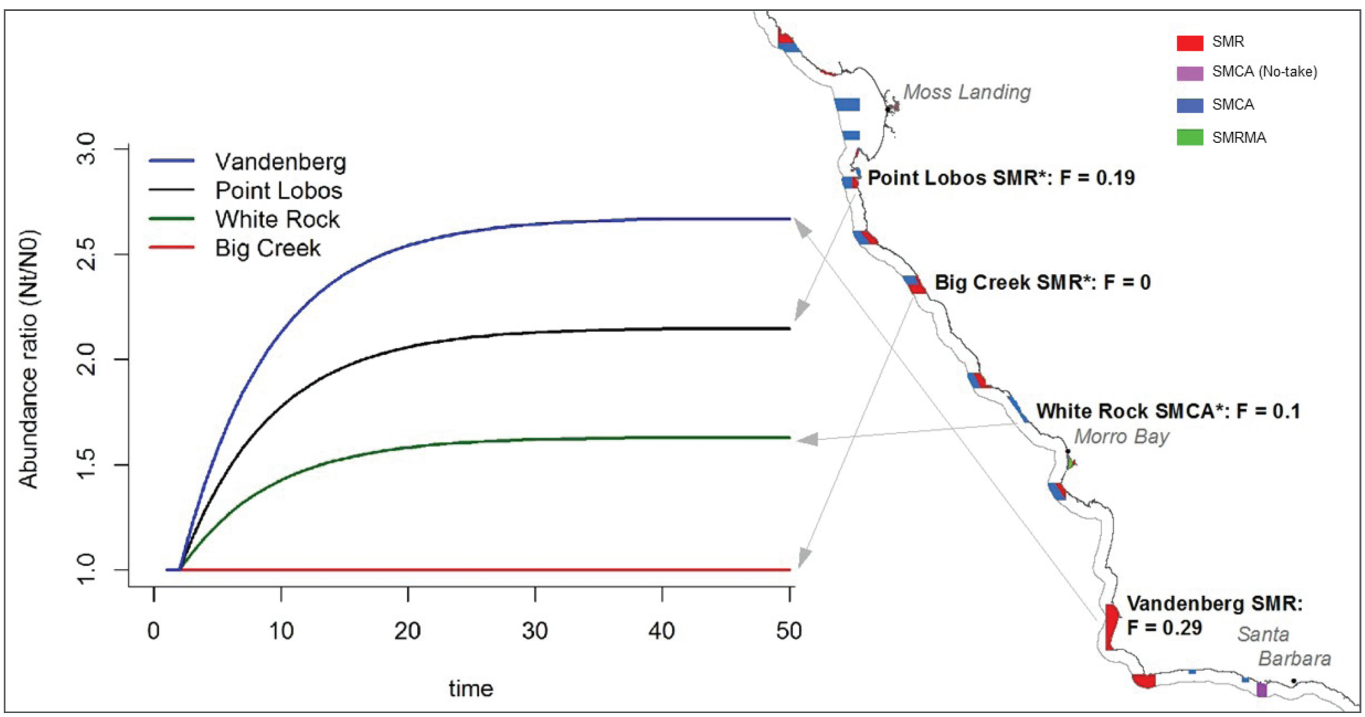


FIGURE 6: Spatial differences in fishing rates on blue rockfish populations before MPA implementation result in differences in expected population responses to MPAs along the central coast. Fishing rates with asterisks are from White et al. (2016); the remainder is from Nickols et al. (in review). (This figure shows preliminary analyses by the UC Davis/CDFW postdoctoral researchers. Manuscripts detailing methodology and results are in preparation.)

ANALYSIS 3: Estimating the Time Frame of Response for Different Species

The time frame for select species population responses to MPA protection depends on a variety of factors, including, but not limited to, species life history traits, rates of fishing mortality before MPA implementation, unique ecological characteristics of the MPA, and unexpected ecological events (Lester et al. 2009, Babcock et al. 2010, Gaines et al. 2010, Moffitt et al. 2013, White et al. 2013, Caselle et al. 2015, Starr et al. 2015, White et al. 2016). The time frame for reaching the maximum expected changes in abundance and biomass for 19 commonly targeted nearshore species was generated using an age-structured open population model (Figure 7, Kaplan et al. in prep). The model relies on individual species life history traits and expected harvest rates (i.e., averaged fishing mortality rates from stock assessments across years prior to MPA implementation). In addition to the factors noted above, the time frame for responses depends on monitoring program design and feasibility (i.e., sufficient sample size and scale, where species densities will inevitably set a limit on sampling). Figure 7 therefore provides initial insight into when monitoring might detect expected effects to inform adaptive management. Ongoing investigations by the UC Davis/CDFW postdoctoral researchers are further elucidating the roles of recruitment variability and sampling (Kaplan et al in prep., Perkins et al in prep., Yamane et al in prep.).

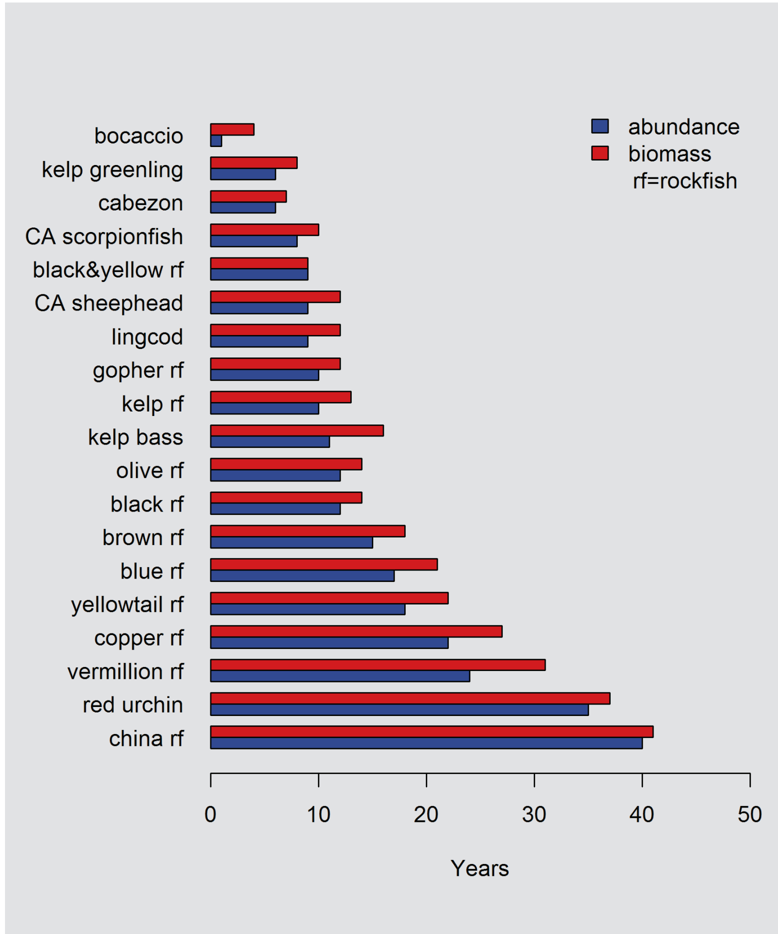


FIGURE 7: Estimated time to reach 95% of final abundance (unfished state), and biomass ratio increase in response to MPA implementation based on a deterministic open population model. rf = rockfish. (This figure shows preliminary analyses by the UC Davis/CDFW postdoctoral researchers. Manuscripts detailing methodology and results are in preparation).

ANALYSIS 4: Informing Long-Term Monitoring Sampling Design

Informing Sample Design for Deep-Water Surveys

Understanding the relationship between sampling effort and the ability to detect change is an additional component of establishing an effective monitoring program (Urquhart 2012). Ecological systems are inherently variable, and additional variability introduced through sampling methods can make detecting long-term trends (e.g., recovery of populations inside MPAs) more difficult. Simulation approaches provide a powerful tool that enables researchers to incorporate the best available scientific knowledge about the system under study, and explore how various factors (i.e. spatial distributions, habitat associations, recruitment variability and likely rates of recovery of populations) interact with the level of sampling effort likely required to detect change.

Mid-depth (30-100 m) and deep (>100 m) habitats, which lie outside of practical SCUBA diving depth limits, comprise more than half of California's MPA Network. Visual tools such as ROVs provide a means of collecting geo-referenced data about biological communities at these depths. For example, combining ROV data with fine-scale data from seafloor mapping projects allows models of habitat associations to be built for species of interest (Young et al. 2010, Wedding & Yoklavich 2015). These models can be used to predict the abundance and distribution of species across larger areas, such as an entire MPA. Moreover, combining this information with projections of expected species recovery inside MPAs compared to reference sites (see section 2.2) allows for realistic simulation of changing population abundance and size structure through time. By utilizing simulation-based approaches to explore the influence of using different numbers of ROV transects during monitoring to detect projected changes, this type of work can result in practical recommendations regarding the level of sampling required for effective long-term monitoring of California's MPA Network using ROVs (Figure 8).

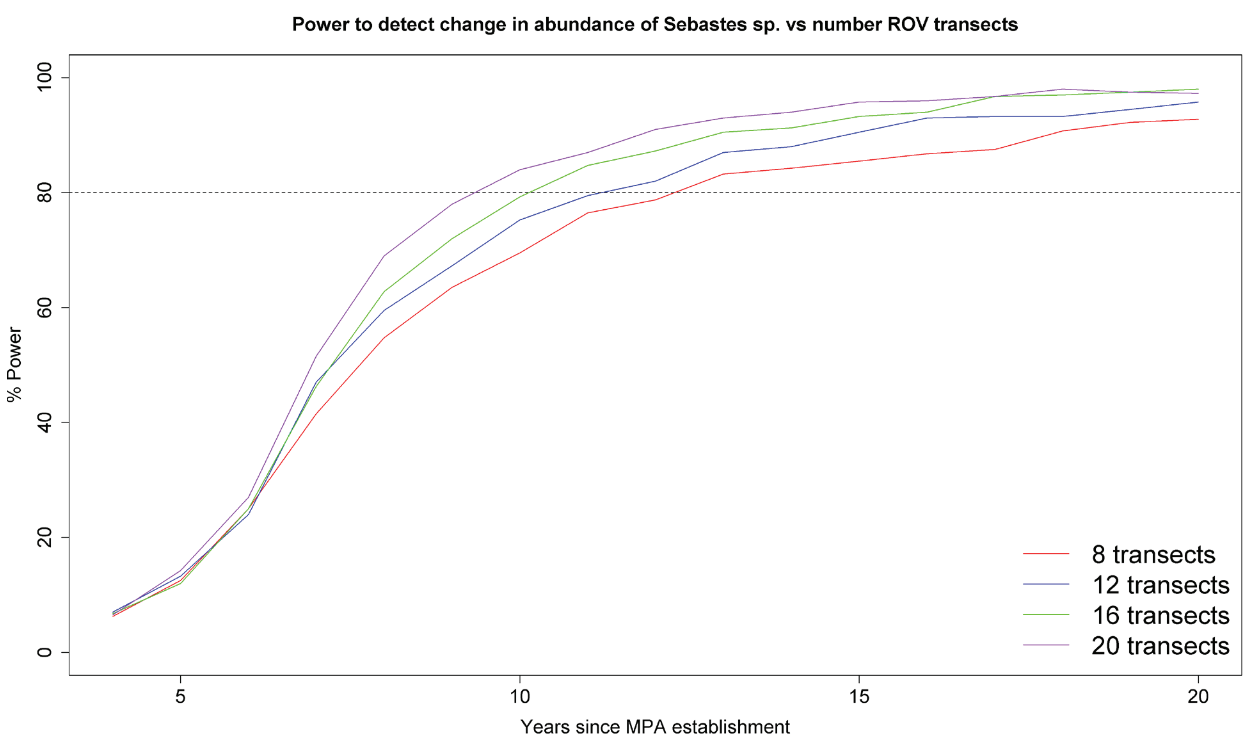


FIGURE 8: Statistical power to detect change in abundance of *Sebastes* spp. vs number of remotely operated vehicle transects. Example plot showing the trade-off between sampling effort (number of transects) and the ability to detect statistical difference in abundance of an example rockfish species over time in an MPA compared to a paired reference site. (This figure shows preliminary analyses by the UC Davis/CDFW postdoctoral researchers. Manuscripts detailing methodology and results are in preparation.)

Comparisons of Various Fish Monitoring Techniques

In California, various types of techniques are being used for monitoring nearshore marine ecosystems and MPAs, including SCUBA surveys, experimental fishing, ROVs, manned submersibles, and drop cameras/landers. These monitoring techniques are utilized at different depths and may capture species, or particular life history stages of species, that are unique to a certain monitoring technique or common with other monitoring techniques.

Performing a methodological comparison of various fish monitoring techniques will provide information regarding the species commonly captured by these techniques, potential species dynamics such as ontogenetic habitat shifts where individuals spend their early life in shallow areas then move to deeper areas as they grow bigger, potential depth and latitudinal range of the species, and so on. This information will be useful to ensure that any particular monitoring technique is effective for selected indicator species. Ideally, methodological comparisons will enable managers to identify a suite of techniques that can be used to monitor certain indicator species or identify synergies among different monitoring techniques to collectively inform statuses of indicator species. Combining complementary data from different monitoring techniques that often operate at different time periods, geographic regions, and depths may enhance monitoring frequency and extent in cost-effective ways while potentially providing more meaningful information for assessment and management.

BOX 4: Key Conclusions for Monitoring Expectations

- Simulating the abundance and biomass responses to MPAs, as they arise from a "filling in" of older ages and larger sizes, can inform the choice of indicator species (Figure 7), sampling locations (Figure 6), and estimation of decision timing (Figure 7) for monitoring and adaptive management.
- Response of biomass is always greater than response of abundance.
- The ability to correctly detect differences in population dynamics within and outside MPAs increases over time, where the projected time scales of 19 species responses range from 5 to 40 years.
- Abundance and biomass responses to MPA implementation increase with greater local fishing mortality, which can vary on scales of tens of kilometers (Figure 6).
- The level of monitoring sampling effort determines the statistical power needed to detect change in populations over time (Figure 8).

4. Conclusion

SINCE MPA IMPLEMENTATION, there has been ongoing work to develop quantitative and expert informed approaches to long-term monitoring (CDFW 2016). Using knowledge from the MPA design and siting process, baseline monitoring projects, additional scientific studies in California's MPAs over the past decade, and other emerging scientific tools, the Action Plan identifies a priority list of metrics, habitats, sites, and species for long-term monitoring to aid in the evaluation of the Network's progress towards meeting the goals of the MLPA.

Key MPA Performance Metrics

MPA monitoring from around the world has identified certain ecological, physical, chemical, and human use metrics as the most important for evaluating and interpreting MPA performance. The metrics identified in Section 2.3 are recommended for long-term monitoring to help advance the understanding of conditions and trends across the MPA Network.

Key Habitats and Human Uses

Analyses have indicated that the habitats targeted in the MLPA planning process were successful in achieving representation and replication targets. These habitats are therefore recommended for long-term monitoring, as are both consumptive and non-consumptive human uses (Section 2.3).

Index Sites

Using MPA design criteria, historical monitoring, connectivity modeling, and high resolution recreational fishing effort, MPAs were sorted into one of three tiers to identify which MPAs are good candidates for detecting the potential effects of protection over time (Section 2.3). This tiered approach was designed to create scalable monitoring options, allowing projects to be tailored to available resources and capacity.

Indicator Species

California's MPA Network was implemented, in part, to help conserve ecologically and economically important marine species, as well as to protect the structure and function of marine ecosystems. To that end, this Action Plan provides lists of species and species groups to target for long-term monitoring at MPA and reference sites (Tables 7-10). These lists of fishes, invertebrates, algae and plants, and birds were compiled using several sources, including regional monitoring plans, results from workshops, and the MLMA Master Plan.

This Action Plan should be viewed as a living document. Developed based on the best available science, and informed by peer-review and public input, the document can and will be updated as needed to serve as a guide for long-term monitoring across the entire state (CDFW 2016). These updates will ensure the latest understanding of MPA Network performance evaluation is reflected in the priorities of the Monitoring Program.

5. Glossary

Abiotic: Non-living, physical components of the environment that influence organisms and their habitats. Examples include temperature, wind, sunlight, and other physical oceanographic factors such as water density and movement, wave action, salinity, and nutrient availability.

Abundance: The total number of individual organisms present in a given area.

Adaptive Management: With regard to the marine protected areas, adaptive management is a management policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that, even if they fail, they will provide useful information for future actions, and monitoring and evaluation shall be emphasized so that the interaction of different elements within marine systems may be better understood (FGC §2852(a)).

Areas of Special Biological Significance (ASBS): Ocean areas that are monitored and maintained for water quality by the State Water Resources Control Board. Currently, there are 34 ASBSs in California that support a variety of aquatic life and are primarily focused on regulation of coastal discharges.

Before-After Control-Impact Analyses (BACI): Type of study design that examines the conditions of an area(s) before and after protection ("impact") and compares these conditions over time to those at a reference site(s) ("control") that is not protected (Stewart-Oaten et al. 1986, Block et al. 2001).

Benthic: Organisms and communities that live on and in the ocean floor.

Biodiversity: A component and measure of ecosystem health and function. It is the number and genetic richness of different individuals found within the population of a species, of populations found within a species range, of different species found within a natural community or ecosystem, and of different communities and ecosystems found within a region (PRC §12220(b)).

Biomass: The total mass of organisms in a specified area.

Biotic: Components of the environment that are attributed to living organisms. Examples include plants, animals, algae, primary production, predation, parasitism, competition, etc.

California Current Large Marine Ecosystem (CCLME): A marine region in the North Pacific Ocean from southern British Columbia, Canada to Baja California, Mexico. The CCLME is one of only four temperate upwelling systems in the world, considered globally important for biodiversity because of its high productivity and the large numbers of species it supports.

Community Structure: The types and number of species present in a community, which is influenced by interactions between species and other environmental factors.

Density: The number of individual organisms per unit area or volume in a specified area.

Dissolved Oxygen: Oxygen that dissolves into ocean water, absorbed from the atmosphere or the release of oxygen during photosynthesis of marine plants and algae. Dissolved oxygen is critical for marine organisms; levels in the nearshore environment are affected by physical factors such as changes in temperature and salinity.

Ecosystem: The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of energy and material, which together produce and maintain a characteristic type of biological community (CDFW 2002).

Fishing Mortality: The removal of fish from a population due to fishing activities. Denoted as “F” in fisheries stock assessment and other related models.

Functional Diversity: The components of biodiversity that influence ecosystem function. It is a measure of value and range of traits attributed to an organism or groups of organisms and how that influences ecosystem dynamics such as stability, productivity, and trophic pathways (Tilman 2001, Laureto et al. 2015, Soykan & Lewison 2015).

Measure: ascertain the size, amount, or degree of (something) by using an instrument or device marked in standard units or by comparing it with an object of known size.

Metric: a calculated or composite measure or quantitative indicator based upon two or more indicators or measures.

Natural Mortality: Removal of fish from a population due to causes unrelated to fishing, such as predation, diseases and other natural factors, or pollution. Denoted as “M” in fisheries stock assessment models.

Pelagic: The zone in the ocean composed of the water column above the ocean floor.

pH: A measurement (from 0 to 14) of how acidic or basic a substance is. The lower the pH of a substance, the more acidic; the higher the pH, the more basic.

Size Frequency: The number of individual organisms that fall into a specific size class.

Stability: For the purposes of this Action Plan, ecosystem stability is a measure of ecosystem response over time. A “stable” ecosystem does not experience large changes in community structure and function due to disturbances or effects of other abiotic and biotic factors. Population stability applies to a single species, and refers to changes to a population’s abundance and biomass over time (McCann 2000, Worm et al. 2006, Stachowicz et al. 2007).

Total Alkalinity: The concentration of alkaline substances in ocean water, such as bicarbonate (HCO_3^-), which denotes the water’s ability to resist changes in pH.

Trophic Cascade: Indirect interactions that occur when changes in abundance of a predator alter the behavior of organisms at lower trophic levels, which can in turn cause dramatic changes in ecosystem structure and function (Pinnegar et al. 2002).

Upwelling: A process that occurs when winds push ocean surface water offshore and cold, nutrient-rich water from the deep sea rises up to the surface to replace it.

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7. Appendices

Appendix A:

FUNDING DISBURSEMENT MECHANISMS

Fund Disbursement Mechanisms

About this Document

This memorandum is an overview of the processes and mechanisms by which funds could be disbursed and partnerships pursued to advance the Statewide MPA Monitoring Program. A diversity of funding disbursement mechanisms will enable State investments to be strategically targeted to maximize cost-effectiveness, transparency, and efficiency across the breadth of activities within the program. We provide specific recommendations for when to apply each mechanism, considerations, and estimated timelines for each process. Additionally, Appendix A contains templates for each of these mechanisms, and Appendix B is a more detailed memorandum focused on developing and implementing an Expressions of Interest (EOIs) process.

Requests for Qualifications (RFQs)

Description and Considerations

A RFQ lays out a very specific project plan and solicits competitive bids for completion of the work (see Appendix A for an example). RFQs are most appropriate when the funder already has a very clearly defined need and approach to a project, for example, if the project requirements are known in great detail (e.g., sites, metrics, sampling frequency) or if the RFQ is meant to infuse funds into (or replicate) an existing monitoring program. In these more specific cases, RFQs represent a more efficient option than RFPs and ensure that program needs are met in the first solicitation. The level of review of responses to RFQs is typically less rigorous and is set against the specifics of the RFQ itself. However, for RFQs targeting high value or multi-year projects, review from an outside source knowledgeable in the project specifics may be useful to ensure that the selected response meets the requirements, sets a reasonable timeline, and upholds the scientific rigor required by the program. One potential drawback is that, although possible, highly specific RFQs may not be as well suited for finding contractors with existing monetary support that can leveraged against State funds.

RFQs typically have short open periods (2-4 weeks) and can be used for a variety of projects. For example, an RFQ could target multi-year projects to track the condition of a selected ecosystem or human use category (i.e., consumptive or non-consumptive),or focus on integrative analyses in advance of an anticipated management review. For cases in which the resulting contract extends over multiple years, annual disbursements contingent on performance can protect the State investment.

Estimated time to complete

- 2-4 week open period
- 2 weeks for internal review (add 2-3 weeks for external review)
- 1-2 weeks for revisions respondent(s) (*optional*)

Total: 5-11 weeks, plus time for internal contract/grant execution

Requests for Proposals (RFPs)

Description and Considerations

When operational requirements are more loosely defined than described in the RFQ example above or when multiple approaches may be employed to address a component of monitoring, a RFP allows for more creativity and innovation on the part of applicants (see Appendix A for an example). This is a good option when there is a clearly defined goal, research, or management question, but the approach, tools, location, mechanisms, and/or experimental design are undefined/unrestricted or unknown. Ideally, RFPs allow a funder to solicit and consider a wide range of proposed technical and programmatic approaches, and select the proposal that meets identified evaluation criteria. There may be greater financial risk in this approach, but it can be valuable in stimulating innovation.

Proposals should be peer-reviewed for consideration of the evaluation criteria described in the RFP, often including scientific and technical merits, whether the proposed project meets RFP goals, and overall cost-effectiveness. Peer review processes associated with RFPs typically involve formal internal and external review steps. There are many different approaches to these peer review processes. (See Appendix 2 for examples.)

Estimated time to complete

- 8-12 week open period
- 6-8 weeks for peer review process (often two steps)
- 2 weeks for proposal revision by respondent(s) (*optional*)

Total: 16-22 weeks, plus time for internal contract/grant execution time

Expressions of Interest (EOI)

Description and Considerations

There are two rather different situations in which EOIs are a good tool. First, EOIs are a good fit when limited funding is available and/or the intent is to provide matching funds for an existing program or research project. Second, EOIs are a useful tool when the sampling methods or other project details are unknown. In this case, the EOIs could be used to shape a RFQ or RFP. In both of these situations, EOIs can be used either as the end point (i.e., funding decisions made based on the EOIs) or to create a list of potential contractors from whom full proposals will be requested. In the former case (matching funds), full proposals may not be necessary since the respondent will have already developed a full proposal that was reviewed and funded by another source. The MPA monitoring funder could request the existing proposal as part of the EOI response package. (See Appendix A for an EOI opportunity announcement template.) Leveraging funding from other sources can help the State to move forward more quickly on research and program goals that are of interest to other funders and at the federal level as well. For example, network evaluation questions could be answered through basic research that might attract support from funders such as the National Oceanographic and Atmospheric Administration and National Science Foundation.

EOIs can be an efficient way to solicit and understand interest, develop a standing list of vendors, and seek matching funds. However, if there is targeted or specific need that the State needs to move forward on quickly, it can add an extra step in the proposal process and may not be needed. If the main goal of the EOI process is provide matching funds to existing programs or projects, establishing a pool of funds to be used for this purpose can be a highly cost-effective approach to incentivizing relevant and useful research and monitoring. This approach can be especially useful for components of the program without strict temporal requirements, and those that would benefit from advancing knowledge and best practices and/or development of new methodologies or technologies. See Appendix B for more information on EOIs.

Estimated time to complete

- 4-8 week open period
- 1-2 weeks for internal review (add 2-3 weeks for external review)
- 2-4 weeks for full proposal development by respondents (*optional*)
- 1-2 weeks for internal review (add 2-3 weeks for external review) (*if requesting full proposals*)

Total: 5-13 weeks (*if funds disbursed based on EOIs*), 8-22 weeks (*if requesting full proposals*), plus time for contract/grant execution time

Sole-sourcing

Description and Considerations

In limited circumstances, it can be most efficient and cost-effective to engage directly with a consultant or contractor team with unique expertise or knowledge of the project of interest. For example, sole-sourcing may be most efficient for implementing coordination and synthesis activities, consistent with the rules associated with the funding source and disbursing organization. This approach leverages existing institutional capacity and knowledge developed through the last decade of MPA implementation and MPA monitoring. This option is particularly well-suited for existing grants or contracts that the State is seeking to extend.

Estimated time to complete

- 2-4 weeks for contract/grant development with consultant or contractor team

Total: 2-4 weeks, plus time for contract/grant execution time

Partnerships

Description and Considerations

In many cases, ongoing work by existing programs, institutions, agencies, etc. can directly provide useful data or syntheses that inform our understanding of the ocean conditions and trends inside and outside MPAs. Maintaining and building partnerships can help capitalize on these opportunities. In some cases, a partnership may involve a formal written agreement outlining specific terms and commitments (e.g., memorandum of understanding). In others, the intent to work together may be reflected by mutual acknowledgment of shared interests in planning or other strategic documentation.

Partnerships can also be useful for sharing resources such as infrastructure and technology, and for collaborating on sharing monitoring results. In some cases, funding may be needed to support participation in a partnership, such as a post-doctoral fellow to conduct data analysis. Even when not directly sharing resources, partners can make a valuable contribution simply by maintaining capacity (e.g., trained technicians, databases, visualization tools), which lowers the year-to-year cost of MPA monitoring.

Summary

Funding Mechanism	Purpose/Outcome	Duration
Request for Qualifications (RFQ)	• Clearly defined needs and approach provided by funder	5-11 weeks
Request for Proposals (RFP)	• Open ended solicitation of proposals where innovative solutions or flexible solutions are preferred	16-22 weeks
Expression of Interest (EOI)	• Determine interest of researchers, consultants, NGOs, etc. • Help scope final RFP/RFQ • Searching for leveraged funds	5-22 weeks
Sole-sourcing	• Very specific contract with established or previous vendor	2-4 weeks

Appendix A. Funding Mechanism Templates

This appendix includes templates for disbursing and implementing state funded research and monitoring for the MPA Monitoring Program through three funding mechanisms:

- Expression of Interest Opportunity (EOI) Announcement
- Request for Qualifications (RFQ) template, including selection criteria and process
- Request for Proposals (RFP) template, including selection criteria and process

The California Ocean Protection Council (OPC), California Department of Fish and Wildlife (CDFW), and California Ocean Science Trust (OST) developed these templates collaboratively.

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Template: Expressions of Interest (EOI) Opportunity Announcement

Summary

This template is provides the State and its partners draft language and instruction from which to draft and complete an EOI opportunity announcement and process each year, or as needed, in support of its Statewide MPA Monitoring Program.

Section 1: In Brief

Instructions: Provide a very brief synopsis of the type of funding, the amount, and the timeline. Keep to three sentences/lines, max.

Sample Language: OPC, CDFW, and its partners are seeking expressions of interest from research teams to address the State's long-term monitoring and research needs in relation to its extensive MPA network. [*FOCAL STATEMENT ABOUT TARGETED QUESTIONS OR R&D TOPIC AREA, ETC.*] EOIs are due on *MM DD, YYYY*. If selected, projects could be awarded up $*XX*.

Section 2: Priorities for funding this cycle

Instructions: Create clearly stated priorities for funding. The first step in developing the EOI announcement should be to identify the priority questions/topics prior to each release. The team should work together to decide upon a timeline, process, key partners, and level of detail for developing this information. Link to any information online with the State's funding priorities, bond priorities, strategic plans, etc. for which applicants should tailor the response and research. This section should be as clear and concise as possible with a goal of 5-6 sentences max.

Section 3: Timeline for EOIs

Instructions: Provide all timeline information related to submission and notification to applicants of successful EOIs invited to submit full proposals.

Information to include:

- Date for submission of EOIs
- Date for notification of EOIs invited to submit a full proposal

Section 4: Submission Instructions

Instructions: Provide clear and concise instructions on how, where, and what to submit. Complete the information on how and where an applicant submits the EOI and then tailor the submission instructions to meet the goals and requirements of the current funding cycle, as needed.

Information to include:

- Submission date
- Amount and year range for grant awards
- Where to submit applications (e.g., letter, online, email, etc.)
- Eligibility to submit (or frame as who is not eligible to apply for funds)
- Submission length and required content (select from and edit the following as needed):
    - *Team/Partners (1 paragraph)*: Request a list of the proposed project team and brief description of roles for each.
    - *Amount range; year range proposed (1 sentence)*: State the funding available through this EOI announcement, max per project (if applicable), and project timeline.
    - *Approach to the project and/or project proposal (1-2 paragraphs)*: Request a brief, high-level statement of the approach proposed (if applicant is seeking funds for a defined project, or if announcement targets a specific project that meets the priorities and goals of the particular funding cycle).
    - *Alignment with funder priorities (1 paragraph)*: Request a description of how the proposed project aligns with funder priorities (as outlined in the EOI announcement).
    - *Matching funds (1 paragraph, bulleted list, or table)*: Request a description or list of the matching funds, including other grant funds, in-kind support, etc. (either secured or submitted), that would augment the State's investment in the proposed project.
    - *Other relevant materials*: Request any of the following materials, as needed –
        - Relevant experience via resumes/curriculum vitae of project staff
        - Relevant supporting documents (e.g., funded research proposal(s) for any matching funds, letters of support from project partners)
        - List any current, pending, or potential funds (bulleted list including project title, grantor, and award amount)

Section 5: Process for Selection of EOIs

Instructions: Provide all process information related to submission, selection, and notification to applicants of successful EOIs invited to submit full proposals.

Information to include:

Selection criteria: EOIs will be scored based on the following criteria and weights. (*Select from the following list as applicable. Include weights for criteria.*)

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- Relevance and applicability to priorities of the Statewide MPA Monitoring Program (20%): Assessment of alignment of project goals with the MPA Program purposes and priorities and stated priorities for the current funding cycle.
- Scientific/technical merit (20%): The degree to which the proposed project is innovative and will advance the state of the science or discipline through rigorous state-of-the-art research.
- Users, Participants, and Partnerships (20%): The degree to which users or potential users of the results of the proposed project have been brought into the planning of the project, will be brought into the execution of the project, and will use results. Researchers must work with end-users to develop relevant proposals. Demonstrated knowledge, partnerships, relationships, collaborations or other mechanisms for bringing users and partners into the project.
- Project costs and funding leverage (5%): Description of funds already leveraged or under development for the proposed project. Demonstrated efficiencies in data collection, partnerships, etc.
- Qualifications of project lead(s) and demonstrated access to facilities and resources (10%): Assessment of whether the applicants possess the necessary knowledge, experience, training, facilities, and resources to complete the project
- Project management experience, expertise, and skills (10%): Assessment of project management experience, including a proven track record in completing contracts on-time and within budget; and experience managing and working in multi-party, multidisciplinary teams. Demonstrated list of grants, bringing things to fruition, deliver on contracts, grants, etc.
- Timeliness/Urgency of the Research (5%): Due to changing ocean conditions as a result of both human and natural causes, priority given to research addressing issues needing immediate attention can arise and are not amenable to waiting until the next funding cycle.
- Proof of Concept/Preliminary Data (10%): Does the proposal have proof of concept through a previously funded or currently funded pilot project? Does it already have preliminary data in hand to hone a research proposal or leverage existing data?

Process for evaluating the selection criteria (2-3 sentences)

- Information about review process (e.g., panel/committee, independent reviewers, state agency representatives, etc.)
- Information about how the review process will operate (e.g., scoring, entity with final decision-making authority)

Contact

Questions may be directed to [*NAME*], [*TITLE*], [*ORGANIZATION*], at [*EMAIL*] or [*PHONE*].

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Template: Request for Qualifications (RFQ)

Section 1: Summary

Instructions: This section will provide a high-level summary of the work, objectives, and submission deadline.

Sample Language: The [*AGENCY/ORGANIZATION*] is seeking qualified contractors or teams of contractors (Contractor(s)) to support [*DESCRIBE THE WORK, BRIEFLY, HERE*]. [*ADD 1-2 SENTENCES, AS NEEDED, TO PROVIDE ADDITIONAL DETAILS*] Professional services under this Request for Qualifications will focus on [*#*] main objectives: [*OBJECTIVE 1*], and [*OBJECTIVE 2*]. The deadline for receipt of submissions is [*TIME*] PST on [*DATE*].

Section 2: Background

Instructions: This section will include a description of the organization issuing the RFQ, brief overview of the policy guidance (e.g., MLPA, MLPA Master Plan, Partnership Plan), introduction to the other documents (e.g., workplan, monitoring plan), and where to find additional background information.

Section 3: Description of Work

Instructions: This section will include objectives, a summary of the work (including a list of recommended sites), an outline of expected deliverables and major milestones, and the main tasks associated with the work.

Section 4: Qualifications, Skills, and Expertise

Sample Language: The [*AGENCY/ORGANIZATION*] seeks Contractor(s) with the expertise, demonstrated skills, and proven experience necessary to conduct the MPA monitoring activities described above. Expertise, skills, and experience [*TIE TO DESCRIPTION OF WORK*] and should include the following:

- Extensive experience, rigorous theoretical grounding and proven success in designing and implementing scientific monitoring activities
- [*RELEVANT TOPICAL EXPERTISE, e.g., kelp forest ecology, rocky intertidal ecology*]
- Proven experience building and stewarding broad collaborations among diverse organizations and across disciplines
- Demonstrated excellence in project management and client communication, including proven ability to develop high-quality deliverables and to work within established project timelines and budget.
- Ability to communicate effectively with a broad range of stakeholders a plus
- [*ADD ADDITIONAL EXPERTISE, SKILLS, AND EXPERIENCE, AS RELEVANT/IDENTIFIED*]

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Section 5: Terms

Sample Language: Contactors will report directly to the [*ORGANIZATION*] [*POSITION/TITLE*] and will receive organized advice from [*ORGANIZATION*] staff and partners. Contractors will be expected to coordinate effectively with the [*ORGANIZATION*] using electronic and telephone communication, on-line collaboration tools, in-person meetings, or other appropriate means. The selected Contractors will provide services through [*DATE*] on a contract basis. The fee will be negotiated at the time of selection.

Section 6: Submission Requirements

Sample Language: Respondents should submit their qualifications electronically to [*AGENCY/ORGANIZATION*] no later than [*DATE*]. Submissions should be sent by email to ([*EMAIL ADDRESS*]) with subject line "Response to Statewide Monitoring RFQ".

All submittals must include:

1. A cover letter
2. A statement demonstrating the applicant's understanding of the project, indicating how the applicant meets the desired qualifications, skills and experience
3. An overview of the proposed scope of work and project approaches and key components, including a proposed schedule with approximate schedule or timing of key milestones
4. A description of the applicant's qualifications, such as a resume
5. A statement of availability and loaded daily or hourly rates including fringe and overhead through [*DATE*].
6. A minimum of three references relating to completed projects for the services being requested with full name, title, address, and phone numbers.

Submissions should be no longer than 15 pages. Additional pages are permissible only if or as needed to provide resumes of key personnel. Submissions should be provided as a single electronic file, ideally in PDF format.

Section 7: Submission Review & Selection Process

Sample Language: [*AGENCY/ORGANIZATION*] will evaluate submissions against the following criteria:

1) *Relevance and applicability to the objectives of the Statewide MPA Monitoring Program*: Assessment of alignment of project goals with the Monitoring Program objectives, including:
    - Efficiencies in data collection to address multiple program priorities
    - Ability to conduct paired (inside-outside) monitoring of priority MPAs at the sampling frequency and scope identified for the target ecosystem or human use category (i.e., consumptive or non-consumptive)

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2) *Scientific/technical merit*: Assessment of the conceptual framing and technical approaches proposed to achieve project goals
3) *Partnerships, collaborations, and local expertise*: Assessment of whether the proposal takes best advantage of the knowledge and capacity existing within [*INSERT RELEVANT REGION(S) OR STATEWIDE*], including broad partnerships (e.g., tribes, citizen scientists, fishermen) and multiple forms of science (e.g., traditional ecological knowledge, local knowledge)
4) *Project costs and funding leverage*: Assessment of cost-effectiveness, including project cost relative to Monitoring Program objectives (see above), and ability to leverage other available funds to conduct the project, to reach a minimum of [*XX*]% matching funds
5) *Qualifications of project lead(s) and demonstrated access to facilities and resources* Assessment of whether the applicants possess the necessary knowledge, experience, training, facilities and resources to complete the project
6) *Project management experience, expertise, and skills*: Assessment of multiple facets of project management, including a proven track record in completing contracts on-time and within budget, experience managing and working in multi-party, multidisciplinary teams, and communication skills. Communication skills include the ability to provide clear and effective communication of project goals, approaches and results to diverse audiences interested in monitoring information.

When considered together, these criteria will provide the basis for evaluating the overall value of each submission with the aim of securing the most advantageous arrangement to meet the program objectives. Selection of the preferred Consultant(s) is expected to be a two-step process in which short-listed applicants will be contacted for follow-up telephone and/or in-person meetings. Should more than one applicant advance beyond step one, these short-listed applicants may be requested to make brief presentations in support of their applications. We expect that Consultant(s) will be selected by [*DATE*].

Contact

Questions may be directed to [*NAME*], [*TITLE*], [*ORGANIZATION*], at [*EMAIL*] or [*PHONE*].

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Template: Request for Proposals (RFP)

Section 1: Summary

Instructions: This section will provide a high-level summary of the objectives, scope, and submission deadline.

Sample Language: [*STATEMENT ABOUT HOW THIS RFP AND OTHER GUIDING DOCUMENTS (e.g., workplan) WAS DEVELOPED*] [*HIGH-LEVEL STATEMENT ABOUT FUNDING SOURCE*]

Proposals are requested that address two main objectives:

1. To assess the condition of [*INSERT ECOSYSTEM OR HUMAN USE CATEGORY (I.E., CONSUMPTIVE OR NON-CONSUMPTIVE) HERE*] inside and outside MPAs
2. To assess the trend in condition of [*INSERT ECOSYSTEM OR HUMAN USE CATEGORY (I.E., CONSUMPTIVE OR NON-CONSUMPTIVE) HERE*] using newly collected data together with data from the baseline monitoring program and other existing data, where available.

All proposals will be evaluated against the criteria listed in Section X, including alignment with objectives, scientific and technical merit, demonstration of partnerships, incorporation of local expertise, costs, funding leveraging, and qualifications of project leads. [*INSERT 2-4 SENTENCES THAT DESCRIBE THE EVALUATION AND SELECTION PROCESS SPECIFIC TO THIS ANNOUNCEMENT*] Final decisions will be made jointly by staff of [*AGENCIES/ORGANIZATIONS*].

Questions related to proposal requirements should be directed to [*AGENCY/ORGANIZATION*] (see Section X for guidance and contact information). Answers to frequently asked questions and any updates relating to this RFP will be available on the [*AGENCY/ORGANIZATION*] website ([*ENTER WEBSITE HERE*]). Persons intending to submit proposals in response to this RFP should consult this website frequently for updates and additional information. The deadline for receipt of submissions is [*TIME*] PST on [*DATE*].

Section 2: Background

Instructions: This section will include a description of the organization issuing the RFP, brief overview of the policy guidance (e.g., MLPA, MLPA Master Plan, Partnership Plan), introduction to the other documents (e.g., workplan, monitoring plan), and where to find additional background information.

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Section 2: Objectives

Instructions: This section will describe the objectives specific to the ecosystem or human use category (i.e., consumptive or non-consumptive) being targeted with the RFP.

Sample Language: The projects described herein have [#] objectives:

1. Assess the condition of [*INSERT ECOSYSTEM OR HUMAN USE CATEGORY (I.E., CONSUMPTIVE OR NON-CONSUMPTIVE) HERE*] inside and outside MPAs in the [*INSERT TARGET REGION(S) OR STATEWIDE*]. Activities must focus on the sites identified in the Scope (see Section X) and metrics identified in the Statewide MPA Monitoring Action Plan.
2. Assess the trend in condition of [*INSERT ECOSYSTEM OR HUMAN USE CATEGORY (I.E., CONSUMPTIVE OR NON-CONSUMPTIVE) HERE*] inside and outside MPAs in the [*INSERT TARGET REGION(S) OR STATEWIDE*]. This should include using newly collected data together with data from the baseline monitoring program and other existing data, where available.

[*INSERT ADDITIONAL OBJECTIVE(s) HERE, AS IDENTIFIED*]

Section 4: Scope

Instructions: This section will describe the geographic (list of recommended sites), temporal, and scientific scope for proposals.

Section 5: Guidance and Deliverables

Instructions: This section will describe the programmatic guidelines (e.g., focus on objectives, importance of a partnership-based approach) and expected deliverables (e.g., data and metadata, progress reports, final report).

Section 6: Application and Submission Information

Instructions: This section will include requirements and guidelines for developing and submitting application packages, including proposal components (e.g., cover letter, narrative, budget with match/leveraging) and other required documents (e.g., curriculum vitae, letters of support).

Section 7: Proposal Review

Sample Language: [*AGENCY/ORGANIZATION*] will evaluate submissions against the following criteria:

1) *Relevance and applicability to the objectives of the Statewide MPA Monitoring Program*: Assessment of alignment of project goals with the Monitoring Program objectives, including:
    - Efficiencies in data collection to address multiple program priorities

- Ability to conduct paired (inside-outside) monitoring of priority MPAs at the sampling frequency and scope identified for the target ecosystem or human use category (i.e., consumptive or non-consumptive)

2) *Scientific/technical merit*: Assessment of the conceptual framing and technical approaches proposed to achieve project goals
3) *Partnerships, collaborations, and local expertise*: Assessment of whether the proposal takes best advantage of the knowledge and capacity existing within the [*INSERT TARGET REGION(S) OR STATEWIDE*], including broad partnerships (e.g., tribes, citizen scientists, fishermen) and multiple forms of science (e.g., Indigenous traditional knowledge, fishermen's knowledge, local knowledge)
4) *Project costs and funding leverage*: Assessment of cost-effectiveness, including project cost relative to Monitoring Program objectives (see above), and assessment of ability to leverage other available funds to conduct the project, to reach a minimum of [*XX*]% matching funds
5) *Qualifications of project lead(s) and demonstrated access to facilities and resources*: Assessment of whether the applicants possess the necessary knowledge, experience, training, facilities and resources to complete the project
6) *Project management experience, expertise, and skills*: Assessment of multiple facets of project management, including a proven track record in completing contracts on-time and within budget, experience managing and working in multi-party, multidisciplinary teams, and communication skills. Communication skills include the ability to provide clear and effective communication of project goals, approaches and results to diverse audiences interested in monitoring information.

[*ADDITIONAL SELECTION CRITERIA: Additional selection criteria should be added that are specific to the announcement described in the RFP.*]

When considered together, these criteria will provide the basis for evaluating the overall value of each submission with the aim of securing the most advantageous arrangement to meet the program objectives. Selection of the preferred Consultant(s) is expected to be a two-step process in which short-listed applicants will be contacted for follow-up telephone and/or in-person meetings. Should more than one applicant advance beyond step one, these short-listed applicants may be requested to make brief presentations in support of their applications. We expect that Consultant(s) will be selected by [*DATE*].

Section 8: Selection Process

Instructions: This section will include a description of the review & selection process, which may vary based on the specifics of the announcement described.

Contacts

Questions may be directed to [*NAME*], [*TITLE*], [*ORGANIZATION*], at [*EMAIL*] or [*PHONE*].

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Appendix B. Expressions of Interest: Overview and Process Design

Background

As the regional baselines near completion, California is designing and implementing Phase 2 of the Statewide MPA Monitoring Program -- long-term, statewide monitoring. Phase 2, reflects current State priorities and management needs, while building on the knowledge, capacity, and unique considerations for each region. With an efficient, leveraged, long-term monitoring program, California is delivering on data and information that support near-term and long-term decisions.

Strategic investments in research and development and long-term monitoring can advance us toward programmatic objectives, from addressing short- and long-term evaluation questions to advancing technology and fundamental research to improve MPA monitoring approaches. To advance the efficacy and efficiency of the MPA Monitoring Program, a transparent and competitive process is needed to select contractors for future work in these areas.

Expressions of Interest (EOI) are one of the ways in which companies, NGOs, foundations, and governmental organizations can begin the grant or contracting process. It is one of several options for proposal processes from which either all or just one can be done, depending upon the needs of the funder (See Table 1). EOIs are often done earlier in the granting process, than, for example, a Request for Qualifications, especially when either the institutions interested or the types of solutions or research needed to address the scientific or industry problem are largely unknown.
California intends to use an EOI for the following purposes:

- To create a short list of vendors from which to solicit full proposals later in a process/ get applicants interested in applying with a full proposal later in the process.
- To solicit for research and monitoring in support of the program for which matching funds are already in hand from other sources (e.g. NOAA, NSF, SeaGrant, State General Funds).

Table 1: A short description of the different types of proposal solicitations and associated terminology.

Type of process (in order of specificity)	Purpose/Outcome
Request (or Registration) for information (RFI)	• Determining stakeholder and client interest and needs • Supplier pre-qualification process (get on list to submit EOIs or proposals later)
Expression of Interest (EOI)	• Determine interest of researchers, consultants, NGOs, etc. • Help scope final RFP/RFO/RFQ
Request for Proposals/Request for Offer (RFP/RFO)	• Open ended solicitation of proposals where innovative solutions or flexible solutions are preferred
Request for Qualifications or Quotation (RFQ)	• Clearly defined needs and approach provided by funder

Developing the EOI Announcement

The first step in developing the EOI announcement should be to identify the priority questions/topics prior to each release. The team should work together to decide upon a timeline, process, key partners, and level of detail for developing this information.

Once the priority questions are developed the team can then create the EOI announcement itself. EOIs can contain a wide array of information provided by the funder about the opportunity, including details about information requested from the applicant. We have provided an initial list of both of these for the group to consider when crafting the EOI announcement. The end of this document contains links to example EOI announcements. The goal length for the entire EOI announcement should be 2-4 pages.

Other example EOI announcements include some of the following information by the funder:

- Clearly define the opportunity and/or project
- Provide a solid process plan with timelines
- Clearly stated priorities
- Include a general outline of the evaluation criteria for the subsequent proposal submission, evaluation, and selection process
- Address potential questions (e.g., FAQs such as who is eligible to apply)
- Submission length and required content
- Invite those who are interested to respond
- Amount range; year range up for grabs

Applicants are often asked to provide the following information in their EOI:

- Team/partners and key personnel
- Relevant experience, submitted as a resume or curriculum vitae (*often an evaluation criterion*)
- Approach to the project (1-2 paragraphs)
- Scientific merit (*often an evaluation criterion*)
- How the proposal is in alignment with the funder stated priorities (*often an evaluation criterion*)
- Any current, pending, or potential matching funds (*submitted as an attachment with all funds listed with grantor, title, award amount, etc.*)
- Details about matching funds, in kind support, etc. (*often an evaluation criterion*)
- Relevant supporting documents (e.g., funded research proposal(s) for matching funds, resume/curriculum vitae, letters of support from project partners, etc.)

Solicitation, Evaluation, & Selection Processes

EOI announcements should have a relatively clearly delineated process for soliciting, evaluating, and selecting applicants from whom to solicit full proposals. Likewise, the proposals received should also have a clearly delineated evaluation and selection process.

Questions and examples for consideration are provided below for each of three process steps:

Solicitation

Questions and issues to address include:

- How will the solicitation be publicized and through what channels
    - OceanSpaces blog & newsletter
    - CDFW blog
    - OPC listserv
    - Ocean Science Trust newsletter
    - Collaborative Network newsletter
    - OPC-SAT: request members send it through their home institution channels
    - Tribes: consider sending out letters, presenting at a Fish and Game Commission Tribal Committee Meeting, regional Tribal Chairmen’s Association Meetings, and other formal bodies
    - MPA Statewide Leadership Team: request members send it through their agency/organization channels
    - FGC Marine Resources Committee: consider presenting at a Committee meeting

  - Secretary Laird's twitter feed
  - FGC: consider requesting Craig Shuman include this in his Marine Region update or make an announcement during the public comment period at relevant/upcoming FGC Meeting (if timing works out)
- How will we ensure to reach and appeal to the right depth and breadth of teams to apply?
  - Distribution to the above list
  - Appeal: Invite academic creativity and innovation in the project described in the EOI.
  - Breadth: Evaluation criteria and expression of prioritization emphasize partnerships, interdisciplinary approaches (if applicable), etc.
- How often is the EOI announcement released? (e.g., rolling/always open? open period once per year or twice per year? if not rolling/always open, what time of year?)
  - Funding cycle may govern this – open period once a year may make sense, from a funding perspective
  - Timing of the first release -- need to consider R&D needs in upcoming funding cycle (FY17.18), and future data collection needs in FY18.19 funding cycle

Evaluation

Evaluation criteria vary depending on the funder, type of grant, and monetary amount. Evaluation criteria can be very project specific. Evaluation criteria can also be made to be very general. The team should work together to determine which level of criteria or combination thereof makes the most sense for this particular EOI process (and proposals), considering Monitoring Program goals to decide priority evaluation criteria. Example evaluation criteria are provided below:

- Relevance and applicability to priorities of the Monitoring Program: Assessment of alignment of project goals with the Monitoring Program purposes and priorities
- Scientific/technical merit: The degree to which the proposed project is innovative and will advance the state of the science or discipline through rigorous, state-of-the-art research.
- Users, participants and partnerships: The degree to which users or potential users of the results of the proposed project have been brought into the planning of the project, will be brought into the execution of the project, and will use results. Researchers must work with end-users to develop relevant proposals. Demonstrated knowledge, partnerships, relationships, collaborations or other mechanisms for bringing users and partners into the project.
- Project costs and funding leverage: Description of funds already secured or under development for the proposed project. Demonstrated efficiencies in data collection, partnerships, etc.
- Qualifications of project lead(s) and demonstrated access to facilities and resources: Assessment of whether the applicants possess the necessary knowledge, experience, training, facilities and resources to complete the project

- Project management experience, expertise, and skills: Assessment of project management, including a proven track record in completing contracts on-time and within budget, experience managing and working in multi-party, multidisciplinary teams. Demonstrated list of grants, bringing projects to completion, delivering on contracts and grants, etc.
- Communication/Outreach component: Include the ability to provide clear and effective communication of project goals, approaches, and results to diverse audiences interested in monitoring information. Ability to create text, figures, documents for a variety of audiences outside of academia. Demonstrated established channels or partnerships on project team for outreach efforts.
- Timeliness/Urgency of the research: Due to changing ocean conditions as a result of both human and natural causes, priority given to research addressing issues needing immediate attention can arise and are not amenable to waiting until the next funding cycle.
- Proof of concept/Preliminary data (*if applicable*): Does the proposal have proof of concept through a previously funded or currently funded pilot project? Does it already have preliminary data in hand to hone a research proposal or leverage existing data?

Evaluation criteria, once selected, need to be weighted for their importance for use in the final scoring process (i.e., scientific/technical merit is 20% of the score, while partnerships is 30%).

Selection

Selecting EOIs to continue on to a full proposal submission often takes the form of peer review for many granting authorities (e.g., Sea Grant, NIH, NSF). Sometimes a peer review panel or committee is selected by the funder and either meets in-person to score and make selections, or reviews and scores independently, submitting their reviews to the funder, who makes a final funding decision. In other cases, the selection process has multiple steps, including independent reviews, followed by an in-person review panel. Examples are provided below:

- National Science Foundation (detailed and clearly delineated approach to their review methodologies): http://www.nsf.gov/bfa/dias/policy/merit_review/
- California Sea Grant: https://caseagrant.ucsd.edu/grants-and-funding/call-for-full-proposals

The project team should decide upon an EOI selection process that takes into consideration:

- How to nominate and select peer reviewers, such as –
    - Who should select the review team?
    - Is there a role for the OPC-SAT?
    - Is there a role for the MPA Statewide Leadership Team?
    - What should the composition of reviewers be? (e.g. one CDFW, One OPC, academic, NOAA, etc.)

- Does the team remain the same or change from year-to-year or from EOIs to full proposals?
- Are reviewers compensated for their time?
- How to score the EOIs under review: There are many different options – .
  - Average of scored reviews (reviewers score independently): if there is a wide range of scores then this method may not be viable
  - Consensus, following independent reviews and in-person discussion
  - Lead reviewer considers all independent reviews and makes final decision
- What sort of transparency should there be in terms of sharing reviews and providing feedback to teams who submitted EOIs or full proposals?
- How will the reviews be conducted?
  - Independent ("mail-in") review
  - Conference call with review panel/committee
  - In-person workshop
  - Combination of the above
- Is the same review process used for EOIs as for full proposals? Or are different approaches used?

Selected example EOIs

- ***Schmidt Ocean Institute***: http://schmidtocean.org/apply/expression-of-interest/
  Partial list of example evaluation criteria from the Schmidt Ocean Institute (full list here: http://schmidtocean.org/apply/expression-of-interest/) –

  Opportunities for the advancement of ocean research technologies, practices, and method: Do the project objectives include R&D, prototyping, or testing of new oceanographic technologies, practices, or methods? How significant are the implications of the proposed technology/methodology R&D for ocean sciences? How clearly is the proposed R&D approach articulated? How well does the proposed R&D approach address the key pertinent project challenges?

  Evidence of significant intrinsic intellectual merit and impact potential**:** How important is the proposed research for ocean sciences? How significant are the implications of the proposed research for the society? What is the quality of the proposed research plan? How comprehensively does the proposed research plan address the stated project objectives?
- ***Florida Sea Grant***: https://www.flseagrant.org/funding/open/biennial_call_for_proposals/

Memorandum: Fund Disbursement Mechanisms
Statewide MPA Monitoring Program

Example evaluation criteria from Florida Sea Grant EOI announcement –

Scientific Merit: The degree to which the proposed project is innovative and will advance the state of the science or discipline through rigorous state-of-the-art research.

Users, Participants and Partnerships: The degree to which users or potential users of the results of the proposed project have been brought into the planning of the project, will be brought into the execution of the project, and will use results. Researchers must work with end-users to develop relevant proposals.

Expected Results, Applications and Benefits: The degree to which the completed project is expected to create new commercial opportunities, improve technological and economic efficiency, promote environmental sustainability, or improve management decisions, in Florida or possibly nationally.

- ***European Science Foundation***: http://www.esf.org/index.php?eID=tx_nawsecuredl&u=0&g=0&t=1471543933&hash=1623a13d905e0f82eac3f0e525d1ac3395b86256&file=fileadmin/be_user/activities/Career_Tracking/CT_CALL_TEXT_final.pdf

Appendix B:

PERFORMANCE EVALUATION QUESTIONS AND METRICS

TABLE B1: Performance objectives, questions, and metrics for network evaluation at meeting the goals of the Marine Life Protection Act (MLPA).

MLPA GOAL 1: PROTECT THE NATURAL DIVERSITY AND ABUNDANCE OF MARINE LIFE, AND THE STRUCTURE, FUNCTION, AND INTEGRITY OF MARINE ECOSYSTEMS		
PERFORMANCE OBJECTIVE	**MEASURABLE QUESTION**	**LONG-TERM MONITORING INDICATOR**
Protect areas of high species diversity and maintain species diversity and abundance, consistent with natural fluctuations of populations in representative habitats	Do focal and/or protected species inside of MPAs differ in size, numbers, and biomass relative to reference sites?	Size/age structure of focal species, abundance, and biomass measures
	Does functional diversity differ in MPAs relative to reference sites?	Functional diversity metrics
	Do MPAs that include multiple habitat types harbor higher species abundance or more diverse communities than those that encompass a single habitat type or less diverse habitat types?	Size/age structure, abundance, and biomass of focal species, community diversity measures in MPAs with high habitat diversity and low habitat diversity
Protect natural trophic structure and food webs in representative habitats	Do the abundance, size/age structure, and/or diversity of predator and prey species differ inside MPAs, or outside areas of comparable habitat?	Trophic structure metrics
Protect ecosystem structure, function, integrity, and ecological processes to facilitate the recovery of communities from both natural and human disturbances	Does the nature or timing of recovery of natural communities from disturbance events differ in different types of MPAs relative to outside areas?	Ecosystem structure and function metrics and their diversity

MLPA GOAL 2:

HELP SUSTAIN, CONSERVE, AND PROTECT MARINE LIFE POPULATIONS, INCLUDING THOSE OF ECONOMIC VALUE, AND REBUILD THOSE THAT ARE DEPLETED

PERFORMANCE OBJECTIVE	MEASURABLE QUESTION	LONG-TERM MONITORING INDICATOR
Protect, sustain, and conserve regional populations of selected harvested or non-harvested species and the habitats on which they depend	How does spatial variability in fishing effort and fishing mortality rates prior to and after MPA implementation affect the abundance and/or size/age structure of harvested species in MPAs?	Logbook data, California Recreational Fisheries Survey (CRFS) data, local fishing mortality rates, size/age structure of focal species, abundance and biomass measures
	How do species differ in their rate of response to MPA implementation?	Population models, size/age structure of focal species, abundance and biomass measures
	What is the relationship between MPAs and the displacement, compaction, and concentration of nearshore fishing efforts? Did overall fishing effort/mortality rates and yield change since MPA implementation?	Fishing effort and catch data, local fishing mortality rates, catch-per-unit-effort
	Do differences in fishing distribution, magnitude, and mortality rates prior to MPA implementation affect changes in the abundance and/or size/age structure of populations of focal species within MPAs relative to reference sites over time?	Fishing effort and catch data, local fishing mortality rates, size/age structure of focal species, abundance, and biomass measures
	What is the rate and distribution of adult spillover of targeted fishery species from MPAs into adjacent areas?	Tagging studies, density patterns relative to distance across MPA boundaries
	Is the implementation of MPAs as a habitat-based approach to marine fisheries management more or less effective in maintaining sustainable fisheries than traditional management strategies such as limiting harvest in a non-spatially explicit manner?	Logbook data, CRFS data, local fishing mortality rates, stock assessments
	What are the economic effects of MPA placement; specifically distance from ports and location relative to fishing grounds?	Fishing effort and catch data, local fishing mortality rates, catch-per-unit effort, distance from port to fishing grounds
	What is the value of the ecosystem services provided by California's MPAs?	Examples include measures of the role MPAs play in climate change resilience, recreation and tourism, cultural uses, science and educational uses, and conservation of economically important fisheries

MLPA GOAL 3:

TO IMPROVE RECREATIONAL, EDUCATIONAL, AND STUDY OPPORTUNITIES PROVIDED BY MARINE ECOSYSTEMS THAT ARE SUBJECT TO MINIMAL HUMAN DISTURBANCES, AND TO MANAGE THESE USES IN A MANNER CONSISTENT WITH PROTECTING BIODIVERSITY

PERFORMANCE OBJECTIVE	MEASURABLE QUESTION	LONG-TERM MONITORING INDICATOR
Ensure MPAs are accessible for recreational, educational, and study opportunities	Are researchers accessing MPAs, and has research increased over time in MPAs?	Trends in number of research studies conducted in MPAs over time; dissemination of results of research studies within MPAs
	Has the magnitude and variety of recreational/educational use increased over time in MPAs?	Visitor use surveys
	How has non-consumptive use and enjoyment of marine ecosystems changed since MPA implementation? Has the public's perceived value or desire to visit the areas where the MPAs have been implemented changed due to their presence?	Contingent valuation studies (willingnes to pay for access to MPAs)
	Are recreational consumptive users able to mitigate short-term costs of displacement from MPAs by conducting activities along the edge of MPAs? Will there be long-term benefits from the edge effect?	Changes in use patterns and catch of targeted species by consumptive users over time
	How are knowledge, attitudes, and perceptions regarding the MPAs changing over time?	Public and user group knowledge, attitudes, and perceptions of MPAs
Protect or enhance recreational experience by ensuring natural size and age structure of marine populations	Are non-consumptive recreational experiences in areas subject to reduced fishing improving? What are the attitudes and perceptions of users and their recreational experience and how has that changed over time?	Predicted increase in user group satisfaction based on user group surveys
	Is the size/age structure of recreationally valued species increasing in MPAs over time?	Differential size/age structure of selected species inside and outside MPAs over time; onboard and dockside sampling of recreational catch, location and effort

MLPA GOAL 4:

PROTECT MARINE NATURAL HERITAGE, INCLUDING PROTECTION OF REPRESENTATIVE AND UNIQUE MARINE LIFE HABITATS IN CALIFORNIA WATERS FOR THEIR INTRINSIC VALUE

PERFORMANCE OBJECTIVE	MEASURABLE QUESTION	LONG-TERM MONITORING INDICATOR
Protect representatives of all marine habitats identified in the MLPA across a range of depths	Have unique habitats been adequately represented and protected by the current distribution and designation of MPAs?	Habitat mapping within MPAs to groundtruth what is captured in MPAs
	Does the abundance or quality of habitat (geologic, oceanographic, biogenic) increase or remain the same within an MPA?	Habitat metrics (e.g., derived from seafloor maps, water quality, and species that form biogenic habitat)
Protect marine natural heritage	Have endangered species and/or culturally significant species benefited from the presence of California's MPAs?	Population trends of special status species (Section 2.3, Indicator Species Selection)
	Do MPAs limit the spread of invasive species?	Comparison of the presence and abundance of invasive species inside and outside of MPAs (Refer to list of current invasive species in California)[1]

[1] https://www.wildlife.ca.gov/Conservation/Invasives

MLPA GOAL 5:

ENSURE CALIFORNIA'S MPAS HAVE CLEARLY DEFINED OBJECTIVES, EFFECTIVE MANAGEMENT MEASURES, AND ADEQUATE ENFORCEMENT, AND ARE BASED ON SOUND SCIENTIFIC GUIDELINES

PERFORMANCE OBJECTIVE	MEASURABLE QUESTION	LONG-TERM MONITORING INDICATOR
For the MPA Network, develop objectives and a long-term monitoring plan that includes a strategy for MPA evaluation	Are efforts to collect long-term monitoring data coordinated sufficiently such that cohesive conclusions can be formed about MPA Network performance?	Results from funded long-term monitoring studies
	Does the MPA Monitoring Action Plan produce sufficient information that enables the evaluation of Network performance and informs adaptive management?	Peer review of the MPA Monitoring Action Plan; cost-efficient spending and funding
Ensure adequate enforcement and compliance with MPA regulations	Is monitoring of human activity and enforcement adequate for preventing illegal take in MPAs?	Trends in number of citations/enforcement actions for violations of MPA regulations
	Do penalties for non-compliance deter users from violating regulations?	Trends in number of citations/enforcement actions for violations of MPA regulations
	How has the level of compliance changed over time since the MPAs were first implemented and what factors influence variation in compliance within and among MPAs?	Trends in number of citations/enforcement actions for violations of MPA regulations as a function of MPA features (e.g., size, location, level of protection, enforcement), socioeconomic factors, and human uses in proximity to MPAs
	Does locating a boat ramp or other access point affect the level of enforcement and compliance with MPA regulations?	Trends and spatial distribution of number of citations/enforcement actions for violations of MPA regulations
	Are there incentives that can help reduce noncompliant behavior inside MPAs?	Evaluate if incentive programs exist for ensuring compliance with MPA regulations
	Do State Marine Reserve (SMR)/State Marine Conservation Area (SMCA) clusters provide greater protection than stand-alone SMRs?	Size/age structure of focal species, abundance and biomass measures; evaluate clusters in comparison to stand-alone MPAs as part of Network evaluation
	Does the level of compliance differ between SMRs and SMCAs?	Trends and spatial distribution of number of citations/enforcement actions for violations of MPA regulations

MLPA GOAL 6:

ENSURE THAT THE STATE'S MPAS ARE DESIGNED AND MANAGED, TO THE EXTENT POSSIBLE, AS A NETWORK

PERFORMANCE OBJECTIVE	MEASURABLE QUESTION	LONG-TERM MONITORING INDICATOR
Evaluate network functionality and MPA sizing and spacing guidelines that were implemented under the MLPA	What are the demographic effects of siting MPAs in larval source or sink locations, and how do demographic responses to MPAs contribute to larval production and connectivity of MPAs in the network?	Demographic-connectivity model for determining linkages of MPAs in the network and their effects on population; evaluation of demographic-connectivity projections with size/age structure of focal species, abundance and biomass data collected through long-term monitoring
	How does the distance and larval contribution between a source MPA and sink MPA influence the ecosystem response inside the sink MPA?	Evaluation of demographic-connectivity model with size/age structure of focal species, abundance and biomass data collected through long-term monitoring
	How does the level of connectivity and larval supply from an MPA to areas outside of MPAs affect fisheries?	Demographic-connectivity model projections of larval supply from MPAs to areas outside MPAs
	Are MPAs with higher connectivity more resilient to sudden environmental disturbance as compared to more isolated MPAs with higher self-retention?	Size/age structure of focal species, abundance and biomass data, evaluation dependent on stressor
	How do other stressors impact the management of MPAs over time (e.g., water quality, oil spills, desalination plants, ocean acidification, sea level rise)?	Size/age structure of focal species, abundance and biomass data, evaluation dependent on stressor
	Do MPAs with higher connectivity have lower variability in population trends compared to more isolated MPAs?	Evaluation of demographic-connectivity model with size/age structure of focal species, abundance and biomass data collected through long-term monitoring

Appendix C:

CALIFORNIA ESTUARY AND WETLAND MONITORING SURVEY

Estuarine & Wetland Ecosystems: the first steps in developing an approach to leveraging existing monitoring programs

Brent B. Hughes

UC Santa Cruz

A report prepared for California Ocean Science Trust

June 2017

Table of Contents

About this Document

The goal of this document is to characterize existing and emerging capacity and resources for monitoring conditions and trends of estuarine and wetland ecosystems (including both ecological and physical metrics), inside and outside of California MPAs. This project was completed in coordination with the author, California Ocean Science Trust, California Ocean Protection Council, and the California Department of Fish and Wildlife. We thank the following people for helpful comments and discussion during the preparation of this report: Mark Carr, David Gill, Frank Shaughnessy, Jeff Crooks, and all of the other scientists and managers who provided useful information.

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Definitions and acronyms used in this report:

CAERS: California Estuarine Research Society
CDFW: California Department of Fish and Wildlife
CEDEN: California Environmental Exchange Network
CMECS: Coastal and Marine Ecological Classification Standard
DO: Dissolved oxygen
MLPA: Marine Life Protection Act
MPA: Marine Protected Area
NERR: National Estuarine Research Reserve
NEP: National Estuary Program
NPS: National Park Service
NT: No-Take Reserve
OPC: Ocean Protection Council
OST: Ocean Science Trust
PISCO: Partnership for Interdisciplinary Studies of Coastal Oceans
PMEP: Pacific Marine and Estuarine Fish Habitat Partnership
SCP: Scientific Collection Pertmit
SMCA: State Marine Conservation Area
SMR: State Marine Reserve
SMRMA: State Marine Recreational Management Area
SONGS: San Onofre Nuclear Generating Station Mitigation Monitoring Program
SWQCB: State Water Quality Control Board
TNC: The Nature Conservancy

Summary

A key first step in evaluating the performance goals of Marine Protected Areas (MPA) is establishing baseline-monitoring programs. The establishment of California Marine Life Protection Act (MLPA) established 23 estuarine MPAs. These MPAs were subdivided into 5 regions, each with its own target metrics to evaluate their performance in meeting MPA goals. The purpose of this report was to determine the existing monitoring programs in California estuaries that could provide leverage to monitoring as outlined in the MLPA. To do this we aimed to develop a comprehensive list of monitoring programs within the 23 estuarine MPAs, identify estuaries outside of the MPA network that would serve as good reference sites, and determine the important gaps that exist for estuarine monitoring within the MLPA framework. Working with partners from UC Santa Cruz, the California Ocean Science Trust (OST), the Ocean Protection Council (OPC), and California Department of Fish and Wildlife (CDFW), we developed a database of existing long-term (committed to greater than 4 years of monitoring) for target metrics in estuaries across the state. Together we identified 176 monitoring projects for the various target metrics across California estuaries. Despite this seemingly high number of monitoring programs most were limited to certain estuaries (e.g., Elkhorn Slough and Humboldt Bay) or programs (e.g., National Estuarine Research Reserve or San Onofre Nuclear Generating Station Mitigation Monitoring Program) or were limited to certain metrics (Dissolved Oxygen, pH, and eelgrass). We identified where many of the existing monitoring gaps occurred and discussed how future efforts could fill these gaps. These strategies include: establishing a network of researchers across the state to coordinate monitoring efforts, establishing other target monitoring metrics that could readily support MLPA goals, and using a regional conference to establish a network of researchers to take on monitoring of target metrics.

Introduction

Leveraging ecological monitoring to support the CA MPA program

Marine protected areas (MPAs) are a modern solution to managing and conserving ocean resources. Recent advances in theory on MPA design have determined that traditional MPAs, usually developed on small site-specific scales, can have little effect to maintaining the diversity and abundance of ocean resources over larger regional scales (Gaines et al. 2010). Since many anthropogenic disturbances and threats (e.g., climate change and over-fishing) to marine ecosystems occur over larger scales there is a high demand for developing networks of MPAs that can aid in mitigating harmful stressors.

An essential feature of determining the effectiveness of MPAs is the development of monitoring protocols that document conditions before and after implementation, and inside and outside of MPAs to monitor changes in target populations (e.g., fishery species), species assemblages, environmental conditions, and other factors necessary for impact evaluation (Ahmadia et al. 2015, Gill et al. 2017). In California, the 1999 Marine Life Protection Act (MLPA) called for the redesign of existing MPAs and the establishment of a statewide network. The MLPA also requires monitoring inside and outside of this network to assess conditions and evaluate MPA performance.

One of the eight coastal and nearshore ecosystems in California MPAs is estuaries. The establishment of the MPA network and the MLPA's monitoring requirement, created the need for monitoring inside and outside 20 estuaries that fall within MPAs across four regions: North Coast, North Central Coast, Central Coast, and South Coast (Figure 1). There are pre-existing monitoring programs within individual estuaries or across multiple that could help to achieve this task, such as those led by: state agencies (e.g., California Department of Fish and Wildlife - CDFW, State Water Quality Control Board - SWQCB), federal agencies (e.g., National Estuarine Research Reserve - NERR, National Estuary Program - NEP, National Park Service NPS), academic institutions, non-profit organizations, and citizen science programs (e.g., Elkhorn Slough Volunteer Water Quality Monitoring Program[1], Sea Otter Savvy[2], and Bay Net[3]. However, a grand challenge is determining whether or not these programs are collecting data and information at spatial, temporal, and taxonomic scales that are relevant to evaluating MPA performance, and more specifically, whether the metrics being monitored by existing programs align with those identified as top priorities for MPA monitoring.

The objectives of this project were to: 1) identify estuarine and wetland MPA and reference sites across the state of California, 2) identify the existing programs and program managers, 3) identify the metrics being sampled by each program, 4) determine if these programs are planning to be long-term (>4 years), so as to inform the effectiveness of established MPAs.

For this project we (Brent Hughes in collaboration with the Ocean Science Trust (OST), California Ocean Protection Council (COPC), and CDFW) aimed at bridging the gap between researchers who are engaged in long-term monitoring and the science needs of the MPA Monitoring Program, by doing the following: 1) develop a database that catalogues estuarine and wetland monitoring programs in California, including documentation of biological and water quality metrics, data management, accessibility to existing information, and program/project duration (MLPA-Partnership 2016, Hughes et al. 2017), and 2) document common metrics among existing estuarine monitoring programs and MPA monitoring metrics for estuaries and wetland ecosystems, as identified in the regional MPA Monitoring Plans.

[1]http://www.elkhornslough.org/research/waterquality_volunteer.htm
[2]http://www.seaottersavvy.org/volunteer
[3]http://montereybay.noaa.gov/getinvolved/volunteer/baynet.html

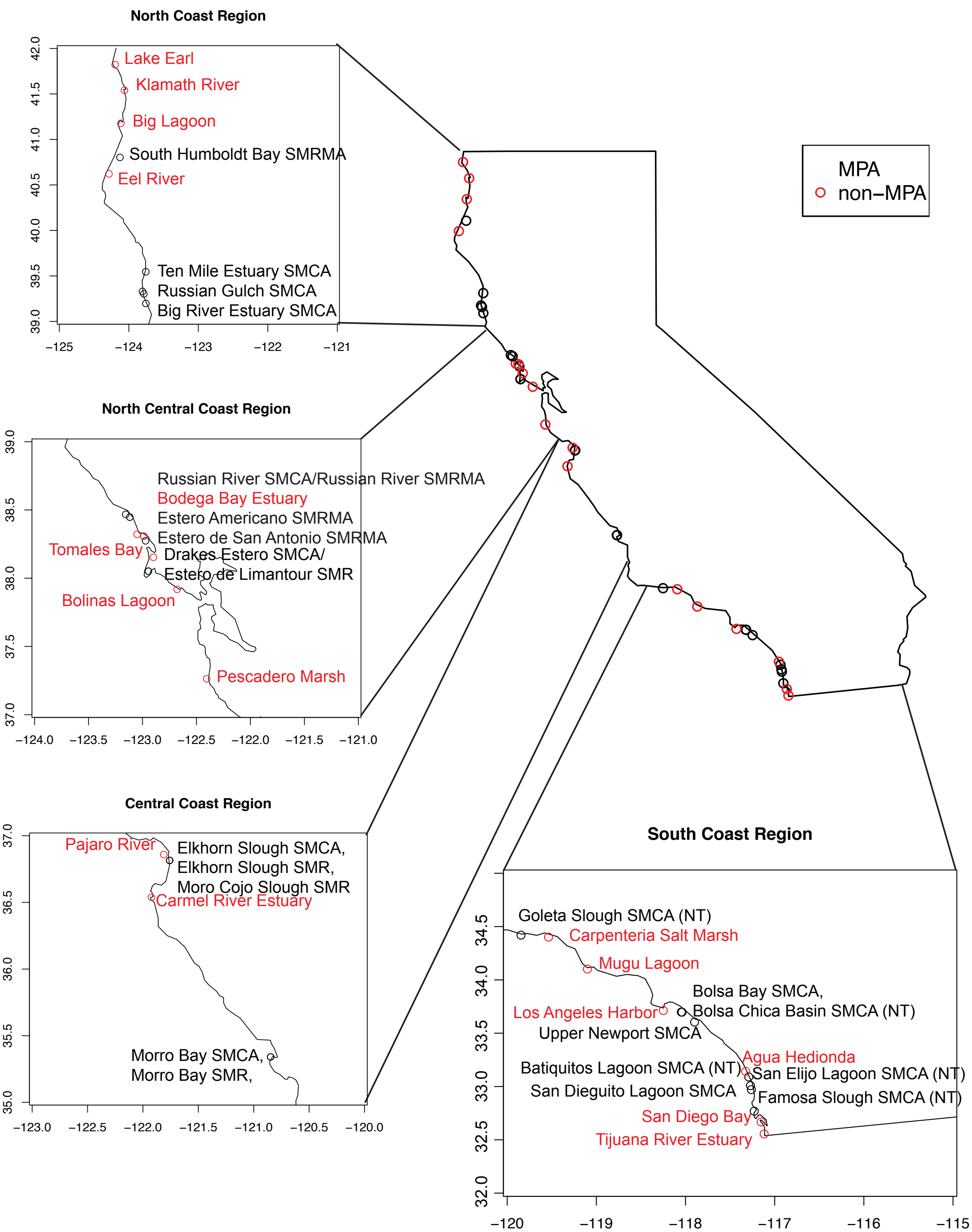

Figure 1. Distribution of estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California. The MLPA defined a fifth region in California, San Francisco Bay, but to-date the MLPA MPA siting process has not begun in that region. NT = No-Take MPA.

Methods

Identification of MPA and reference sites: a crosswalk with previous efforts

We started with a preliminary list of 23 potential estuarine MPAs provided by OST and CDFW. Not all of these MPAs turned out to be estuaries, mainly because, while the name implies estuary, the MPA is actually offshore (e.g., Tijuana River Mouth State Marine Conservation Area - SMCA). We aimed to identity a proportional number of “control” estuaries to compare with MPAs across all four coastal regions. A recent study done by The Nature Conservancy (TNC) and Pacific Marine and Estuarine Fish Habitat Partnership (PMEP) identified 184 estuaries in California that range in size from <1 ha to >10,000 ha (i.e., San Francisco Bay) (Hughes et al. 2014). This database encompassed all estuarine MPAs in California and served as a baseline to identify:

- Estuaries that have known fish and invertebrate monitoring.
- Potential non-MPA (control) estuaries based on the following attributes:
    - Regional representation (among the 4 MPA regions)
    - Estuary type, i.e., lagoon, riverine, bar built, etc.
    - Estuary acreage to ensure that MPAs and control sites are of comparable size.
    - Existing monitoring programs as outlined by the regional MPA monitoring target metrics.

After MPA sites and candidate reference sites were determined (Appendix 1, Table 1), we gathered all target monitoring metrics from regional MPA monitoring plans (MPA Monitoring Enterprise 2010, 2011, 2014) (Appendix 1, Table 2). Each metric was tabulated and compared across the four regions to determine overlap and/or lack of overlap among regions. These metrics were used to evaluate alignment of monitoring efforts in California estuaries with the regional MPA monitoring plans.

Developing the estuarine and wetland monitoring database

After the preliminary list of estuaries was assembled, we developed key attributes for each monitoring program among the candidate list of MPA and control sites. This information aimed to identity the key attributes for each target metric that has known monitoring. To avoid including shorter-term sampling or experimental programs that had no guarantee of commitment to long-term monitoring we set a definition of “long-term monitoring programs”. We used the recent definition of long-term monitoring being greater than four years commitment to monitoring (Hughes et al. 2017). By using this strict definition we were able to identify monitoring programs that are likely to extend into the future and worthy of assessing effects from MPAs.

Elkhorn Slough was the first site included in the database – it is a well-studied estuary with many known monitoring programs, and has some of the richest monitoring programs[1] among California estuaries outside of San Francisco Bay. Being part of the NERR system, the statewide MPA network, and a central location for researchers in Monterey Bay made this the ideal first site for this project.

While populating the database for Elkhorn Slough monitoring programs, we generated a list of researchers with potentially relevant monitoring programs and started contacting key researchers and managers. This list was generated using an exhaustive search, which included:

- A list of known fish monitoring in estuaries from the recent TNC and PMEP effort (Hughes et al. 2014).

[1] http://www.elkhornslough.org/research-program/

- Professional contacts of the contractor.
- Suggestions from project partners.
- A list of all researchers conducting estuarine research according to the CDFW scientific collecting permit (SCP) database.
- Leads produced by contacts.

In total this effort produced contacts of 52 researchers and managers across California estuaries (List available upon request)[1].

Populating the MPA monitoring database, a multi-tiered approach

Once contact was established with targeted researchers, we reached out to request information on relevant monitoring programs (see Appendix 2 for form letter requests). This approach began with an email introducing this project and major collaborators, followed with a few short questions:

- Do you monitor any of the following metrics (Table 1)?
- Is this monitoring program committed to the next five years or more?
- Can you provide me specific details about the monitoring program to populate the database?

Table 1. List of target metrics for estuarine monitoring listed for the MLPA monitoring process across all 4 regions (Figure 1).

Acipenser spp.	Marine mammal density
Anas spp.	Native oyster bed areal extent/abundance
Anthya spp.	*Oncorhyncus* spp.
Arthropod biomass	Pacific gaper clam abundance
Bat ray abundance	Parasite diversity
Black Brandt	pH/Carbonate chemistry
Black seaperch density & size structure	Pickleweed areal extent
CA halibut abundance & size frequency	Pile surfperch density & size structure
Cancer magister density	Piscivorous bird richness & abundance
Clam adundance and size frequency	Pleuronectidae
Common littleneck clam abundnce	Scolopacidae
Croaker abundance & size frequency	Shorebird richness & abundance
Diamond turbot density $ size structure	Spotted sand bass density & size structure
DO (dissolved oxygen)	Spp diversity (invert and fish functional groups)
Eelgrass areal extent	Spp richness (inverts and fishes)
Eelgrass density & % cover	Starry flounder abundance & size frequency
Fat innkeeper worm	Surfperch abundance & size frequency (any spp.)
Ghost and/or mud shrimp abundance	Topsmelt denisty & size structure
Gobies density & size structure	*Ulva* areal extent
Harbor porpoise	Washington clam abundance
Leopard shark density & size structure/abundance	Western Gull
Marine bird richness & abundance	

[1]Contact Erin Meyer (erin.meyer@oceansciencetrust.org) for access to the complete list of contacts.

For some of the lesser-known programs on the list and to further investigate potential programs, we performed online searches to find monitoring programs across the state, which included the following databases:

- California Environmental Exchange Network (CEDEN)
- CDFW
- NERR
- NEP
- San Onofre Nuclear Generating Station Mitigation Monitoring Program (SONGS)

These databases were checked for monitoring metrics and long-term commitment to monitoring. When applicable, researchers from each program were contacted to verify if monitoring was planned as long-term (> 4 years).

In addition, CDFW provided a list of all known research efforts in California estuaries based on their SCP database. We contacted all researchers in this database to ask them the multi-tiered questions as described above and limited any follow-up research (Appendix 2) to those programs/projects committed to long-term monitoring.

Analysis and Results

Using our MPA monitoring database[1], we generated summary figures of the following:

- Map of locations with known monitoring programs, coded as MPA v. non-MPAs(Figure 1).
- Assessment of target metrics across the coast (Table 1) to address thefollowing questions:
    - What metrics are most common across MPAs?
    - What are the biggest gaps in target metrics?

Figures 2-18 show the distribution of monitoring programs where more than one site has monitoring of a given target metric.

What metrics are most common across MPAs?

Out of all of the target metrics for the 23 MPA and 15 reference sites, dissolved oxygen (n = 7 MPAs, n = 6 reference sites), pH (n = 5 MPAs, n = 6 reference sites), and eelgrass areal extent (n = 6 MPAs, n = 4 reference sites) has the greatest number of long-term monitoring sites (Figures 2-3, Table 2). Each of the four regions has some monitoring of pH and DO, but only the North Coast lacks a reference site. For eelgrass, all regions except for the North Central Coast have monitoring, and the North Coast only has one MPA site.

What are the biggest gaps in target metrics, MPAs vs. Reference sites, and regions?

For this assessment of the 23 MPAs and 15 non-MPA reference sites (N = 38 sites), there appears to be a general lack of monitoring of estuaries (MPA or non-MPA) across the state of California. Other than DO, pH, and eelgrass areal extent, there are no other metrics monitored at ten or more monitoring sites (Table 2). However, it should be noted that most metrics are region-specific making it challenging to assess monitoring target metrics across the state.

[1]Contact Erin Meyer (erin.meyer@oceansciencetrust.org) for access to the monitoring database.

Over the entire state of California, monitoring programs are proportionally distributed among MPA sites (n = 77) and non-MPA reference sites (n = 64). However, at finer regional scales, these proportions are not consistent. For example, in the North Coast, only Humboldt Bay has representative monitoring programs, compared to only one non-MPA reference site, Eel River Estuary, where sturgeon is monitored. The Central Coast has good representation of monitoring in MPAs, but has no monitoring in non-MPA reference sites. This is partly due to the lack of estuaries in the region because of geological factors, and that the four MPAs (Elkhorn Slough SMR/ State Marine Conservation Area - SMCA, Moro Cojo Slough SMR, and Morro Bay State Marine Recreational Management Area - SMRMA) are monitored as part of two federal programs: NERR and NEP. The region with the most representation of monitoring programs is the South Coast (Table 2). This is expected because of the greater abundance of estuaries compared to the other regions (Hughes et al. 2014). However, certain programs exist, such as SONGS, which has long-term mitigation monitoring programs established at four estuaries (1 MPA, 3 non-MPA) in the region.

Table 2. Collated target monitoring metrics across the four coastal MPA regions. NA signifies that the metric is not a target metric for the region.

REGION, **M** = MPA (N = 23), **R** = Reference (N = 15)

	North		***N. Central***		***Central***		***South***		**TOTAL**	
Target Metric	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**
Acipenser *spp.*	0	1	NA	NA	NA	NA	NA	NA	**0**	**1**
Anas *spp.*	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Anthya *spp.*	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Arthropod biomass	0	0	NA	NA	NA	NA	1	3	**1**	**3**
Bat ray abundance	0	0	0	0	NA	NA	NA	NA	**0**	**0**
Black Brandt	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Black seaperch density & size structure	NA	NA	NA	NA	0	0	NA	NA	**0**	**0**
CA halibut abundance & size frequency	1	0	0	0	NA	NA	1	3	**2**	**3**
Cancer magister density	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Clam abundance and size frequency	0	0	0	0	3	0	1	3	**4**	**3**
Common littleneck clam abundance	0	0	0	0	NA	NA	1	3	**1**	**3**
Croaker abundance & size frequency	NA	NA	NA	NA	NA	NA	1	3	**1**	**3**
Diamond turbot density & size structure	NA	NA	NA	NA	0	0	NA	NA	**0**	**0**
DO (dissolved oxygen)	1	0	0	2	5	0	1	4	**7**	**6**
Eelgrass areal extent	1	0	0	0	4	0	1	4	**6**	**4**
Eelgrass density & % cover	0	0	0	0	1	0	0	0	**1**	**0**
Fat innkeeper worm	0	0	0	0	1	0	NA	NA	**1**	**0**
Ghost and/or mud shrimp abundance	0	0	0	0	0	0	1	3	**1**	**3**
Gobies density & size structure	1	0	NA	NA	NA	NA	1	3	**2**	**3**
Harbor porpoise	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Leopard shark density & size/abundance	1	0	0	0	NA	NA	1	3	**2**	**3**
Marine bird richness & abundance	0	0	2	0	5	0	0	0	**7**	**0**
Marine mammal density	0	0	2	0	5	0	0	0	**7**	**0**
Native oyster bed areal extent/abundance	0	0	0	0	2	0	NA	NA	**2**	**0**
Oncorhyncus *spp.*	1	0	NA	NA	NA	NA	NA	NA	**1**	**0**
Pacific gaper clam abundance	0	0	0	0	1	0	0	3	**1**	**3**
Parasite diversity	NA	NA	NA	NA	NA	NA	0	0	**0**	**0**
pH/Carbonate chemistry	1	0	0	2	3	0	1	4	**5**	**6**
Pickleweed areal extent	NA	NA	0	0	NA	NA	1	4	**1**	**4**
Pile surfperch density & size structure	NA	NA	NA	NA	0	0	NA	NA	**0**	**0**
Piscivorous bird richness & abundance	0	0	NA	NA	5	0	0	0	**5**	**0**
Pleuronectidae	1	0	NA	NA	NA	NA	NA	NA	**1**	**0**
Scolopacidae	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Shorebird richness & abundance	0	0	NA	NA	5	0	0	0	**5**	**0**
Spotted sand bass density & size structure	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
Spp diversity (invert and fish functional groups)	NA	NA	0	0	NA	NA	3	3	**3**	**3**
Spp richness (inverts and fishes)	NA	NA	0	0	NA	NA	3	3	**3**	**3**
Starry flounder abundance & size frequency	1	0	0	0	NA	NA	NA	NA	**1**	**0**
Surfperch abundance & size frequency	0	0	NA	NA	0	0	NA	NA	**0**	**0**
Topsmelt denisty & size structure	NA	NA	NA	NA	0	0	1	3	**1**	**3**
Ulva *areal extent*	0	0	0	0	3	0	NA	NA	**3**	**0**
Washington clam abundance	NA	NA	NA	NA	NA	NA	1	3	**1**	**3**
Western Gull	0	0	NA	NA	NA	NA	NA	NA	**0**	**0**
TOTAL	**9**	**1**	**8**	**4**	**43**	**0**	**21**	**59**	***77***	***64***

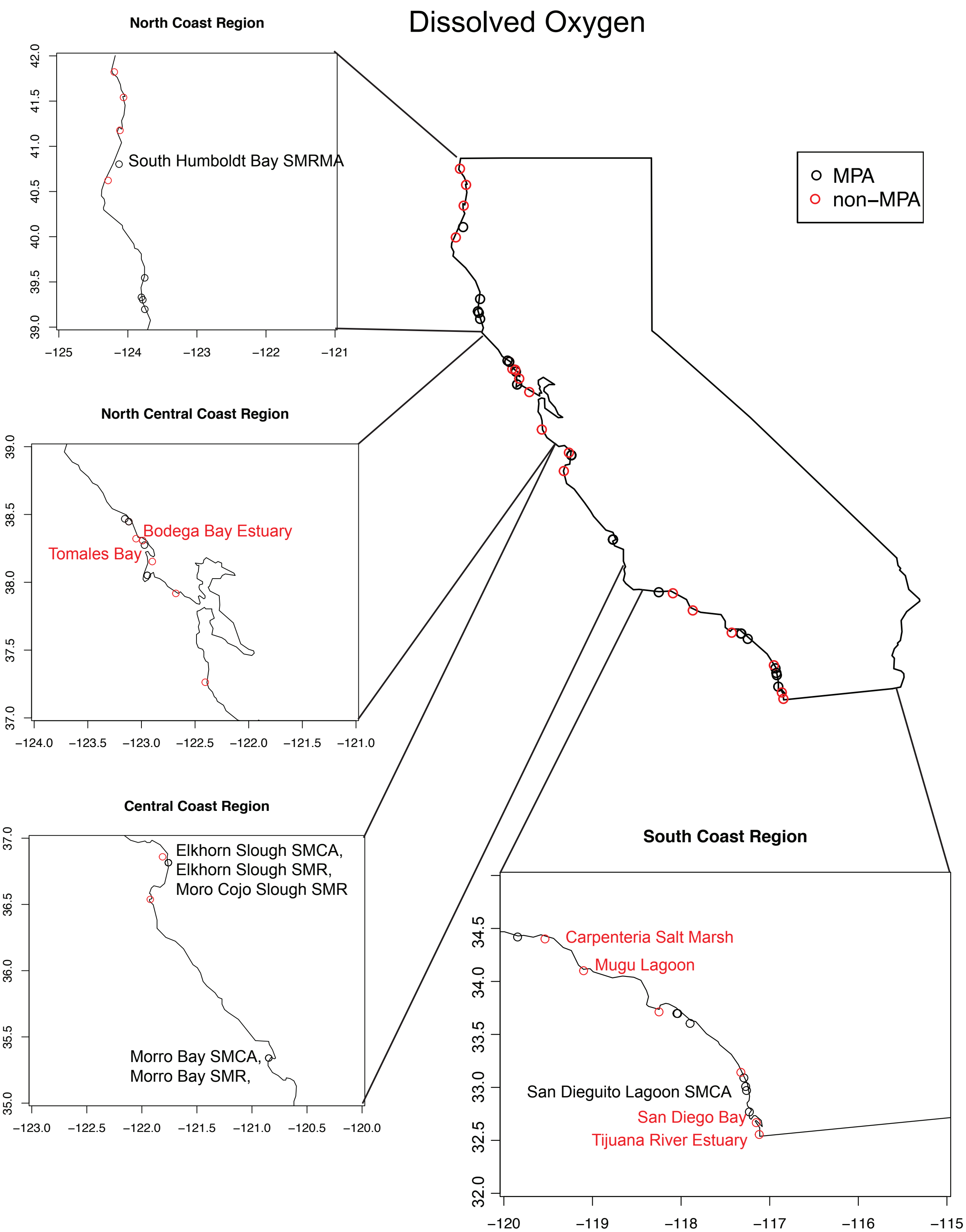

Figure 2. Distribution of dissolved oxygen monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

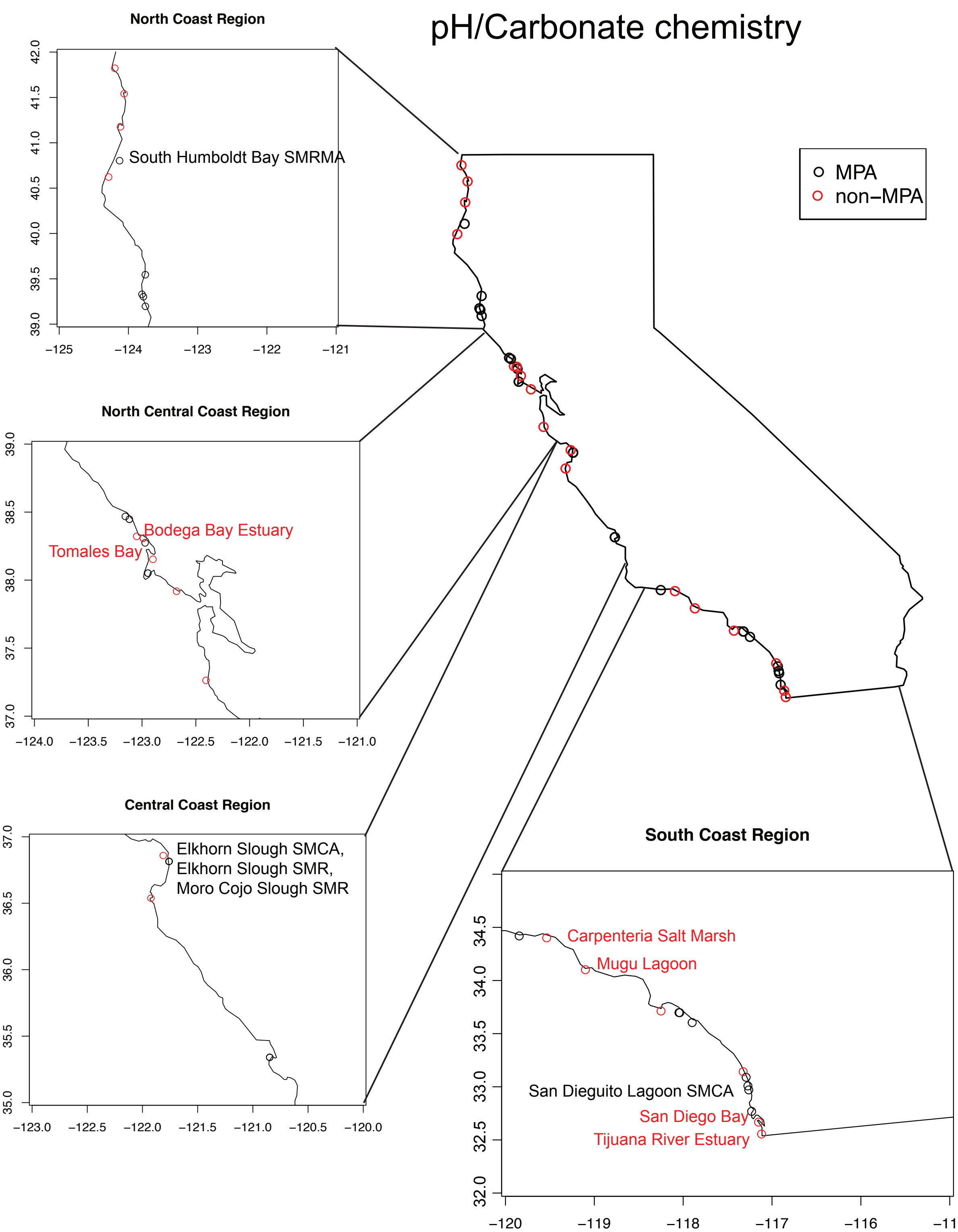

Figure 3. Distribution of pH monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

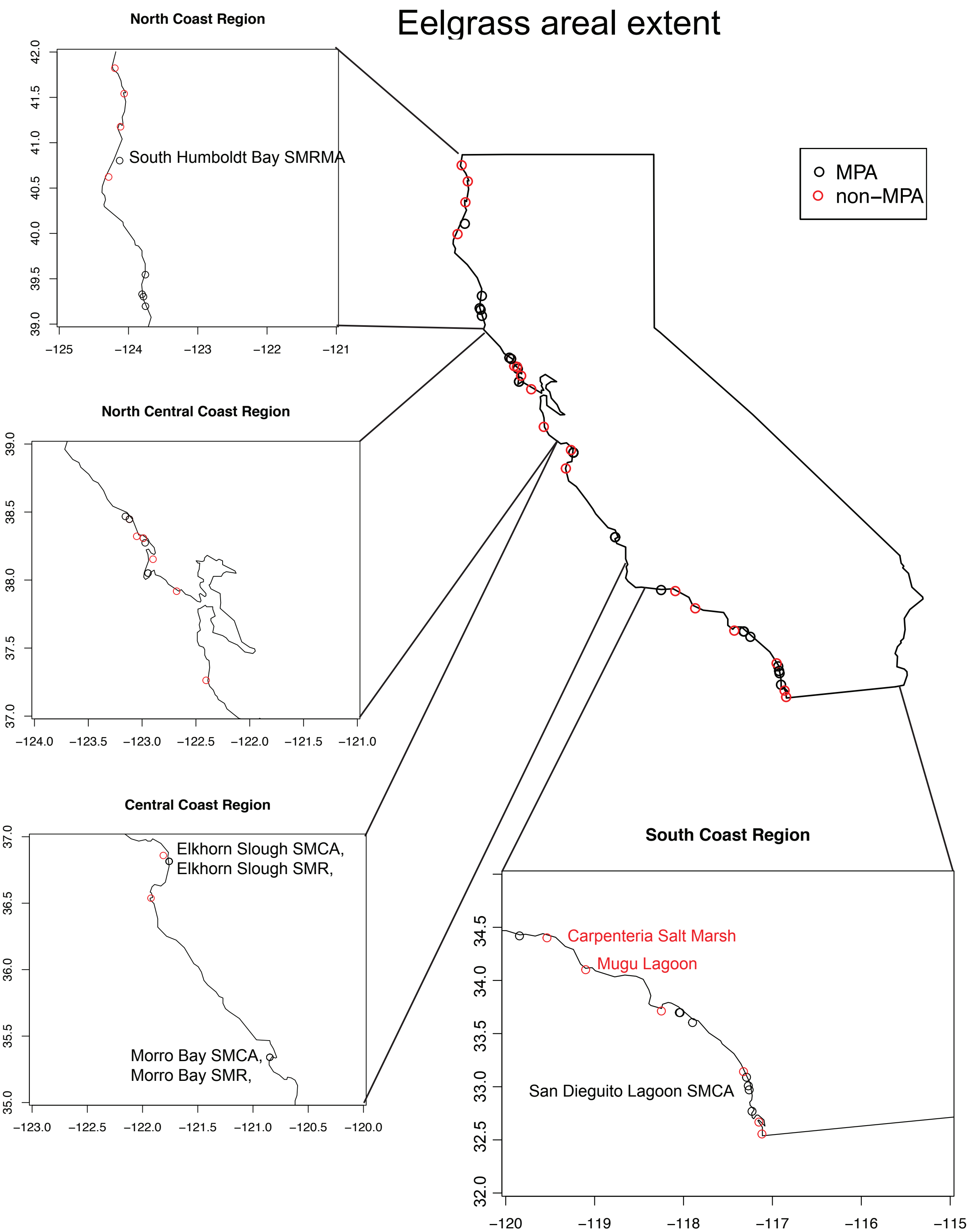

Figure 4. Distribution of eelgrass (*Zostera marina*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

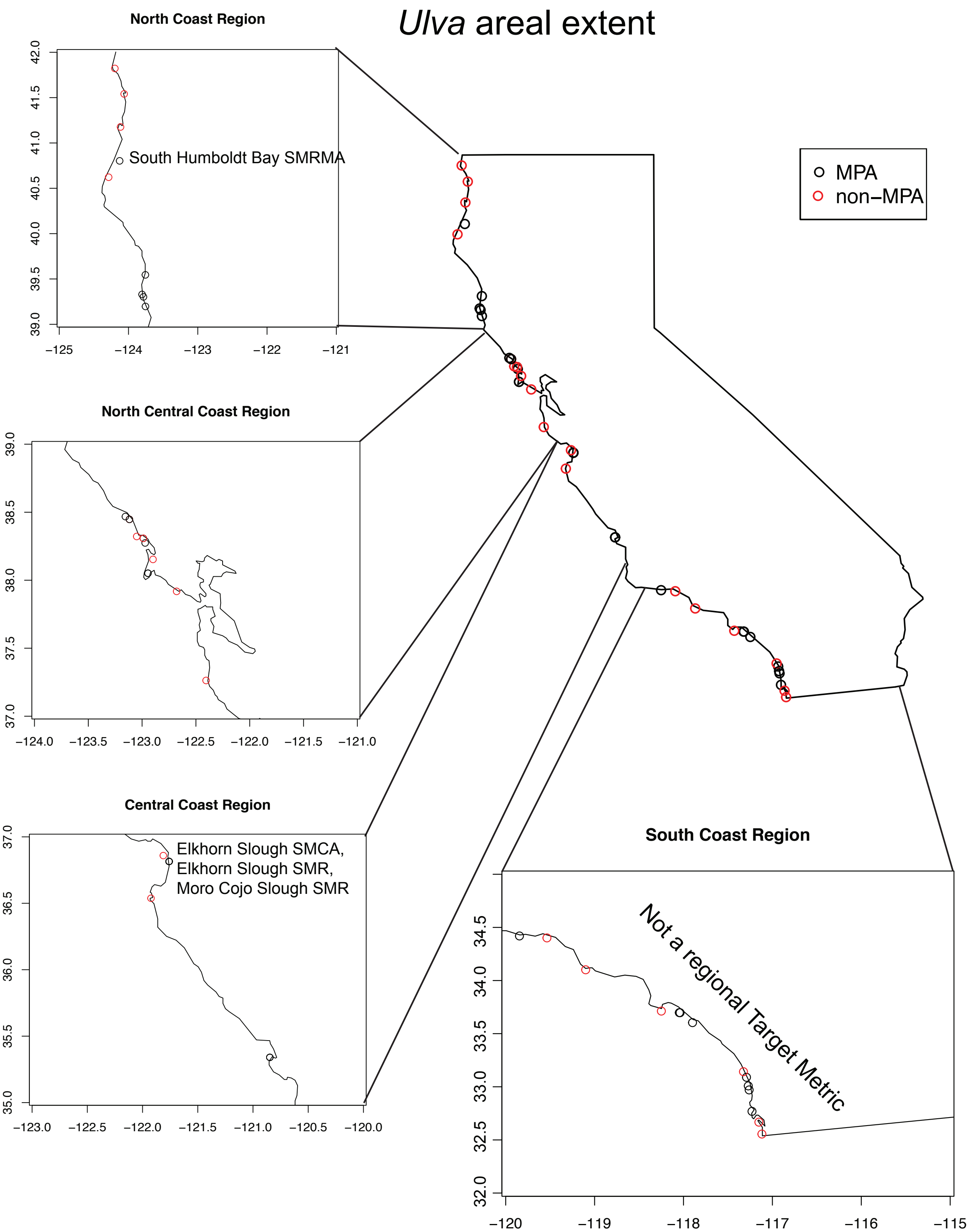

Figure 5. Distribution of green alga *Ulva* spp. monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

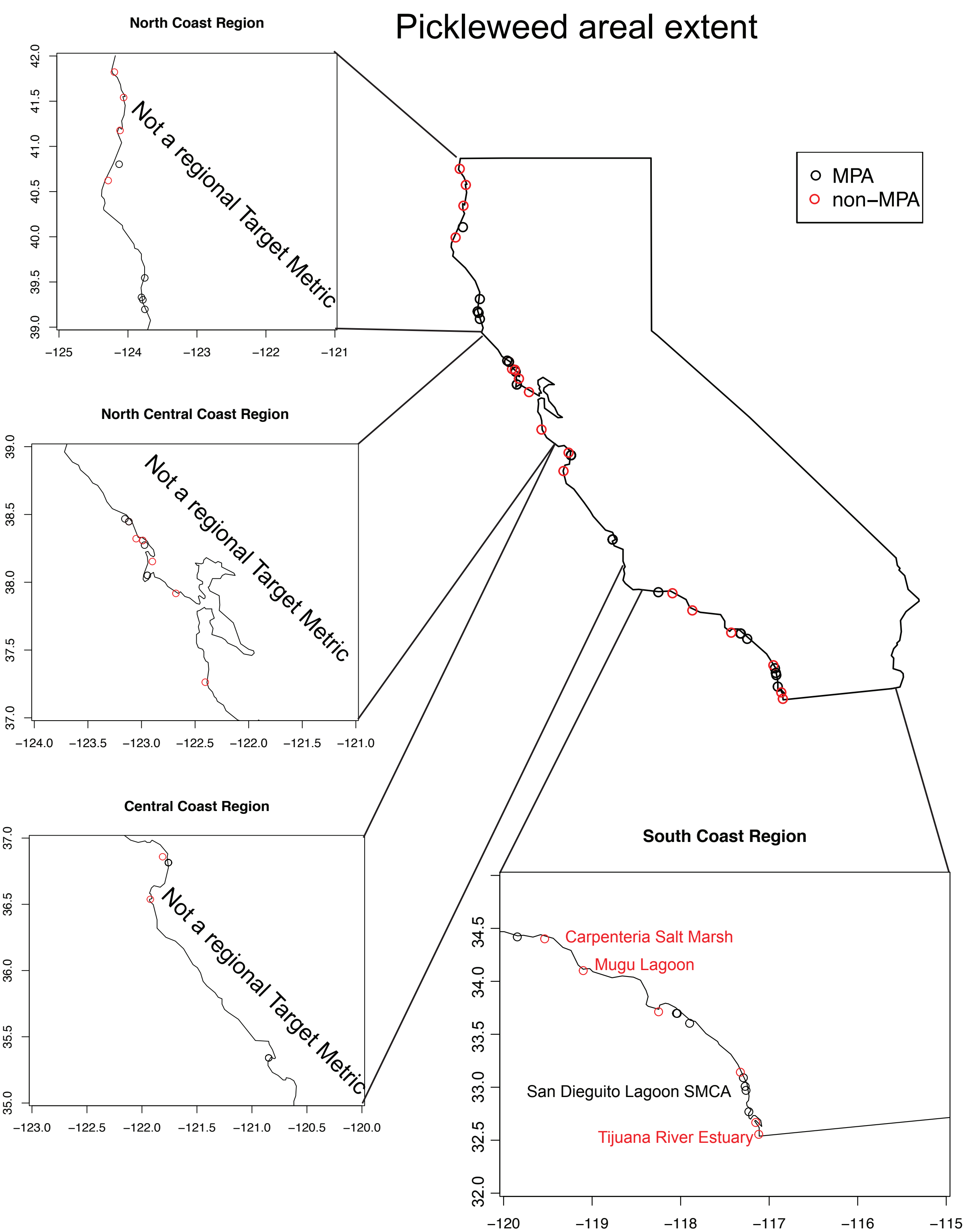

Figure 6. Distribution of pickleweed salt marsh (*Salicornica virginica*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

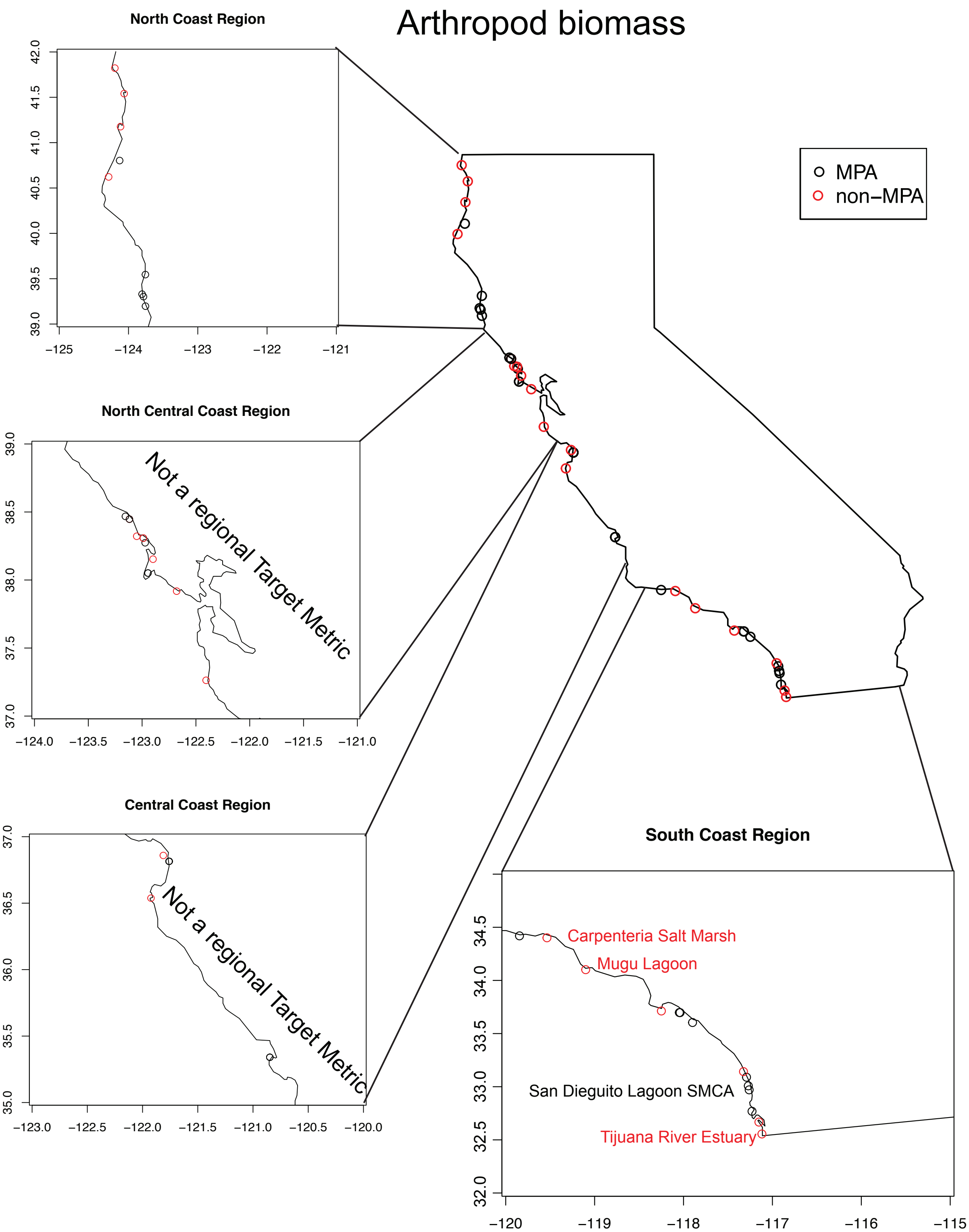

Figure 7. Distribution of arthropod biomass monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

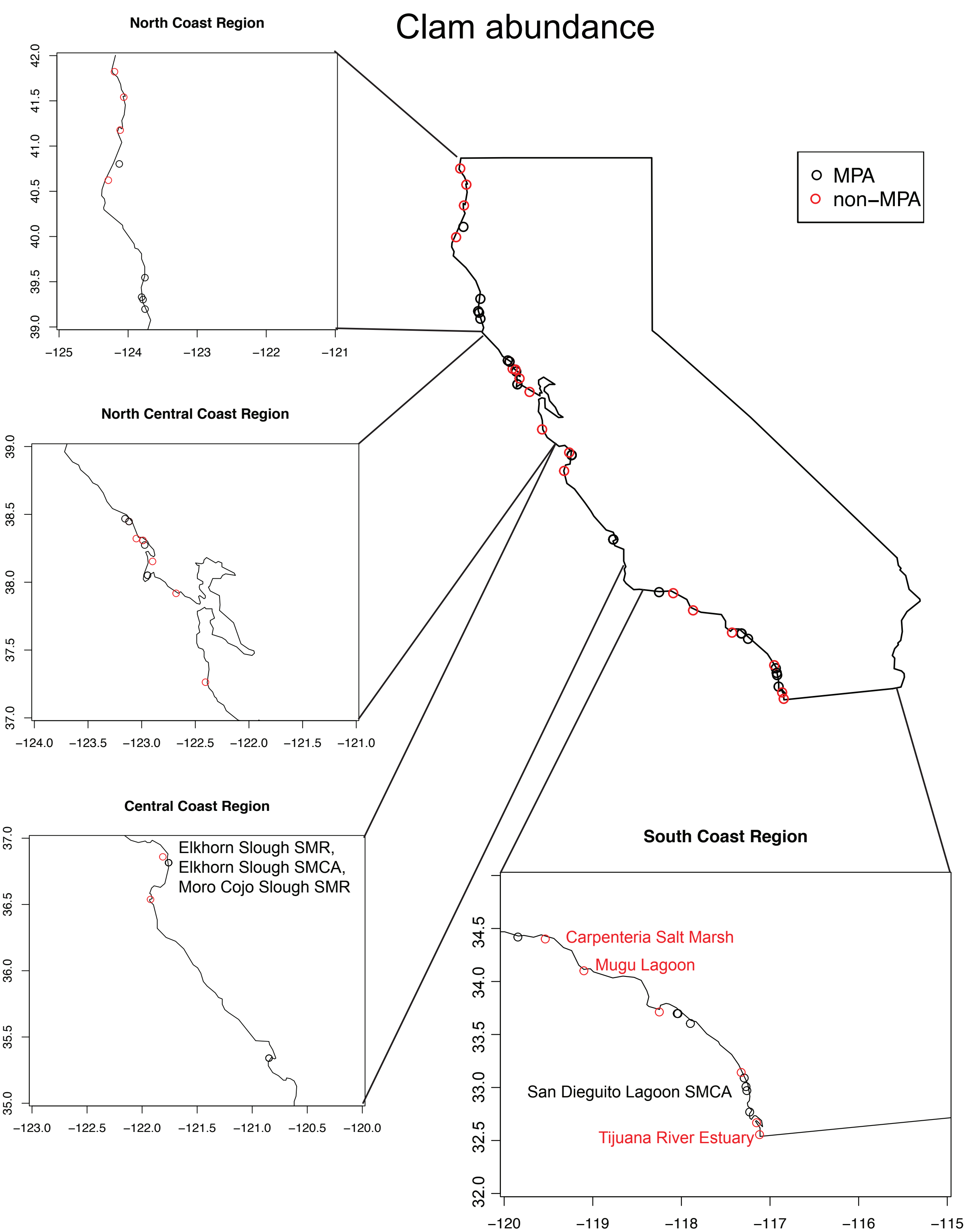

Figure 8. Distribution of clam abundance monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

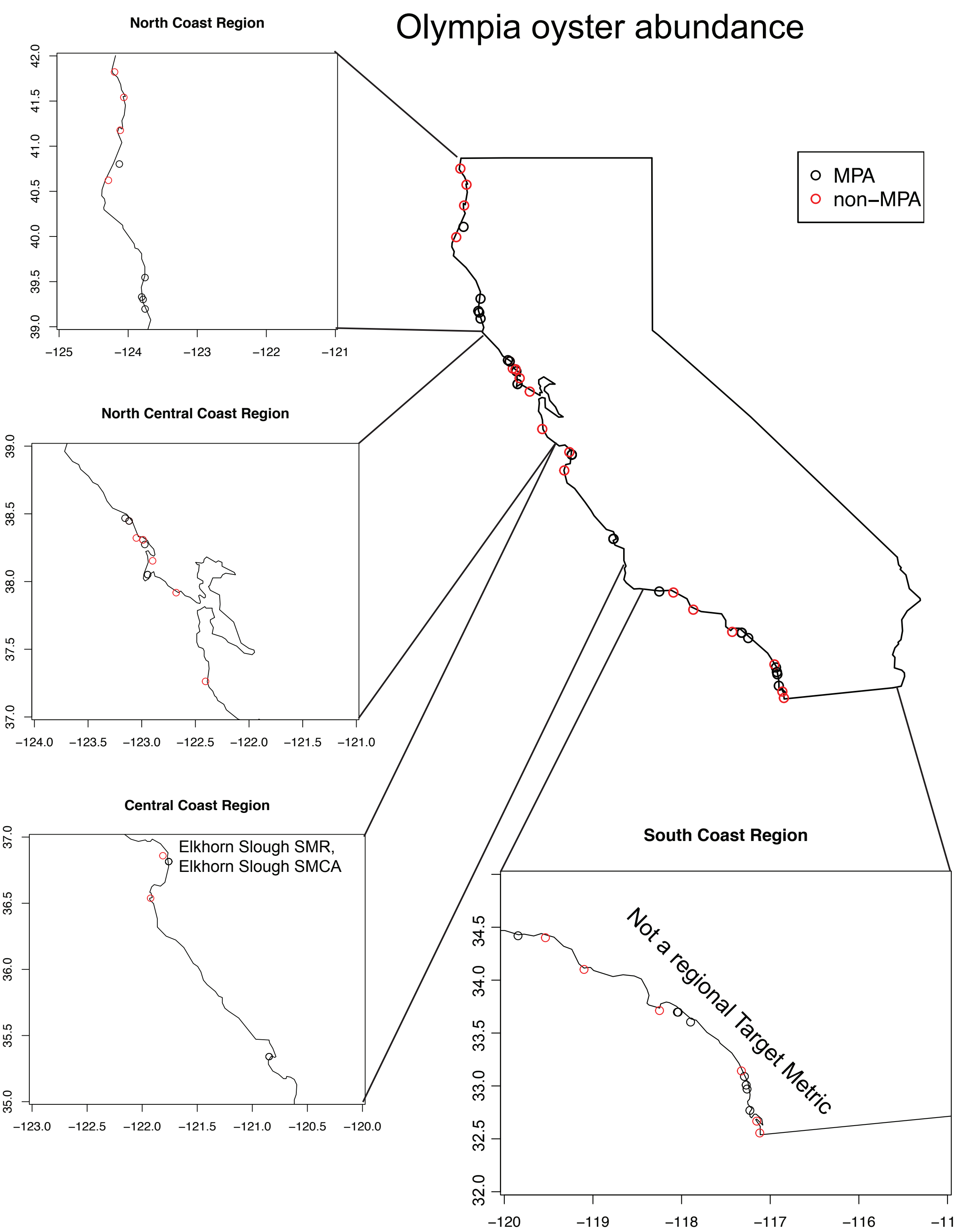

Figure 8. Distribution of Olympia oyster (*Ostrea lurida*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

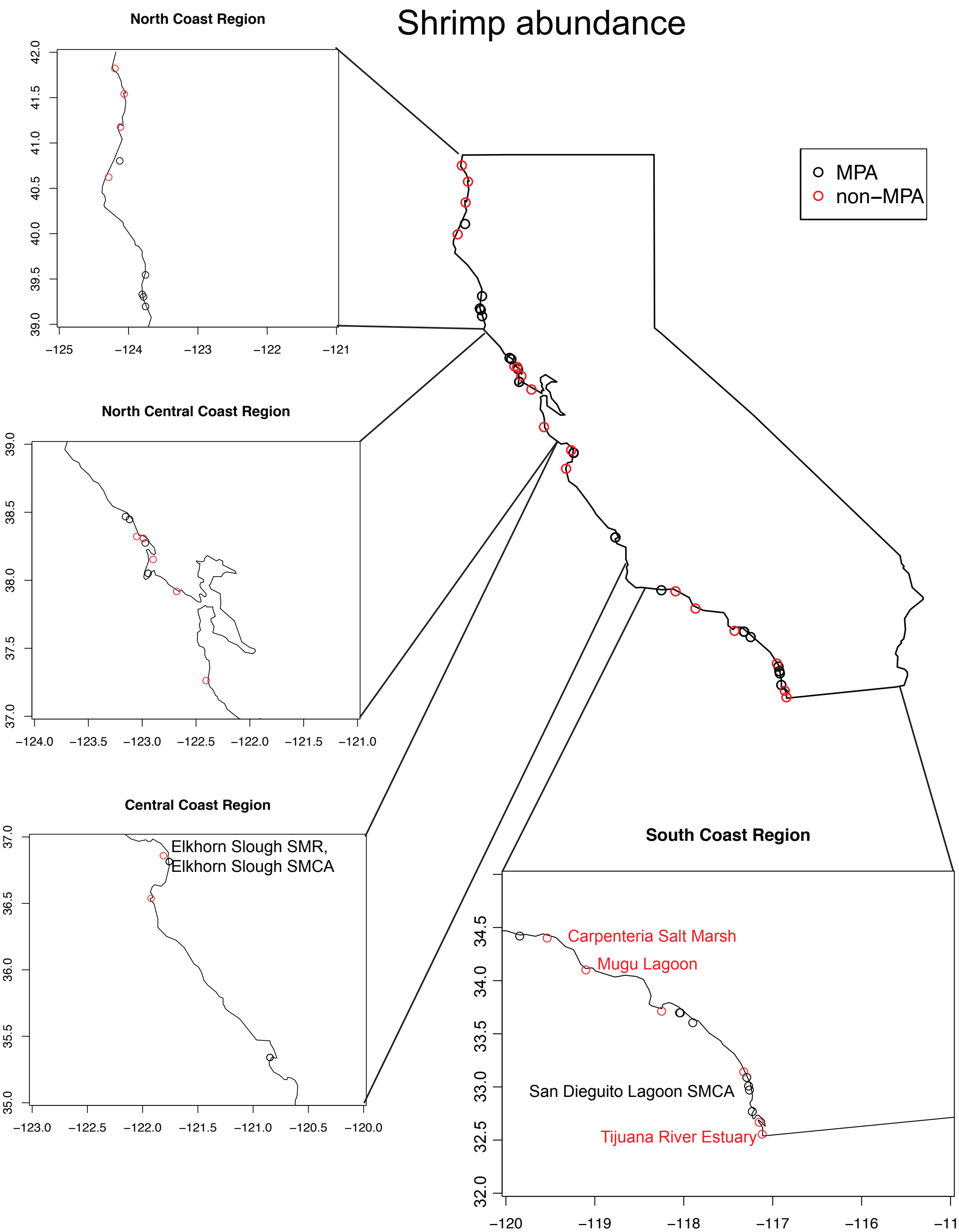

Figure 9. Distribution of shrimp monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

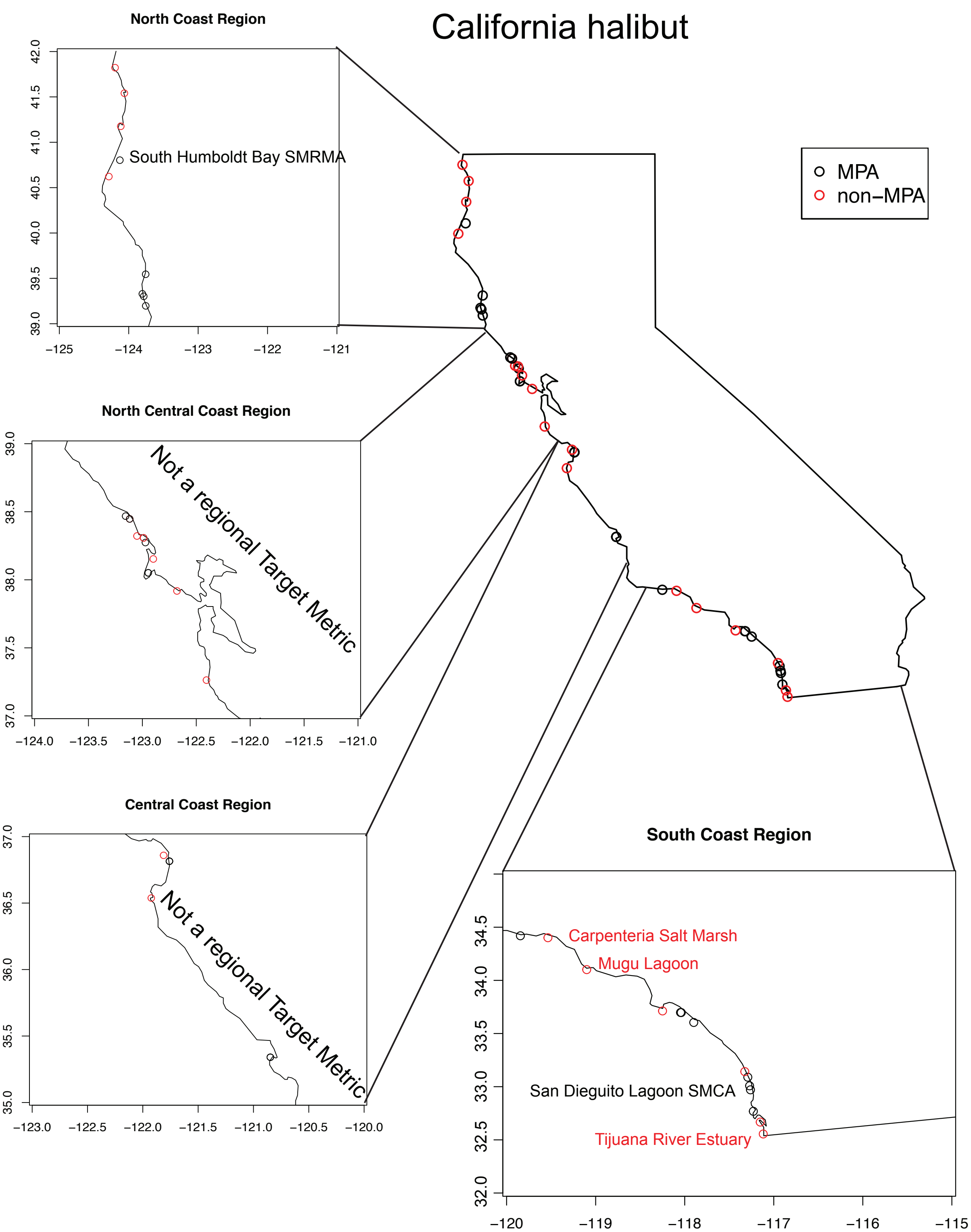

Figure 10. Distribution of California halibut (*Paralichthys californicus*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

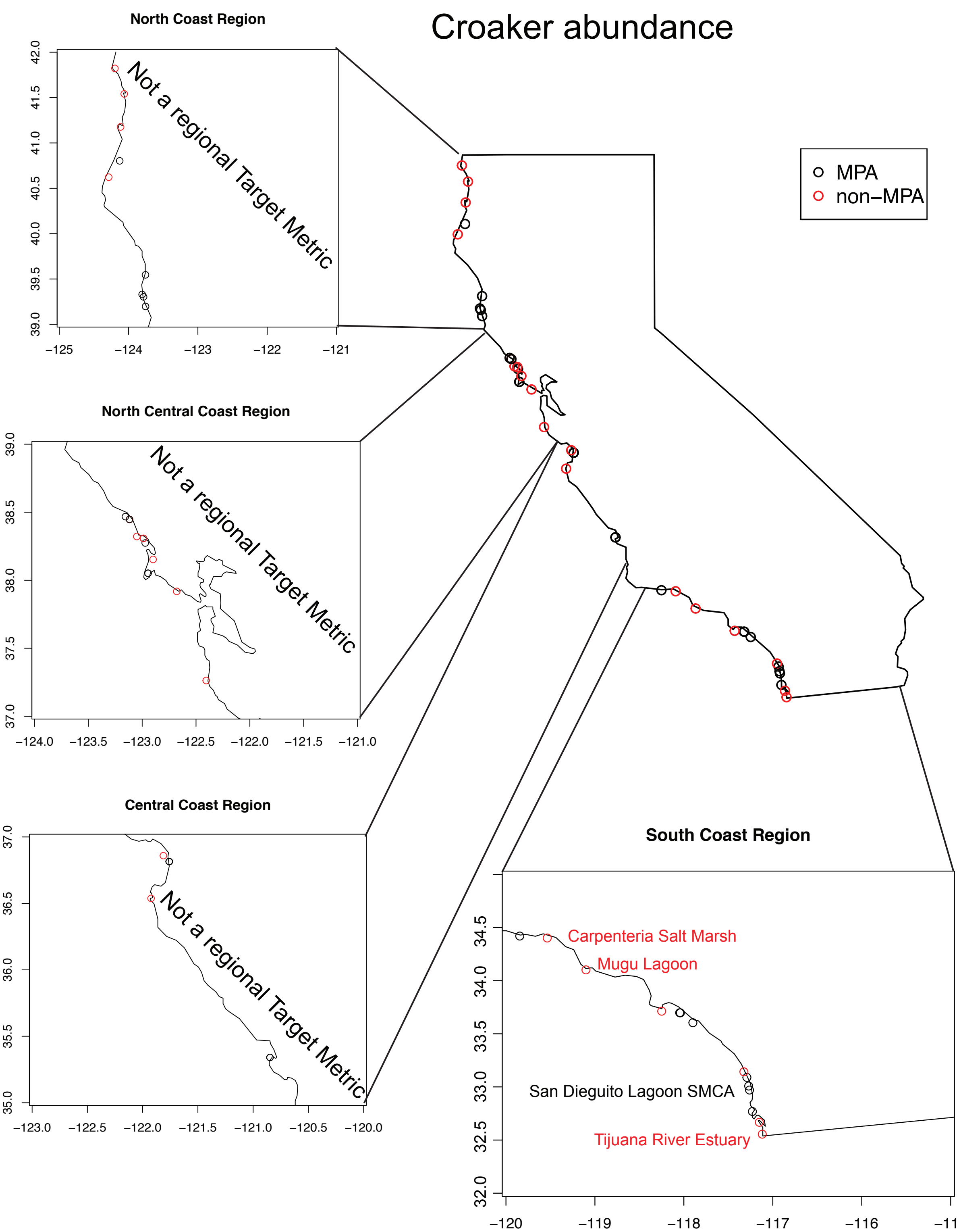

Figure 11. Distribution of croaker (*Menticirrhus* sp.) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

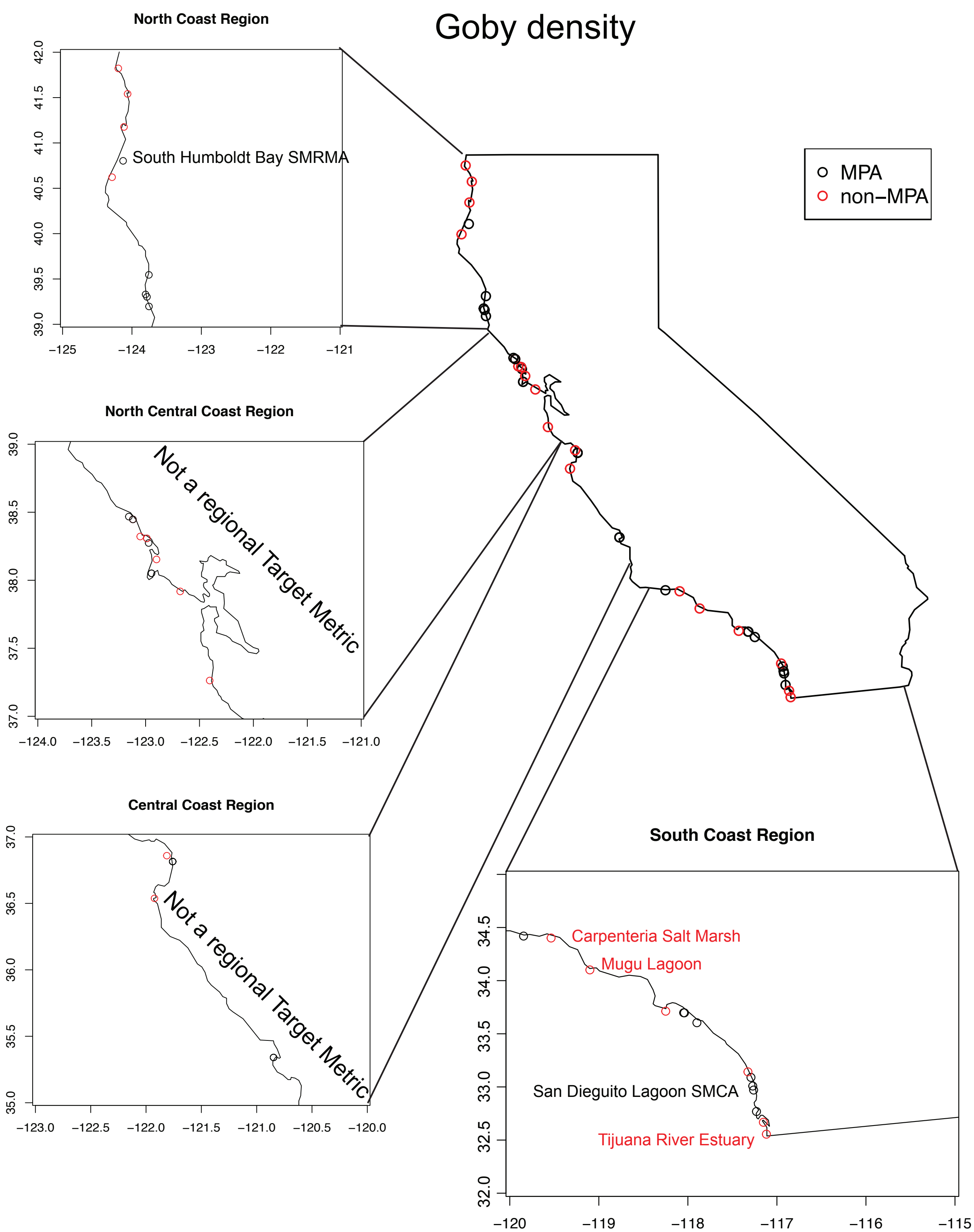

Figure 12. Distribution of Goby (family Gobiidae) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

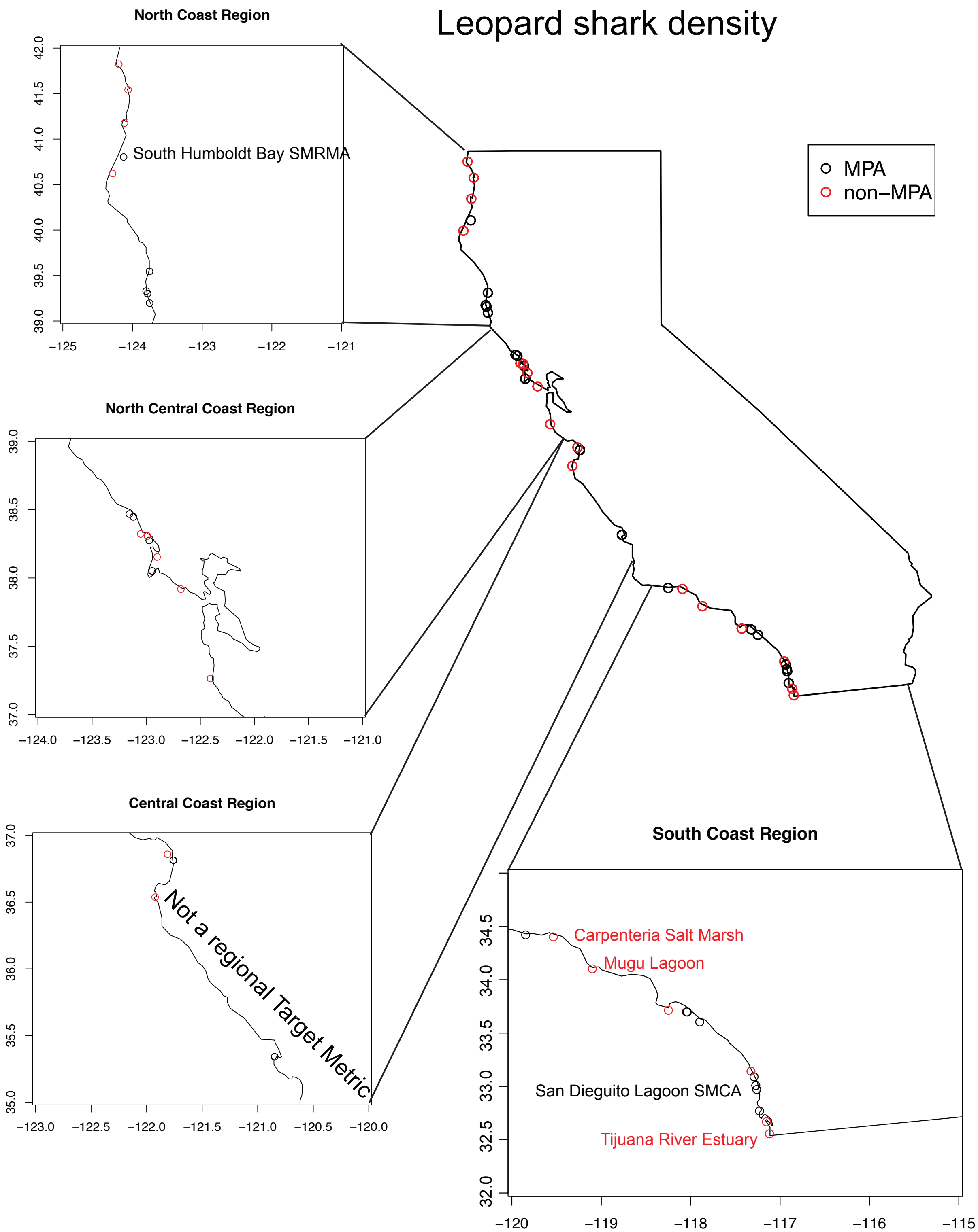

Figure 13. Distribution of leopard shark (*Triakis semifasciata*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

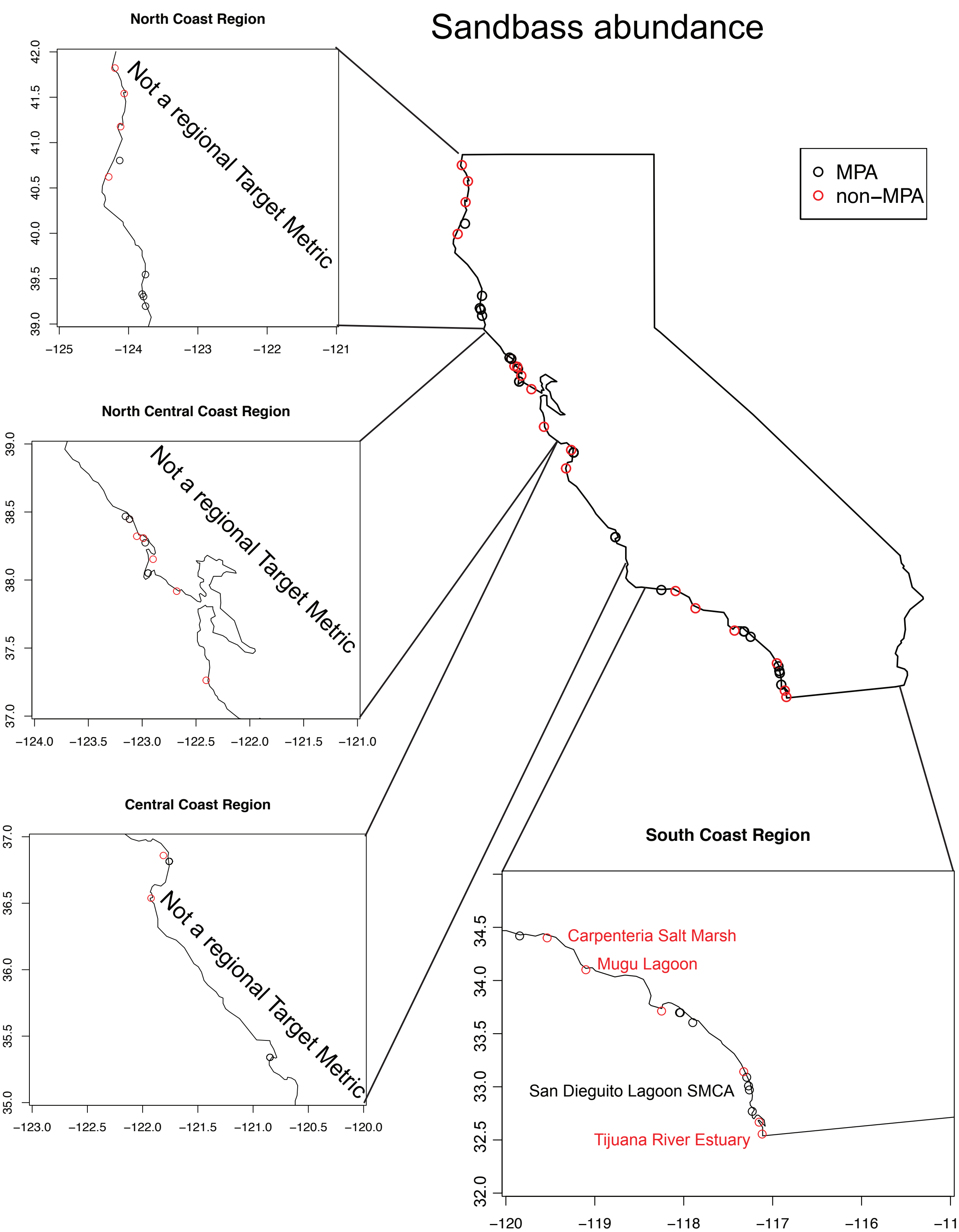

Figure 14. Distribution of spotted sandbass (*Paralabrax maculatofasciatus*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

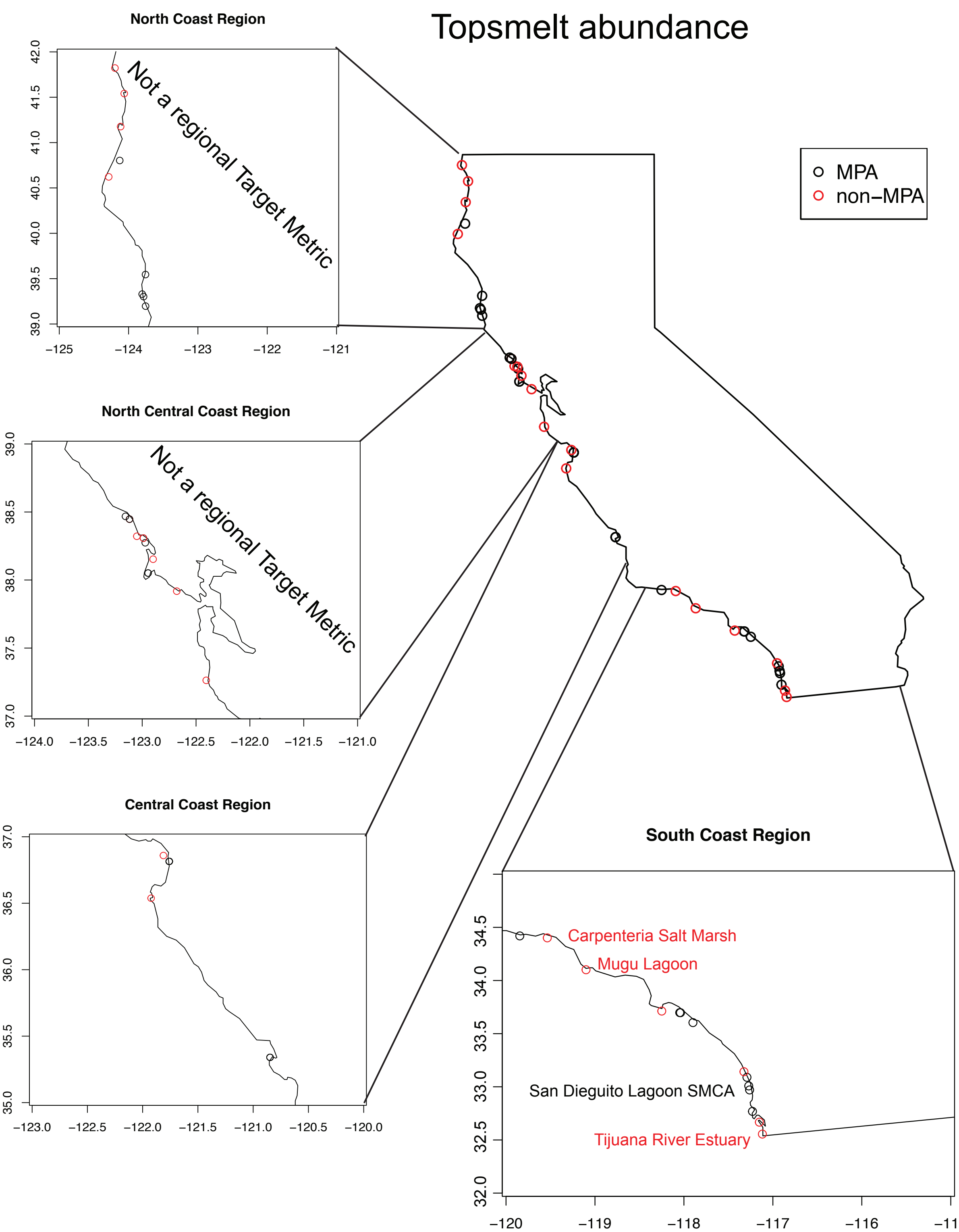

Figure 15. Distribution of topsmelt (*Atherinops affinis*) monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

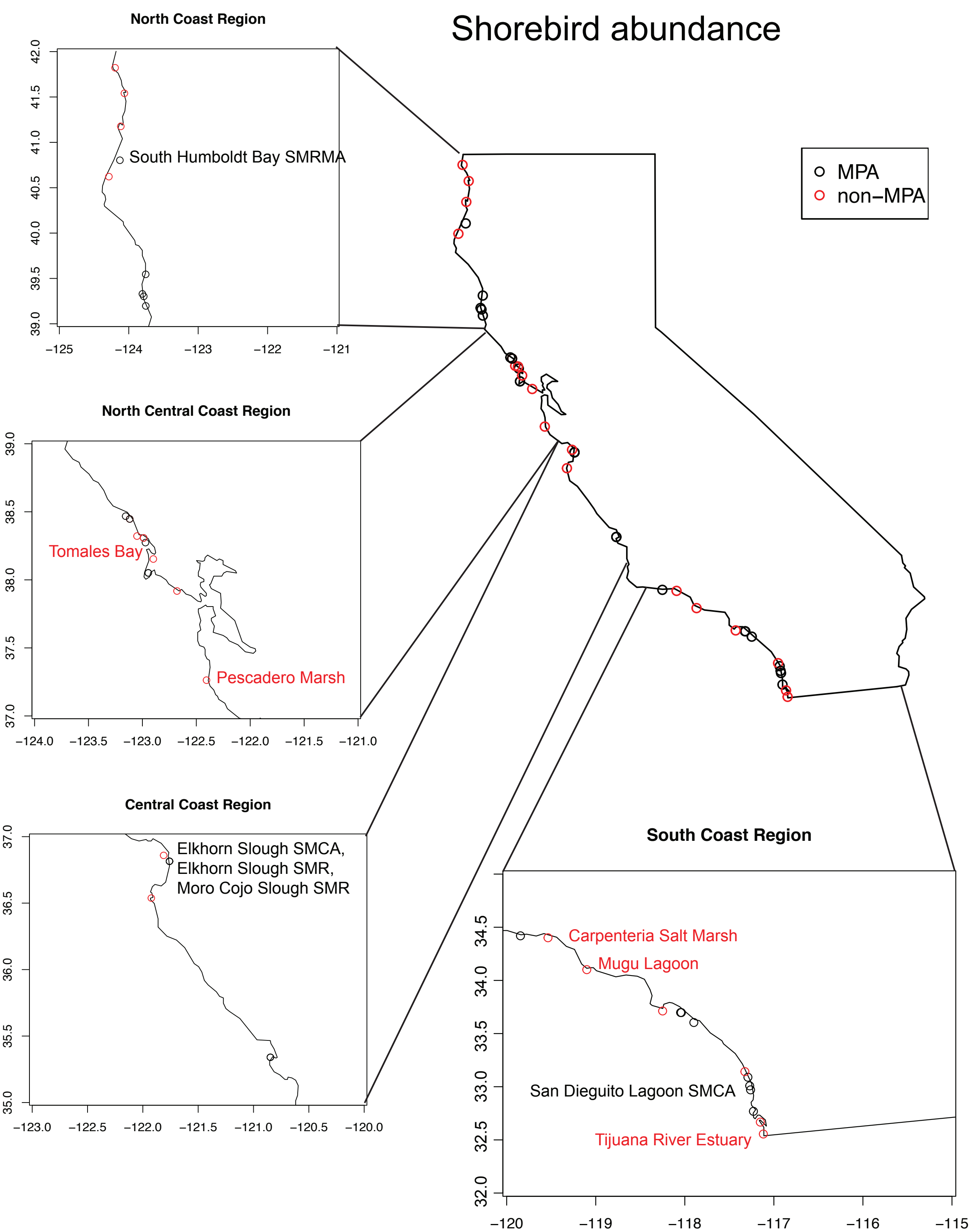

Figure 16. Distribution of shorebird monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

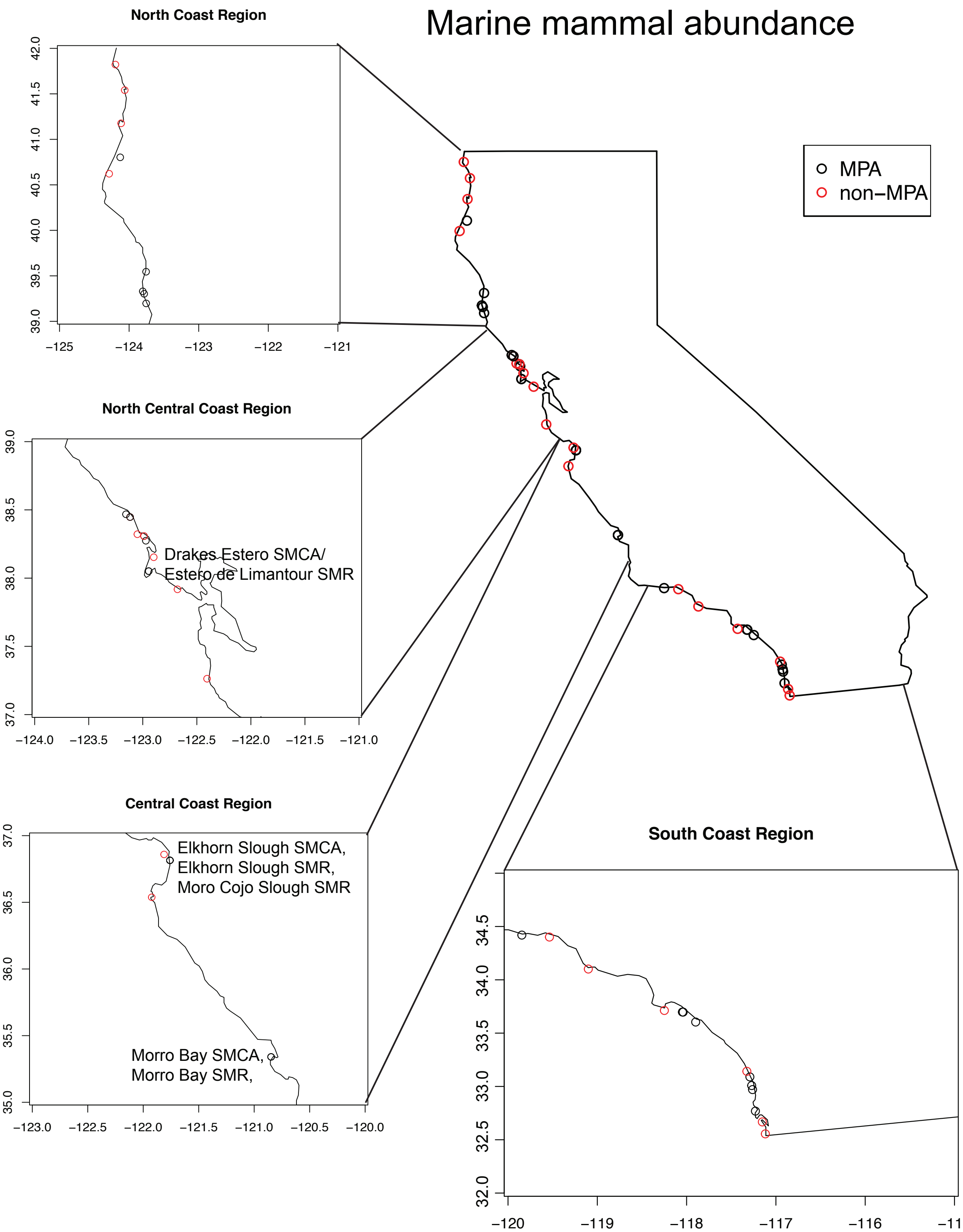

Figure 17. Distribution of marine mammal monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

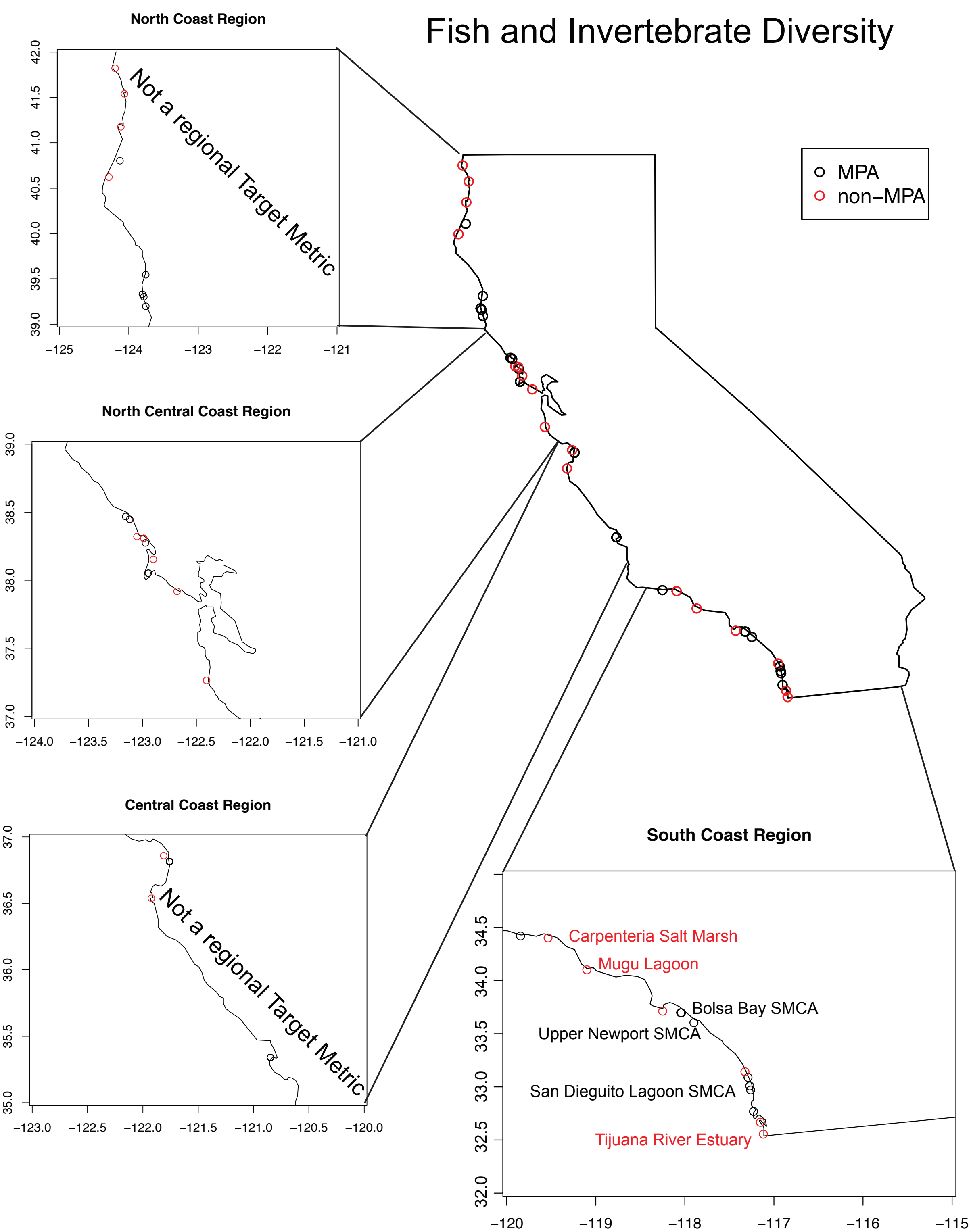

Figure 18. Distribution of species diversity monitoring programs in estuarine MPAs (black) and non-MPA reference sites (red) in four regions across California.

Discussion, Recommendations and Next Steps

Paucity of existing monitoring programs and funding for CA estuaries

This project demonstrates that there is a general lack of monitoring in California estuaries, including within the MPA network. The programs that do exist are not integrated into a larger network. This translates to a lack of standardized methodologies making it difficult to assess MPA performance and goals.

Throughout the four regions targeted in this report there are few target metrics that are consistent across the entire range (Table 2). The metrics that are targets across all four regions include: 1) eelgrass areal coverage, 2) clam abundance, 3) marine/shorebird abundance, 4) marine mammal abundance, 5) DO, and 6) pH. The latter two were not originally target metrics from the Regional Monitoring Plans (MPA Monitoring Enterprise 2010, 2011, 2014), but were added based on OST and OPC recommendations. These six target metrics could be used as indicators of condition across estuarine MPAs and reference sites given the higher overall distribution of these six metrics.

Funding for long-term monitoring is generally lacking across the world. Trends in funding indicate the investment into long-term monitoring is going down (Hughes et al. 2017). Within the California MPA network, investment in monitoring estuarine and wetland ecosystems has fallen behind other MPA ecosystems (e.g., kelp forests and rocky intertidal). Without more funding California estuarine MPAs might not meet essential monitoring goals, or, if left to only a few target metrics, monitoring might not capture MPA performance.

Recommendations moving forward

Other than the six consistently monitored target metrics, other metrics could be added to a statewide monitoring program. Marine vegetation (e.g., seagrass, macroalgae, salt marsh) is consistently found in estuaries across the entire state. Various types of vegetation are also indicators of change resulting from either increased human stress or management (Cloern 2001, Dyke and Wasson 2005, Hughes et al. 2011). For example, healthy and stable seagrass beds and salt marshes (e.g., *Zostera marina*) are indicators of a healthy ecosystem (Waycott et al. 2009). Whereas certain species of macroalgae (e.g., *Ulva* sp. and *Gracilaria* sp.) can be indicators of nutrient overenrichment (Burkholder et al. 1992, 2007, Huntington and Boyer 2008). Additionally, marine vegetation is relatively easy to monitor from LIDAR and aerial photography, so effort in monitoring is minimal compared to other metrics. Salt marshes, a key feature of almost every estuary in California, are conspicuously absent in monitoring programs across the state, or where there is monitoring of salt marshes they are not in a region in which they are recognized as a target metric (Table 2).

Other recommendations from results of this effort and other researcher input include:

- Salinity: should be a commonly targeted metric as it can inform on changes in land-use, and can be a good predictor of estuarine communities.
- Nutrients (nitrate, ammonia, phosphate): Are key drivers of estuarine food-webs and can shift community states (Cloern 2001)
- Invasive species: the presence of invasive species is a key feature of California estuaries and is a good indicator of overall estuary health.

- Olympia oysters: These populations have suffered heavy losses over the last century due to poor water quality and species invasions (Cheng et al. 2015, Jeppesen et al. 2016, Wasson et al. 2016). They are also relatively easy to monitor.
- Fish sampling: protocols should be developed to standardize monitoring of fish communities because they could achieve monitoring objectives for many target metrics (Tables 1 and 2). Developing standardized beach seining could help achieve these goals.
- Estuarine MPA Symposium: There is now a need for to bring together key estuarine researchers (e.g., conference, symposium, workshop) to:
    - Search for traditional and non-traditional funding sources.
    - Integrate metrics and sampling protocols
    - Develop control sites that will be used to measure MPA effectiveness.
    - Addressing key monitoring gaps.
    - Develop a network of researchers across the state, much like Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), ReefCheck, or NERR.
    - This could be achieved using regional conferences, such as CAERS[1].

[1]http://caers.squarespace.com

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APPENDIX 1: TABLES

Table 1. Cross-walk of estuaries from the PMEP/TNC inventory of 303 California estuaries and the MPA network, along with non-MPA reference sites. Ha = Hectares, Lat = Latitude, Long = Longitude. Coastal and Marine Ecological Classification Standard (CMECS) categories determines estuary types based on local geology.

Estuary_PMEP	Estuary_MPA	MPA_type	Ha_PMEP	Lat_PMEP	Long_PMEP	CMECS	Region_MPA
Lake Earl	Reference	NA	1565	41.821	-124.196	Lagoonal Estuary	North Coast
Klamath River	Reference	NA	375	41.540	-124.062	Riverine Estuary	North Coast
Big Lagoon	Reference	NA	720	41.176	-124.114	Lagoonal Estuary	North Coast
Humboldt Bay	South Humboldt Bay SMRMA	SMRMA	7211	40.802	-124.127	Embayment/Bay	North Coast
Eel River	Reference	NA	1277	40.622	-124.286	Riverine Estuary	North Coast
Ten Mile River	Ten Mile Estuary	SMCA	61	39.545	-123.756	Lagoonal Estuary	North Coast
Russian Gulch (Mendocino)	Russian Gulch SMCA	SMCA	1	39.329	-123.803	Lagoonal Estuary	North Coast
Big River Mendocino	Big River Estuary SMCA	SMCA	91	39.302	-123.783	Riverine Estuary	North Coast
Navarro River	Navarro River Estuary SMCA	SMCA	36	39.197	-123.754	Lagoonal Estuary	North Coast
Russian Gulch (Sonoma)	Russian River SMCA	SMCA	2	38.467	-123.155	Lagoonal Estuary	North Central Coast
Russian River	Russian River SMRMA	SMRMA	172	38.447	-123.117	Lagoonal Estuary	North Central Coast
Bodega Bay Estuary	Reference	NA	372	38.321	-123.049	Embayment/Bay	North Central Coast
Estero Americano	Estero Americano SMRMA	SMRMA	65	38.307	-122.988	Lagoonal Estuary	North Central Coast
Estero de San Antonio	Estero de San Antonio SMRMA	SMRMA	17	38.273	-122.971	Lagoonal Estuary	North Central Coast
Tomales Bay	Reference	NA	3126	38.153	-122.898	Embayment/Bay	North Central Coast
Drakes Estero/Estero de Limantour	Drakes Estero SMCA	SMCA	1115	38.051	-122.945	Embayment/Bay	North Central Coast
Drakes Estero/Estero de Limantour	Estero de Limantour SMR	SMR	1115	38.051	-122.945	Embayment/Bay	North Central Coast
Bolinas Lagoon	Reference	NA	471	37.918	-122.679	Embayment/Bay	North Central Coast
Pescadero Marsh	Reference	NA	124	37.262	-122.405	Lagoonal Estuary	Central Coast
Pajaro River	Reference	NA	82	36.859	-121.812	Lagoonal Estuary	Central Coast
Elkhorn Slough/Moro Cojo/Salinas River	Elkhorn Slough SMCA	SMCA, SMR	1390	36.814	-121.759	Embayment/Bay	Central Coast
Elkhorn Slough/Moro Cojo/Salinas River	Elkhorn Slough SMR	SMCA, SMR	1390	36.814	-121.759	Embayment/Bay	Central Coast
Elkhorn Slough/Moro Cojo/Salinas River	Moro Cojo Slough SMR	SMCA, SMR	1390	36.814	-121.759	Embayment/Bay	Central Coast
Carmel River Estuary	Reference	NA	37	36.537	-121.923	Lagoonal Estuary	Central Coast

Morro Bay Estuary	Morro Bay SMR	SMR, SMRMA	1026	35.340	-120.847	Embayment/Bay	Central Coast
Morro Bay Estuary	Morro Bay SMRMA	SMR, SMRMA	1026	35.340	-120.847	Embayment/Bay	Central Coast
Goleta Slough	Goleta Slough SMCA (No-Take)	SMCA (No-Take)	97	34.419	-119.845	Lagoonal Estuary	South Coast
Carpenteria Salt Marsh	Reference	NA	85	34.401	-119.536	Embayment/Bay	South Coast
Mugu Lagoon	Reference	NA	937	34.101	-119.100	Riverine Estuary	South Coast
Los Angeles Harbor	Reference	NA	1332	33.712	-118.248	Embayment/Bay	South Coast
Muted Bolsa Bay	Bolsa Bay SMCA	SMCA	80	33.697	-118.047	Embayment/Bay	South Coast
Bolsa Chica-Fully Tidal	Bolsa Chica Basin SMCA (No-Take)	SMCA (No-Take)	171	33.697	-118.038	Embayment/Bay	South Coast
Newport Bay	Upper Newport Bay SMCA	SMCA	671	33.604	-117.898	Embayment/Bay	South Coast
Agua Hedionda	Reference	NA	152	33.141	-117.325	Embayment/Bay	South Coast
Batiquitos Lagoon	Batiquitos Lagoon SMCA (No-Take)	SMCA (No-Take)	224	33.089	-117.291	Embayment/Bay	South Coast
San Elijo Lagoon	San Elijo Lagoon SMCA (No-Take)	SMCA (No-Take)	215	33.008	-117.271	Embayment/Bay	South Coast
San Dieguito Lagoon	San Dieguito Lagoon SMCA	SMCA	75	32.970	-117.261	Embayment/Bay	South Coast
Mission Bay/Famosa Slough	Famosa Slough SMCA (No-Take)	SMCA (No-Take)	880	32.768	-117.229	Embayment/Bay	South Coast
San Diego Bay	Reference	NA	5026	32.667	-117.151	Embayment/Bay	South Coast
Tijuana River estuary	Reference	NA	354	32.555	-117.118	Riverine Estuary	South Coast

Table 2. Representation of target monitoring metrics distributed across the four regions.

Target_Metrics	Type	Key Attribute	South Coast	Central Coast	North Central Coast	North Coast	Total
Black seaperch density & size structure	Feature Assesment	Trophic Structure: Resident fishes	0	1	0	0	1
Diamond turbot density $ size structure	Feature Assesment	Trophic Structure: Resident fishes	0	1	0	0	1
Pile surfperch density & size structure	Feature Assesment	Trophic Structure: Resident fishes	0	1	0	0	1
Pickleweed areal extent	Assesment Add-on	Biogenic Habitat	0	0	1	0	1
Fat innkeeper worm	Feature Assesment	Trophic Structure: Infaunal Assemblage	0	1	1	0	2
Anas spp.	North Coast metric	Dabbling Ducks	0	0	0	1	1
Anthya spp.	North Coast metric	Diving Ducks	0	0	0	1	1
Black Brandt	North Coast metric	Black Brandt	0	0	0	1	1
Western Gull	North Coast metric	Western Gull	0	0	0	1	1
Scolopacidae	North Coast metric	Shorebirds	0	0	0	1	1
Acipenser spp.	North Coast metric	Sturgeon	0	0	0	1	1
Oncorrhyncus spp.	North Coast metric	Salmonids	0	0	0	1	1
Pleuronectidae	North Coast metric	Pleuronectidae	0	0	0	1	1
Urechis caupo	North Coast metric	Fat Innkeeper Worm	0	0	0	1	1
Cancer magister	North Coast metric	Dungeness Crab	0	0	0	1	1
Harbor porpoise	North Coast metric	Harbor porpoise	0	0	0	1	1
Pinnipedia	North Coast metric	Pinnipedia	0	0	0	1	1
Surfperch abundance & size frequency	Feature Checkup/Vital Sign	NA	0	1	0	1	2
Eelgrass density & % cover	Feature Assesment	Biogenic Habitat: Plants	0	1	0	1	2
Starry flounder abundance & size frequency	Feature Checkup/Vital Sign	NA	0	0	1	1	2
Bat ray abundance	Feature Assesment	Trophic Structure: Predatory fishes	0	0	1	1	2
Eelgrass shoot density	Assesment Add-on	Biogenic Habitat	0	0	1	1	2
Starry flounder abundance & size frequency	Assesment Add-on	Diversity	0	0	1	1	2
CA halibut abundance & size frequency	Assesment Add-on	Diversity	0	0	1	1	2
Shiner perch density & size	Feature Assesment	Trophic Structure: Resident	0	1	1	1	3

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structure		fishes					
Striped seaperch density & size structure	Feature Assesment	Trophic Structure: Resident fishes	0	1	1	1	3
Marine mammal density	Feature Assesment	Habitat Provisioning: marine mammals	0	1	1	1	3
Native oyster bed areal extent/abundance	Assesment Add-on	Biogenic Habitat	0	1	1	1	3
Ulva areal extent	Assesment Add-on	Biogenic Habitat	0	1	1	1	3
Croaker abundance & size frequency	Feature Checkup/Vital Sign	NA	1	0	0	0	1
Pickleweed areal extent	Feature Assesment	Biogenic Habitat: Plants	1	0	0	0	1
Washington clam abundance	Feature Assesment	Trophic Structure: Infaunal Assemblage	1	0	0	0	1
Spotted sand bass density & size structure	Feature Assesment	Trophic Structure: Resident fishes	1	0	0	0	1
Croaker density & size structure	Feature Assesment	Trophic Structure: Resident fishes	1	0	0	0	1
Parasite diversity	Assesment Add-on	Trophic Structure	1	0	0	0	1
Topsmelt denisty & size structure	Feature Assesment	Trophic Structure: Resident fishes	1	1	0	0	2
Spp richness (inverts and fishes)	Assesment Add-on	Diversity	1	0	1	0	2
Spp diversity (invert and fish functional groups)	Assesment Add-on	Diversity	1	0	1	0	2
CA halibut abundance & size frequency	Feature Checkup/Vital Sign	NA	1	0	0	1	2
Arthropod biomass	Feature Checkup/Vital Sign	NA	1	0	0	1	2
CA halibut density & size structure	Feature Assesment	Trophic Structure: Predatory fishes	1	0	0	1	2
Gobies density & size structure	Feature Assesment	Trophic Structure: Resident fishes	1	0	0	1	2
Arthropod biomass	Feature Assesment	Producitivty	1	0	0	1	2
Abundance & foraging rates of shorebirds	Assesment Add-on	Trophic Structure: Infaunal Assemblage	1	0	0	1	2
Piscivorous bird richness & abundance	Feature Assesment	Trophic Structure: Predatory birds	1	1	0	1	3
Shorebird richness & abundance	Feature Assesment	Trophic Structure: Predatory birds	1	1	0	1	3
Common littleneck clam abundnce	Feature Assesment	Trophic Structure: Infaunal Assemblage	1	0	1	1	3
Leopard shark density & size	Feature Assesment	Trophic Structure: Predatory	1	0	1	1	3

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structure/abundance		fishes					
pH/Carbonate chemistry	COST/OPC	NA	1	1	1	1	4
DO	COST/OPC	NA	1	1	1	1	4
Eelgrass aereal extent	Feature Checkup/Vital Sign	NA	1	1	1	1	4
Ghost and mud shrimp abundance	Feature Checkup/Vital Sign	NA	1	1	1	1	4
Clam adundance and size frequency	Feature Checkup/Vital Sign	NA	1	1	1	1	4
Marine bird richness & abundance	Feature Checkup/Vital Sign	NA	1	1	1	1	4
Marine Mammal/Pinniped abundance	Feature Checkup/Vital Sign	NA	1	1	1	1	4
Eelgrass aereal extent	Feature Assesment	Biogenic Habitat: Plants	1	1	1	1	4
Mud shrimp abundance	Feature Assesment	Trophic Structure: Infaunal Assemblage	1	1	1	1	4
Ghost shrimp abundance	Feature Assesment	Trophic Structure: Infaunal Assemblage	1	1	1	1	4
Pacific gaper clam abundance	Feature Assesment	Trophic Structure: Infaunal Assemblage	1	1	1	1	4

APPENDIX 2: FORM LETTERS

Initial Request for information on long-term monitoring:

Dear Colleague,

I am working on a project with California Ocean Science Trust, the Ocean Protection Council, and the California Department of Fish and Wildlife to develop on inventory of monitoring programs in estuaries throughout California to inform monitoring goals as established by the MPA program. The goal of the project is to see who is doing what across the CA estuaries (especially MPAs), and to determine what key MPA metrics are being monitored and what is missing.

You are being contacted because we have determined that you have been monitoring estuaries in California. Although we aware of your monitoring efforts, we are asking for your help in giving us more specific details on your projects. We are only concerned with projects that will monitor estuaries for the next 5 years or longer. So if your plan is to only sample a given estuary for 4 years or less then you can just respond as "My project is not long-term".

However, if your project is expected to be long-term we are looking for the following target metrics as outlined in each MPA region:

Acipenser spp.	Marine mammal density
Anas spp.	Native oyster bed areal extent/abundance
Anthya spp.	*Oncorhyncus* spp.
Arthropod biomass	Pacific gaper clam abundance
Arthropod biomass	Parasite diversity
Bat ray abundance	pH/Carbonate chemistry
Black Brandt	Pickleweed areal extent
Black seaperch density & size structure	Pile surfperch density & size structure
CA halibut abundance & size frequency	Piscivorous bird richness & abundance
Cancer magister density	Pleuronectidae
Clam adundance and size frequency	Scolopacidae
Common littleneck clam abundnce	Shorebird richness & abundance
Croaker abundance & size frequency	Spotted sand bass density & size structure
Diamond turbot density $ size structure	Spp diversity (invert and fish functional groups)
DO (dissolved oxygen)	Spp richness (inverts and fishes)
Eelgrass areal extent	Starry flounder abundance & size frequency
Eelgrass density & % cover	Surfperch abundance & size frequency (any spp.)
Fat innkeeper worm	Topsmelt denisty & size structure
Ghost and/or mud shrimp abundance	*Ulva* areal extent
Gobies density & size structure	*Urechis caupo*
Harbor porpoise	Washington clam abundance
Leopard shark density & size structure/abundance	Western Gull
Marine bird richness & abundance	

Please let me know if you are planning on monitoring any of these metrics over the next five years in California estuaries. If you can please let me know the following for each metric you are monitoring:

1. The target metric.
2. The estuary where you are sampling each target metric.

This project aims to identify who, what, and where is being monitored in CA estuaries, and allow us to assess where monitoring gaps occur. All of which is a first step in establishing rigorous monitoring programs in CA estuaries (both MPA and non-MPA).

I look forward to any input you might be able to provide. Please forward on to anyone who might be interested. We are hoping to collect all responses by March 17, 2017.

Kind regards,

Brent Hughes
bbhughes@ucsc.edu

Follow-up Request for long-term monitoring information:

Dear Colleague,

A few weeks ago I contacted you requesting details of your monitoring programs in California estuaries. I am hoping that you could spare a few moments to respond to the request, and give us some brief details about your monitoring program.

Purpose:

The California Ocean Science Trust, the Ocean Protection Council, and the California Department of Fish and Wildlife are developing an inventory of monitoring programs in estuaries throughout California to inform monitoring goals as established by the MPA program. The goal of the project is to see who is doing what across the CA estuaries (especially MPAs), and to determine what key MPA metrics are being monitored and what is missing.

Details:

We are only concerned with projects that will monitor estuaries for the next 5 years or longer. So if your plan is to only sample a given estuary for 4 years or less then you can just respond as "My project is not long-term".

However, if your project is expected to be long-term we are looking for the following target metrics as outlined in each MPA region:

Acipenser spp.	Marine mammal density
Anas spp.	Native oyster bed areal extent/abundance
Anthya spp.	*Oncorhyncus* spp.
Arthropod biomass	Pacific gaper clam abundance
Arthropod biomass	Parasite diversity

Bat ray abundance	pH/Carbonate chemistry
Black Brandt	Pickleweed areal extent
Black seaperch density & size structure	Pile surfperch density & size structure
CA halibut abundance & size frequency	Piscivorous bird richness & abundance
Cancer magister density	Pleuronectidae
Clam adundance and size frequency	Scolopacidae
Common littleneck clam abundnce	Shorebird richness & abundance
Croaker abundance & size frequency	Spotted sand bass density & size structure
Diamond turbot density $ size structure	Spp diversity (invert and fish functional groups)
DO (dissolved oxygen)	Spp richness (inverts and fishes)
Eelgrass areal extent	Starry flounder abundance & size frequency
Eelgrass density & % cover	Surfperch abundance & size frequency (any spp.)
Fat innkeeper worm	Topsmelt denisty & size structure
Ghost and/or mud shrimp abundance	*Ulva* areal extent
Gobies density & size structure	*Urechis caupo*
Harbor porpoise	Washington clam abundance
Leopard shark density & size structure/abundance	Western Gull
Marine bird richness & abundance	

Please let me know if you are planning on monitoring any of these metrics over the next five years in California estuaries. If you can please let me know the following for each metric you are monitoring:

1. The target metric.
2. The estuary where you are sampling each target metric.

This project aims to identify who, what, and where is being monitored in CA estuaries, and allow us to assess where monitoring gaps occur. All of which is a first step in establishing rigorous monitoring programs in CA estuaries (both MPA and non-MPA).

I look forward to any input you might be able to provide. We are hoping to collect all responses by March 31, 2017.

Kind regards,

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Appendix D:

RECOMMENDATIONS FOR HUMAN USES MONITORING

RECOMMENDATIONS FOR THE LONG-TERM MONITORING OF HUMAN USES IN THE CONTEXT OF CALIFORNIA'S MPA NETWORK

Authors: Dr. Cheryl Chen; Dr. Noah Enelow; Jon Bonkoski; Dr. Laurie Richmond

1. INTRODUCTION

This report is the second of two deliverables that describe and recommend a socioeconomic monitoring program for California's Marine Protected Area Network. Under the California Marine Life Management Act (MLMA), state managed fisheries are required to implement ecosystem-based and adaptive management measures to ensure the ecological and economic sustainability of ocean resources into the future. However, to effectively design and implement these management regimes requires leveraging existing data collection efforts and developing cost-effective and innovative approaches to fill data gaps and address programmatic data collection limitations. Having the necessary robust, fine-scale, and spatially explicit socioeconomic human use data will better enable marine resource managers to design, monitor, and adapt the targeted management measures needed to effectively reach sustainability goals.

A significant amount of fisheries and human use data has been collected by state agencies and researchers over the years yet overall the state's marine protected areas still lack the robust ongoing streams of data needed to inform ecosystem-based and adaptive management approaches. This patchwork of information leads to an unclear understanding of the historical, current, and potential future status of marine resources that is necessary to prioritize and develop effective management plans.

Given this, the California Ocean Protection Council (OPC) is seeking to understand how best to design a socioeconomic monitoring program to assess the impact of recently established marine protected areas (MPAs). The overall goal of this project is to develop a set of well-supported recommendations of methods and metrics that could be used in the long-term socioeconomic monitoring of California's MPAs. These recommendations will lay the groundwork for a rigorous performance measurement system for identifying and tracking the effects of the MPA network on key sectors of the coastal economy: commercial and recreational fishing and coastal recreation. The outputs from this project are a suite of recommended indicators and metrics, and an associated design for monitoring the socioeconomic dimensions of MPAs.

This project has two objectives. The first is to develop a comprehensive list of relevant data sources, including data the state can use to determine MPA effects and identify where there are current data gaps (see Deliverable 1). The second objective is to provide design recommendations for a socioeconomic monitoring program that fills the identified data gaps and proposes mechanisms for obtaining new data along with available data streams. To accomplish these objectives, we have split the tasks into two deliverables. This second deliverable includes this report organized into three monitoring tiers under which is the recommended monitoring metrics for each sector: commercial fishing, Commercial Passenger Fishing Vessels (CPFV), recreational fishing, and coastal recreation. In addition, we have developed an organized list of key metrics and monitoring tier (provided in an excel workbook) as another format for understanding the monitoring tiers.

1.1. <u>Overarching Approach to Monitoring Human Uses in the Context of MPA Monitoring</u>

It is important to recognize the differences between the monitoring of biological resources and monitoring of human uses in order to inform how overarching approaches to MPA monitoring should be framed and designed.

The monitoring of human use data can be thoughts of as composing of two major components. Spatially explicit data and overall population wide trends. Due to the inherent spatial nature of MPAs - human use monitoring data must be spatially referenced in order to determine the location of activities and monitor how the location and the intensity of those activities change over time. However, these changes in the spatial patterns of use must be contextualized within larger overall population wide trends in order to have a more complete understanding of the drivers behinds observed changes and trends at the site level. Thus, it is critical to capture both spatially explicit and overall population wide trends in order to comprehensively monitoring California's MPA network. Our recommendations in this report focus on presenting key metrics to monitor across both these two major components.

Additionally, the biological monitoring of MPAs is often framed as monitoring specific sites inside and outside MPAs in order to determine an MPA effect. However, particularly for consumptive human uses, this at times is not a useful framing as often consumptive human uses are not allowed within MPAs. Thus, in order to monitor and evaluate an 'MPA effect', the monitoring of consumptive human uses largely focuses on understanding how MPAs may be impacting the overall socioeconomic status and health of consumptive user populations as well as how consumptive activities may be impacting areas outside of designated MPAs. Thus, several of the recommendations within this report focus on gathering census or population wide data (including spatially explicit data) as opposed to just focusing on specific sites in order to understand the larger socioeconomic impacts of MPAs.

2. OVERARCHING RECOMMENDATIONS

The following is a set of overall recommendations that apply more broadly to developing a socioeconomic monitoring system.

2.1. Engaging Tribes in MPA Monitoring and Evaluation

This report does not include specific recommendations for including tribal entities in the socioeconomic monitoring program. However, Native American Tribes in California have a distinct political status as well as unique historical and cultural connections to and uses of marine resources affected by MPA management. In her analysis of the involvement of Native people in the planning for MPAs in Washington and British Columbia, Singleton (2009), describes how these planning processes mistakenly assumed Native groups were equivalent to other kinds of stakeholders invested in MPA outcomes. She describes how Tribes have significant differences in terms of legal rights, political capacity, and historical and cultural connections to resources when compared to other stakeholder groups and, as such, should be treated differently. Additionally, there are several California (SB 18, 2004; AB 52, 2004) and Federal policies (EO 13175) that require agencies to consult with and consider potential impacts to Tribes and traditional tribal cultural places in any actions that attempt. Finally, the state of California recognized the unique legal status of Tribes in relation to the MLPA initiative by establishing a government-to-government consultation process with affected Tribes and the inclusion of protections for Tribal harvest in the MPA regulations. Given these factors, we are not including specific monitoring methodologies for California's Tribal communities. However, we recommend that special attention be paid to developing a Tribal component of any long-term socioeconomic monitoring program for California's MPAs; and that the Tribal governments are directly included in the design and implementation of a monitoring system.

2.2. Data Accessibility and Visualization

A robust socioeconomic monitoring effort is often a collaboration between state agencies, NGOs, and academic researchers. Analysis of the data collected across monitoring programs will be key in developing a robust and comprehensive understanding of the socioeconomic status of human uses as it relates to

California MPAs. Thus, central to engaging partners in the monitoring effort would be to devise better tools for making monitoring data accessible to partners in a format that also protects confidentiality requirements.

Digital data visualization and query tools can be a very effective means for making data accessible to interested parties. The fisheries data explorer on OceanSpaces (http://oceanspaces.org/fisheries-data-explorer) is an example of a data viewer that could be updated and added to in order to support the monitoring effort. The ocean spaces data explorer contains data from commercial and CPFV fisheries, but recreational and other human use data gathered through the monitoring effort could be added to a similar type of viewer. Additionally, the underlying data in the data explorer is available for download allowing for research to integrate these datasets into their own datasets for integrated analyses. Working with a programming team, it may also be possible to developed tools that develop and publish annual "snap-shot" summaries of socioeconomic datasets related to MPA monitoring each year. This would help to both elevate the profile on the socioeconomic dimensions of MPAs but also build a community of socioeconomic researchers that could collaborate on advancing research in this area into the long term.

2.3. The Role of Technology in MPA Monitoring

In this digital age, there is a large role technology can play in cost-effectively implementing and scaling data collection efforts on human uses of coastal and ocean areas. Technology can serve a multitude of uses in human use data collection.

One simple way of utilizing technology is to develop robust spatially explicit online surveys. For example, annual surveys to fishermen or coastal recreation users can be developed as web-based surveys which are cost effective and easily replicable over time. These web-based surveys may be developed to have spatial mapping components in order to capture data and associate those data with spatial use patterns--creating a powerful tool for MPA monitoring and evaluation. Because MPAs by their nature are spatial, any data gathered to monitor MPAs must be spatially explicit as well.

A more advanced and systemic use of technology is the use of mobile digital data collection technology in fisheries data collection. Fisheries across the globe are piloting digital logbooks or digital data collection applications using GPS enabled mobile phones or tablet devices.

Through these mobile data collection applications, spatial fishing data can automatically be captured using a mobile phone or tablet's GPS unit and associated fishing trip characteristics and economic information may also be digitally captured. These data may then be uploaded to a data server via a cellular data connection after each fishing trip—making data available in near real-time to fisheries managers and fishermen themselves. This type of technology would enable fisheries managers to closely and actively monitor and manage fisheries performance and effectively implement adaptive management approaches.

In California, digital fisheries data collection technology would benefit both long-term MPA monitoring as well as fisheries management. Both initiatives require cost-effective technology solutions that tighten the feedback loop between data collection and data analysis needed to support adaptive management measures. Together this would better enable innovative management approaches to be piloted, tested, and refined to advance the way we manage fisheries so that management costs are lowered, fish stocks are sustainable, and economic benefits to fishing communities are maximized.

Modernizing fisheries data collection programs will not only streamline data collection and delivery but also allow MPA and fishery managers to quickly update data collection forms to respond to changing information needs and emerging uses. Digital data collection allows for the flexibility needed to develop, test, and refine fisheries data collection programs that can be integrated across fishing sectors as well as with biological and ecological data. This ability to quickly and iteratively adapt data collection programs will be key to developing the robust socioeconomic fisheries data needed to explore bio-economic linkages and dynamics that are foundational to ecosystem-based and adaptive management approaches.

Furthermore, socioeconomic monitoring is aided by collaboration with a number of government, academic, and community partners. Working with partners in monitoring can be eased through the development of digital tools for displaying and sharing socioeconomic datasets such as the OceanSpaces web platform. Investment in digital tools to make fisheries and socioeconomic data accessible in a way that continues to protect data confidentiality requirements will greatly enhance monitoring efforts.

Indeed, integrating technology into human use data collection program will be key to ensuring the long-term robustness and viability of any MPA monitoring program.

3. HUMAN USE MPA MONITORING PROGRAM RECOMMENDATIONS

In the following sections we provide our recommendations for key metrics and data collection methods for long-term MPA monitoring and evaluation. Our recommendations are presented in three tiers. The tiers are additive as they build upon one another. The first tier includes essential metrics, the second tier includes all of the Tier 1 metrics while also adding metrics and so on for the third tier. We then recommend specific data collection methodology in each tier. The idea behind presenting a tiered approach is to offer monitoring program scenarios based on the extent of funding and resources available.

In each tier we create sections for each sector: commercial fisheries, CPFV fisheries, recreational fisheries, and coastal recreation and tourism. Within each of these sections we organize our recommendation around data collection methodologies/opportunities. We do this as the data collection methodology/opportunity is the principle design element - it centers this report around the specific opportunities we have to collect data. We organize the report in this way as there already exists a landscape of MPA data collection efforts/opportunities and we want to be explicit about how each could be maximized as well as how new efforts could be developed to fill existing gaps. Indeed, we place emphasis on 'how' metrics should be gathered as it is what can vary and determine the robustness and usefulness of the data collected. We also discuss 'why' certain metrics should be gathered such as it provides a core metric, enables analysis to calculate a core metric, or enables cross comparison across human use sectors.

Specifically, in Tier 1 we focus on presenting the metric that are core or of highest priority to gather and the methods to gather those metrics. We indicate what metrics are already being gathered in existing data collection programs and what are new metrics that should be gathered. In Tier 2, we focus on the identifying secondary priority metrics to be gathered as well as expansions/improvement of methods to gather those metrics. Lastly, in Tier 3, we focus on how integrating technology into data collection programs could be utilized and address stuck points and weaknesses in current data collection efforts and overall streamline socioeconomic data collection efforts.

3.1. TIER 1

3.1.1. Commercial Fisheries

Annual License Renewal & Vessel Registration

Annual license and vessel registration renewal is an excellent opportunity to gather basic information from commercial fishermen. When purchasing or renewing a license, the California Department of Fish and Wildlife (CDFW) can require fishermen to provide information in order to receive their license or vessel registration. It is a touch point with fishermen that CDFW should maximize that could serve as a springboard to additional survey efforts to gather census data on commercial fishermen.

Below we provide the metrics that should be gathered using this method and state the rationale for why each metric should be gathered:

- Contact Information (phone, email, home address)
    - Having contact information (especially email) from commercial fishermen will provide the foundation in which a multitude of data collection efforts can be built upon. To collect data, you must be able to contact your study population. This has been a key challenge in current data collection efforts.
- Demographics (Age, gender, ethnicity, household income level, education level, years of experience commercial fishing overall, years of experience commercial fishing in a specific fishery)
    - Understanding the demographic profile of California commercial fishermen will allow researchers to better understand how the impacts of MPAs or fisheries management unfolds unevenly across the population. Furthermore, gathering demographic data over time will help to understand changes and trends in the composition of California's commercial fishing fleet.
    - Population attribute data is key in developing sample designs when it is not feasible to survey the entire commercial fishing population. This will help ensure sampling efforts are representative of the larger population.
    - For the metric of years of experience commercial fishing in a specific fishery, this can be gathered when purchasing fishery specific licenses/permits.
- Vessel/Fisherman Homeport
    - This is not currently gathered by the CDFW but is an important metric for economic analyses. A fisherman's homeport may differ than the port they make landings in and a homeport can be used to determine where - or, in other words, in what regional economy - a fisherman's revenue might be spent.

Landing Receipts

The CDFW requirement to capture data on all commercial landings provides critical census data on harvest amount, revenue, and harvest location. This data is captured at the individual species and landing port level which makes it then possible to summarize to a regional and state level as well as cross-species level (such as the nearshore finfish fishery). This data collection method should continue; however, modifications should be made. That information and the rationale for why each metric should be gathered are recommended below:

- Number of fishermen making landings
    - This is a key metric to understand the overall harvest participation rate in each port and fishery. By capturing the L number or license number of each fishery at landing a backend analyses can then be conducted to determine the number of unique fishermen making landings in a given port/fishery in a given period of time. This is currently already being gathered in landing receipts.
- Landings (lbs.), catch price, and revenue ($) by species
    - These are key metrics to understanding the overall harvest amount and associated gross revenue being derived from the harvest of marine resources. By capturing the pounds and price paid per pound you can then calculate gross revenue. This is currently already being gathered in landing receipts.

- Gear utilized
  - This is a key metric as the gear a fisherman utilizes can different them from other fishers and at times a certain fishery-gear combination may be managed as a separate fishery. The type of gear utilized helps researchers and managers understand how and at what scale (e.g. trawl vs hook and line) marine resources are being harvest. This is currently already being gathered in landing receipts.
- Landing port location
  - This is a key metric to understand where marine resources are being harvested. Being able to tie fishery landings to a port location enable us to understand the fishery dependencies of a port community and the profile of fishermen that make up a port community. This is currently already being gathered in landing receipts.
- Catch per unit effort (CPUE)
  - This is a key metric to determine how the amount of effort it takes fishermen to harvest marine resources may be changing over time. Gathering data on fishery landings alone does not tell us how much more/less effort (which equate to both time and expenses) fishermen may be expending to harvest the same amount of marine resources. This metric should be gathered as the number of days fishing that was expended to make a landing.
  - For some fisheries additional effort data could be captured such as the number of traps a fisherman utilized on their trip in order to achieve a more granular understanding of how the differences in effort across fishermen. This data could potentially be captured in fishery logbook data.
  - Capturing the number of days fishing will also allow CPUE to then be compared to CPFV and recreational fishing CPUE data which is also measured through number of fishing days.
  - The number of days fishing nor the number of traps utilized is not currently captured in landing receipts
- Harvest location
  - This key metric is critical as it allows other metrics (e.g. pounds landed, revenue, fishing effort) to be attributed to a spatial location and underpins the evaluation of where fishing occurs in relation to MPAs.
  - Currently in landing receipts this is gathered as a single 10 x 10 nm block and it is unclear if fishermen or fish buyers fill this information out. It is recommended that the landing receipt form allow for multiple 10x10nm blocks be recorded if fishing occurred in more than one block.
  - For some fisheries logbooks are utilized that may provide higher resolution harvest locations. We recommend landing receipts to also capture the associated logbook record number so that these records can be cross referenced
  - Overall current methods for capturing harvest location are self-reported. Given the vital nature of this data it is important to make improvements to the reliability and validity to this data which we will address in Tier 2 and 3.

Commercial Fishery Specific Logbook Data

As detailed in our previous report assessing current socioeconomic MPA monitoring data streams--there exists specific commercial fishing logbooks in several fisheries. Our overall recommendations for these logbooks are to:

- Ensure uniformity across logbooks. The capture of harvest location should be standardized to GPS location whenever possible
- Ensure logbooks data are tied to landing receipt data. There is currently no feasible way to connect logbook data to landing receipt data. All logbook data records should reference specific landing receipt record numbers in order to be able to cross reference and enable analyses at a more granular level that gathering fishery specific logbook data allows. For example, being able to link these two

data records together will allow landings data (e.g. pounds landed) to be tied to more specific harvest location and effort data.

In general logbook data should focus on gathering these core metrics:

- Harvest location
  - Whenever possible gather harvest location by indicating GPS location to enable the capture of high resolution spatial data
- Effort
  - This should be captured in gear specific metrics. For example, in trap fisheries this should be the number of traps utilized, in dive fisheries this is amount of dive time, in other fisheries this could be the number of hooks utilized, etc.
  - Our recommendation is to capture the amount of fishing days in landings receipt data.
- Estimates in catch
  - This most likely can only be an estimate as there may not be way to weigh the catch on each vessel. However, it is important to estimate catch for each fishing event so that harvest amounts can be attributed to a specific harvest location.

Annual and Semi-Annual Surveys

An annual in-depth survey of commercial fishermen can provide additional information necessary to fully understand the socio-economic health of commercial fisheries. Specifically, surveys can be conducted where more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

Gathering operating costs is a prime example of where an annual or semi-annual survey is necessary. Commercial fishing expenditures occur both on a per-trip basis but also on an annual basis (e.g. insurance, boat slip fee, maintenance, etc.). An annual survey will allow fishermen to summarize their expenses across an entire year for their commercial fishing operations.

There are a few key pieces of information that are vital to effectively design and implement a statistically sound survey effort:

- Your study population - this is a listing of all commercial fishermen
- Contact information - this is your study population's contact information in order to send them a survey. Ideally this contact information is captured during commercial license purchase/renewal
- Characterizing your study population - this is demographic and fishery level economic (landings/revenue) information. Being able to characterize your study population will enable you to determine if your survey sample is statistically representative of the larger population based on the attributes you deem important (e.g. fishery revenue bracket, homeport, age, household income, etc.). Knowing this information will also allow you to develop sample weights that can be utilized to extrapolate the survey data to the larger population.

It is recommended that for an annual survey (could be every 2 years if resources are not available to conduct each year) that the survey be sent to all commercial fishermen. Fishermen could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. The CDFW cannot require these surveys to be taken, however, efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the metrics that should be gathered using this method and the rationale for each key metric:

- Operating costs

    - This is a vital key metric that is needed to monitor the economic health of commercial fishermen. Gather gross-revenue data at time of landing is not enough to determine the economic health of commercial fishermen as understanding changes in operations cost help us understand both the amount of revenue fishermen are able to take home themselves as well as they are expending in the larger economy.
    - Operating costs should be captured to understand what expenses fishermen incur, where those expenses are spent, and how these change over time
- Number of crew members employed (part time vs. full time)
    - This metric is important to gather in order to determine the employee force that commercial fisheries support

It is important to mention that obtaining adequate representative participation and a time series of these data are vital in order to properly evaluate these data and make any statements that could be understood as representative of the entire commercial fishing fleet or adequate at measuring change over time.

3.1.2. CPFV Fisheries

Annual License Renewal & Vessel Registration

Annual license and vessel registration renewal is an excellent opportunity to gather basic information from CPFV operators. When purchasing or renewing a license, the California Department of Fish and Wildlife (CDFW) can require fishermen to provide information in order to receive their license or vessel registration. It is a touch point with fishermen that CDFW should maximize that could serve as a springboard to additional survey efforts to gather census data on CPFV operators.

Below we provide the metrics that should be gathered using this method and state the rationale for why each metric should be gathered:

- Contact Information (phone, email, home address)
    - Having contact information (especially email) from CPFV operators will provide the foundation in which a multitude of data collection efforts can be built upon. To collect data, you must be able to contact your study population. This has been a key challenge in current data collection efforts.
- Demographics (Age, gender, ethnicity, household income level, education level, years of experience operating CPFV overall, years of experience operating in a specific fishery)
    - Understanding the demographic profile of California CPFV operators will allow researchers to better understand how the impacts of MPAs or fisheries management unfolds unevenly across the population. Furthermore, gathering demographic data over time will help to understand changes and trends in the composition of California's CPFV fleet.
    - Population attribute data is key in developing sample designs when it is not feasible to survey the entire commercial fishing population. This will help ensure sampling efforts are representative of the larger population.

CPFV Logbooks

CPFV logbooks are currently the primary method in which managers and researchers are able to collect data from the CPFV fleet. These logbooks are a vital mechanism in which to capture granular trip level data from CPFV operators and should be maximized to gather key metrics necessary long-term monitoring data.

Below we provide the metrics that should be gathered using this method and state the rationale for why each metric should be gathered

- Port of departure and return

  - This is a key metric as this allows trip data and thus socioeconomic changes and dependencies to be associated with a specific port community. This is currently being gathered in CPFV logbooks.
- Number of anglers
  - This is a key metric as it measures the amount of effort being expended in the fishery. This is currently being gathered in CPFV logbooks.
- Trip target species/fishery
  - This is a key metric as it is important to know what the primary target of CPFV trips are in order to properly associate the economic revenue of the trip to a specific fishery. It is important to note that the trip type does not always coincide with what is caught during the trip though and at time may not be fishery specific (e.g. potluck trip). This is currently being gathered in CPFV logbooks.
- Trip length type
  - This is a key metric is it is important to understand the type of trips CPFV operators offer (e.g. ½ day, ¾ day, full day, multi day) and what type of trips are economic drivers in a given port community. This also provide a more granular understand of the amount of effort (in terms of time) that is being expended by CPFV anglers. Only single day or multi day trip type data is currently being gathered in CPFV logbooks.
- Fishing location
  - This key metric is critical as it allows trips data to be attributed to a spatial location and underpins the evaluation of where fishing occurs in relation to MPAs.
  - Currently harvest location is gathered as a single 10 x 10 nm block. CPFV logbooks should also allow for the entry of multiple 10 x 10 nm blocks.
  - The current methods for capturing harvest location is self-reported. Given the vital nature of this data it is important to make improvements to the reliability and validity to this data which we will address in Tier 2 and 3.
- Average price paid per angler
  - This is a key metric as currently there is no revenue information being captured for CPFV operators. Knowing the price paid per angler for a given trip will allow managers and researchers to extrapolate the gross revenue generated from a given trip. This will help us understand overall gross revenue, but also gross revenue derived from different fisheries. This is current not being gathered in CPFV logbooks.
- Number and pounds of fish caught by species
  - This is a key metric as it provides data on the amount of fish caught and harvested. Currently only the number of fish caught by species if being captured by CPFV logbooks which makes it difficult to compare to commercial fishing landing receipt data as they are recorded in pounds.
  - It is recommended that CPFV operators weigh each fish caught to determine the total pounds of fish caught by species and record the information in the CPFV logbooks.
- Number of crew on trip
  - This is a key metric in order to better understand the labor force that CPFV operations employ. This is not currently gathered in the CPFV logbooks.
- Number of fishing days during trip - Effort and CPUE
  - This is a key metric in order to better understand the amount of effort being expended by CPFV anglers. This is not current gathered in the CPFV logbooks and would enable managers and research to calculate effort in terms of angler-days and thus CPUE as well which would then be comparable to commercial and recreational fishing data.

Annual & Bi-Annual Surveys

An annual in-depth survey of CPFV operators can provide additional information necessary to fully understand the socio-economic health of the CPFV fleet. Specifically, surveys can be conducted where more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

Gathering operating costs is a prime example of where an annual or semi-annual survey is necessary. CPFV operation expenditures occur both on a per-trip basis but also on an annual basis (e.g. insurance, boat slip fee, maintenance, etc.). An annual survey will allow CPFV operators to summarize their expenses across an entire year.

There are a few key pieces of information that are vital to effectively design and implement a statistically sound survey effort:

- Your study population - this is a listing of all CPFV operators
- Contact information - this is your study population's contact information in order to send them a survey. Ideally this contact information is captured during CPFV license purchase/renewal
- Characterizing your study population - this is demographic and fishery level economic (landings/revenue) information. Being able to characterize your study population will enable you to determine if your survey sample is statistically representative of the larger population based on the attributes you deem important (e.g. revenue bracket, homeport, age, household income, etc.). Knowing this information will also allow you to develop sample weights that can be utilized to extrapolate the survey data to the larger population.

It is recommended that for an annual survey (could be every 2 years if resources are not available to conduct each year) that the survey be sent to all CPFV operators. Operators could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. The CDFW cannot require these surveys to be taken, however, efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the metrics that should be gathered using this method and the rationale for each key metric:

- Gross-revenue
  - This is a vital key metric as currently no comprehensive revenue information is gathered on CPFV operations. Gathering data on CPFV revenue is critical to understanding the economic contribution of the CPFV fleet and the economic value CPFV operators are able to derive from marine resources.
- Operating costs
  - This is a vital key metric that is needed to monitor the economic health of commercial fishermen. Gather gross-revenue data at time of landing is not enough to determine the economic health of CPFV operators as understanding changes in operations cost help us understand both the amount of revenue fishermen are able to take home themselves as well as they are expending in the larger economy.
  - Operating costs should be captured to understand what expenses operators incur, where those expenses are spent, and how these change over time
- Number of crew members employed (part time vs. full time)
  - This metric is important to gather in order to determine the employee force that the CPFV fleet support

It is important to mention that obtaining adequate representative participation and a time series of these data are vital in order to properly evaluate these data and make any statements that could be understood as representative of the entire commercial fishing fleet or adequate at measuring change over time.

3.1.3. Recreational Fisheries

License Purchase

Recreational fishing license purchase is an excellent opportunity to gather basic information from recreational saltwater anglers. When purchasing a license, the California Department of Fish and Wildlife (CDFW) can require anglers to provide information in order to receive their license. It is a touch point with anglers that CDFW should maximize that could serve as a springboard to additional survey efforts to gather census data on commercial fishermen.

A key recommendation for CDFW is to record if license purchasers are saltwater or freshwater fishing or both. This is a key gap as it prevents managers and researchers to understand what portion of license purchasers are targeting marine resources in order to obtain a general sense of the population size of saltwater anglers and also target their MPA monitoring survey efforts based on our recommendations below.

Below we provide the metrics that should be gathered using this method and state the rationale for why each metric should be gathered:

- Contact Information (phone, email, home address)
  - Having contact information (especially email) from recreational anglers will provide the foundation in which a multitude of data collection efforts can be built upon. To collect data, you must be able to contact your study population. This has been a key challenge in current data collection efforts.
  - Furthermore, capturing home address or even home zip code will allow follow up survey efforts to stratify sample design by zip code which helps to ensure you achieve a representative sample

California Recreational Fishing Survey (CRFS)

The CRFS program collects data on four major modes of fishing: private/rental boats, commercial passenger fishing vessels (CPFVs), man-made structures (e.g., piers), and beaches/banks. Since we assessed available CPFV data in the previous section, in this section we focus upon private recreational fishing and thus only assess the private/rental boats, man-made structures, and beach/bank fishing modes.

The CRFS program conducts on-site surveys to gather catch and effort data and utilize telephone surveys to supplement the on-site collected data in order to extrapolate catch and effort estimates across under sampled fishing sites and times of day (e.g. night fishing). Sampling in the CRFS program generally occurs year-round for all modes and monthly estimates are produced. Catch and effort estimates are produced for each of the six geographic districts (described below) and for each fishing mode.
Given the vast size of California's saltwater recreational angler population the CRFS program is a relatively robust program to both gather data and extrapolate these data to evaluate the status of recreational fishing in California.

Below we provide the metrics that should and are gathered using this method and the rationale for each key metric:

- Catch amount
  - This can only feasibly be captured by number of fish caught but is a key metric as it determines the amount of marine resources harvested. Pounds harvested could be calculated on the backend using an average pound per fish statistic.
- Catch location
  - This key metric is critical as it allows trips data to be attributed to a spatial location and underpins the evaluation of where fishing occurs in relation to MPAs.
  - Currently harvest location is gathered as a single 1 x 1 nm block.

- Catch effort
    - This is a key metric in order to better understand the amount of effort being expended by recreational saltwater anglers. This enables managers and researchers to calculate effort in terms of angler-days and thus CPUE as well which would then be comparable to commercial and CPFV fishing data.

In spatial terms, CRFS data is summarized to large CRFS districts. However, for it to be more useful to long-term MPA monitoring--work needs to be done to explore and understand how spatial fishing location data could be extrapolated and visually displayed to represent spatial patterns of recreational fishing catch and effort. It may be possible to do so, but the data and methodology are not readily available or well understood. It may be that multipliers to take sample data and extrapolate to the specific geographic area of interest may need to be developed on a case-by-case basis. Thus, our Tier 1 recommendation is to engage the CRFS program to understand to what extent CRFS spatial data can be extrapolated to develop a representative spatial map of recreational fishing patterns.

Fishery Specific Report Card Data
CDFW has implemented a report card program for specific fisheries in order to capture more granular and complete data on specific prioritized fisheries. Currently, relevant to marine waters - there are recreational fishing report cards for the spiny lobster, abalone, and north coast salmon. In particular, the report card program is vital to capture data on the lobster and abalone fishery as the CRFS program only captures data on finfish species.

Key metrics that are currently gathered and should continue to be gathered are:

- Location of harvest - this is typically by location name
    - A key issue with recording harvest location by location name is this is does not provide a spatially explicit location. For example, if someone indicated they harvested abalone from Fort Ross it's unclear what the spatial boundaries for Fort Ross are and is left up to the interpretation of the fisherman. A possible solution to this issue will be addressed in Tier 3.
- Effort expended - this is typically fishery specific such as recorded by dive time or days fishing
- Harvest amount - this is the amount harvested by count (vs. weight)

A key issue in fishery report card data is that they suffer from a lack of compliance in returning report cards back to the CDFW. Thus, in the past, extensive phone interviews have been conducted each year with a sample of abalone or lobster license holders to produce estimated catch statistics for the proportion of the license purchasers who did not return their report cards. These estimates are then used to extrapolate report card data statewide. It is important to continue these efforts to account for submitted and unsubmitted report cards in order to gather comprehensive data from recreational fishermen that are relatively small in size but have a high impact on high priority fisheries. A possible solution to this issue is addressed in Tier 3.

Online Surveys
An online survey of CPFV operators can provide additional information necessary to fully understand the economic contribution of the saltwater recreational fishing population. Specifically, surveys can be conducted where more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual time scale.

Gathering recreational fishing expenses is a prime example of where a semi-annual survey is necessary. Currently, no economic information is captured for recreational fisheries - leaving a large gap in understanding the economic contribution of saltwater recreational fishing compared to commercial and CPFV sectors. Gathering this type of information is beyond the scope and design of the CRFS program as recreational fishing expenditures occur both on a per-trip basis but also on an annual basis (e.g. boat maintenance, gear purchase, etc.). A survey conducted every 2-3 years will allow managers and researchers to gain an understanding of the economic aspects of recreational fishing and how they may change over time.

There are a few key pieces of information that are vital to effectively design and implement a statistically sound survey effort:

- Your study population - this is a listing of recreational saltwater anglers
- Contact information - this is your study population's contact information in order to send them a survey. Ideally this contact information is captured during license purchase/renewal
- Characterizing your study population - this is demographic information. Being able to characterize your study population will enable you to determine if your survey sample is statistically representative of the larger population based on the attributes you deem important (e.g. location, age, household income, etc.). Knowing this information will also allow you to develop sample weights that can be utilized to extrapolate the survey data to the larger population. This information could be captured as part of this survey effort. In Tier 2 we also give recommendations of how this could be captured.

The survey can be conducted every 2-3 years depending on available resources and should be sent to a strategically designed sample of recreational anglers. Anglers could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. Efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the metrics that should be gathered using this method and the rationale for each key metric:

- Annual saltwater recreational fishing expenses
  - This key metric is to understand the overall economic contribution of saltwater recreational fishing. This is captured using an annual time frame as recreational fishing expense may occur outside of a per trip basis such as boat maintenance or gear purchase.
- Days fishing last year by mode (private vessel, beach/bank, pier/jetty, etc.)
  - This key metric to capture the amount of fishing effort expended by recreational anglers.
- Last trip expenses
  - This key metric is to understand and capture the expenses of a representative recreational fishing trip. Asking about a specific trip will provide more granular details to trip expenses
- Last trip fishing location(s)
  - This key metric is vital in order to attribute economic information to a specific fishing location and capture more granular details on fishing location that are not captured through other data collection methods listed in this section.

3.1.4. Coastal Recreation and Tourism

Online Surveys

Online surveys are an essential tool for data collection to understand the socioeconomic impact of MPAs. Online surveys can provide statistically valid, demographically weighted random samples of resident populations to understand frequency of recreational visitation, activities of choice, and trip expenditures by category. A well-designed online survey can provide MPA managers and researchers with data on who engages in coastal recreation activity, what activities they engage in, and how much they spend on locally provided goods and services during recreational visits.

From a statewide representative sample, analysts can generate high-level robust summary statistics aggregated to the state level, including: statewide coastal recreation participation rates; statewide spatial distributions of coastal visits; robust estimates of spatial distributions of coastal recreational activities; demographic patterns and trends in coastal recreation (by age, gender, race/ethnicity, household income, etc.), and other important statewide summaries of coastal recreational activity.

Sampling Strategy

Online, web-based surveys can be coordinated through external service providers. For example, Knowledge Networks (KN) is a leading survey firm that maintains a standing Internet panel of survey respondents designed to be demographically representative based on the U.S. Census data. Panel members are randomly recruited by telephone using random digit dialing (RDD). Both listed and unlisted numbers are included. Households without internet are provided with access, including e-mail addresses, and then recruited by e-mail to participate in surveys. KN has developed a weighting system to ensure that its sample is demographically representative by age, gender, race/ethnicity, education, census region, zip code of residence, and household internet access status.

The sample frame for the standing KN panel is the entire U.S. population. To estimate the impact of California MPAs, however, the data collection agency may choose to limit the sample frame to California residents only. If an agency chooses to estimate the impact of MPAs in a region of the California coast (South, North Central, North) then they may choose to limit the sample frame to residents of the counties that comprise that region. For example, the South Coast of California region comprises Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura counties.

Key Metrics

The following represent key metrics necessary to understand the socio-economic impact of MPAs. Online surveys should collect these variables in all cases.

- **Location of Residence.** Knowing where coastal recreational visitors come from is important to understanding the degree to which MPA formation supports the chosen activities of local residents or encourages residents of other areas to visit the MPA region. The location variables that should be collected include:
    - State
    - County
    - ZIP code of residence.

- **Demographics.** The identity of coastal recreational visitors matters. Various population segments may engage in different coastal recreational activities, in different locations. Patterns of coastal recreation may be affected by such factors as racial residential segregation, economic segregation, unequal access to motorized transport, the relative prices of coastal recreational activities, and generational patterns of recreational use. The demographic variables that should be collected include:
    - Age
    - Race/Ethnicity
    - Educational Attainment
    - Gender
    - Household Size/Composition
        - Number of adults
        - Number of children
    - Annual Household Income
    - Employment Status

- **Frequency and Type of Visits (last 12 months).** Identifying spatial and demographic patterns of the frequency and primary purpose of coastal recreational visits can shed light on the socio-economic effects of creating MPAs. How often do members of the public visit the coast? What proportion of coastal visitors tend to engage in recreation as part of trips for other purposes, such as visiting family or friends at the coast? What proportion of coastal visitors engage in recreation as the primary purpose of their visits? The variables related to visitation frequency and type that should be collected include:
    - **# Coastal recreational visits in the past 12 months.** Knowing the proportion of total coastal visits over the past 12 months for which recreation is the primary purpose is useful in understanding the relative importance and context of recreation for coastal visitors.
    - **Date of most recent visit.** Coastal recreational activities differ across seasons; knowing the date of the recreational user's most recent visit can assist in understanding seasonal use patterns.
    - **Primary purpose of most recent visit.** Coastal recreational visits may occur during trips for other purposes, for example: visiting family or friends, traveling for business or work, attending community gatherings or events, or other purposes not directly related to recreation.
    - **Duration of visit/s.** Coastal recreational visits may be day trips, overnight stays, or multi-day stays; knowing the distribution of trip lengths is useful for predicting the impact of increased visitation on revenues for lodging and hospitality businesses.

- **Location of Recreational Visits.** Collecting spatial data on the location of recent recreational visits can provide analysts with insight into where coastal recreational visitors tend to engage in their chosen activities. Collecting spatially explicit activity data over time can lead to understanding of the impact of MPA formation on activity locations. The advantage of an online survey is that the location of where recreation occur can be pinpointed to the exact location by integrating mapping features such as Google Maps.

- **Type/s of and Participation in Activities**
    - **Activity categories.** Data collection agencies should compile a list of recreational categories that is as exhaustive as possible. Survey instruments should include both general beachgoing categories - which include sitting, dog walking, walking, running, kite flying, or other activities such as picnicking - as well as more specific coastal recreational activities such as wildlife watching, photography, surfing, SCUBA diving or freediving, kayaking, sailing, fishing with hook and line, or windsurfing.
    - **12-Month Timeframe.** Knowing the full range of activities that coastal recreational visitors have engaged in over the last 12 months of visits is helpful in understanding overall recreational use patterns.
    - **Most recent visit.** Coastal recreational users will tend to have a clearer memory of the activity or activities that they have engaged in during their most recent visit.
    - **Primary activity.** Coastal recreational visitors often engage in multiple activities over the course of their visit. Understanding the activity that the recreational visitor identifies as primary, or most important, can shed light on changes in coastal recreational use patterns that collection of data encompassing all chosen activities may not detect.

- **Trip Expenditures.** Collecting data on trip expenditures associated with coastal visits, broken down by category, is critical for understanding the local and regional economic impact of changing coastal recreational use patterns. If MPAs bring about changes in the type, frequency, and duration of coastal visits, then the ability to estimate the resulting changes in trip expenditures, and the knock-on effects on coastal economic activity by sector, becomes a primary task of the analyst.

Collection of robust and validated trip expenditure data is a necessary step in the estimation of regional economic impact models. (For the details of how these models work, see Section 4, Economic Models, below.)

The trip expenditure variables that data collection agencies should collect include:

- **Expenditure categories.** Relevant categories include food and beverages from stores and/or restaurants; equipment or vehicle rentals by type (e.g. SCUBA dive equipment, surfboards, boats, kayaks, cars, etc.); charter fees; fishing licenses; entrance fees for museums, aquariums, or parks; fuel/gasoline for boats, cars, RVs, or other vehicles; parking fees; souvenirs or gifts; sundries; and lessons, clinics, or camps; etc.
- **Dollar expenditures by category.** Survey respondents should assign a dollar expenditure figure to each category; these dollar figures can be rough estimates if necessary.

Citizen Science Programs

Citizen science programs have proven to be an effective means of tracking the prevalence of coastal recreational activities across seasons.

Key metrics for citizen science program to gather are simply amount of use by activity category - often time this is simple just a log of the number of people seen engaging in a certain coastal recreation activity.

For example, MPA Watch engages citizen science volunteers in collecting data on coastal recreation using a survey protocol based on *transects*, or specific stretches of beaches of uniform length. Citizen science volunteers walk transects, count the number of coastal recreational users by activity, and record the date, time, and weather conditions. The data collected by citizen science volunteers can be checked against the online survey data for validation or refinement. The presence of a clearly defined protocol and volunteer training system ensures that the data collected is roughly consistent across volunteers.

One important limitation of citizen science programs is that their sampling strategy is dependent on the availability and willingness of volunteers to walk transects. Volunteers are likely to over-sample during good weather conditions and seasons (e.g. sunny and warm days, summer), and likely to under-sample during poor weather conditions and seasons (e.g. rainy or stormy days, winter). This limitation can be addressed in one of two ways: (1) regulating the volunteer sign-up process to ensure a uniform distribution across seasons and weather conditions, with the possibility of paid contractors or employees filling in on days when no volunteers are available, or (2) developing a sample weighting system that can ensure the representativeness of a survey day, given the season and weather conditions.

<u>Data Validation</u>

If the citizen science dataset yields similar results to the online survey data on the relative frequency of coastal recreational activities by type and location, then the robustness of the online survey data can be more easily defended.

<u>Refinement</u>

Citizen science data, if it is collected with sufficient variation by season, time of day, and weather conditions, can also help to refine online survey data by providing a richer understanding of recreational use patterns. If the citizen science data appears to be dramatically different from the online survey data, the analyst can attempt to reconcile the two datasets by comparing them while controlling for key variables, such as the season or month in which the survey was administered.

<u>Tier 1 Citizen Science Recommendations</u>

Overall, MPA managers and research should be integrally involved in guiding and refining the design of citizen science methodologies and protocols in order to maximize their utility in long term MPA monitoring. Furthermore, there may be synergies between citizen science data program that focus on monitoring specific sites and a statewide online survey effort (as detailed above) that could be utilized together to extrapolate site level citizen science data and enable comparison across citizen science program sites. It is recommended in Tier 1 that these efforts are implemented in order to maximize the utilize of citizen science data collection programs.

3.2. TIER 2

Tier 2 recommendations build upon Tier 1 recommendations. It should be assumed that recommendations in Tier 2 are in addition to those recommended in Tier 1. We will specifically identify where Tier 2 recommendations augment Tier 1 recommendations--which are largely recommendations around augmenting a data collection methodology, adding additional metrics or adding complementary data collection efforts.

3.2.1. Commercial Fisheries

Landing Receipts

Our primary Tier 2 recommendation for commercial fishing landing receipts is to record harvest location using 1x1nm mile blocks (instead of 10x10 nm blocks) which are already being utilized by the recreational fishing sector. Landing receipts should also allow for the entry of multiple 1x1nm blocks and allow for the entry of 10x10nm blocks for fisheries that are more expansive such as salmon and tuna fishing.

Capture of Spatial Fishing Data

As stated before, the accurate capture of spatial fishing data is vital in providing data that is trustworthy, reliable, and robust enough to be utilized in long term MPA monitoring efforts. There is great need for fine scale human use data as often times biological data is captured using a fine-scale site specific methodology. In order for human use data to be integrated with biological monitoring data it is important to gather spatial data at a resolution that allows for relational linkages to be made.

That said, in baseline MPA monitoring efforts, in-person survey efforts were conducted to map commercial fishing grounds. These maps where then reviewed with the commercial fishing community overall to verify their accuracy. This type of effort was an effective way to take a snap-shot of spatial fishing patterns but were intensive in terms of the time and resource it took to conduct this data collection effort.

In Tier 1 the capture of harvest locations still remains self-reported and issues remain with capturing harvest location using a single or even multiple 10x10nm fishing blocks. In Tier 3 we discuss how technology could be utilized to more accurately gather harvest location data. However, if Tier 3 recommendations are not feasible to implement we would as a Tier 2 recommendation, that the monitoring program continue to utilize in-person interviews and community engagement methods to both map and verify spatial patterns of commercial fishing activities.

The goal of these mapping efforts would be to capture the spatial fishing patterns of commercial fishing so that it represented at least the majority of the economic value in a given port-fishery combination. Thus, we would recommend that interview sample designs be stratified across revenue levels to ensure interviews are both conducted across revenue levels but also are representing the majority of the economic value in the fishery.

We would like to note that if the primary objective of these in-person interviews is to map fishing patterns that interviews would be significantly streamlined (and thus require less resources) from past in-person interview efforts as much of the data that were gathered in those interviews are recommended to be gathered in other methods mentioned in this report (e.g. online survey).

Annual and Semi-Annual Surveys

As stated in Tier 1 above, a survey that is issued every 1-3 years of commercial fishermen can provide additional information necessary to fully understand the socio-economic health of commercial fisheries. Specifically, surveys can be conducted where more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

It is recommended that for an annual survey (could be every 2-3 years if resources are not available to conduct each year) that the survey be sent to all commercial fishermen. Fishermen could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. The CDFW cannot require these surveys to be taken, however, efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the Tier 2 metrics that are additive to Tier 1 metrics that should be gathered using this method and the rationale for each key metric:

- Perceptions of drivers of economic and ecological changes
    - This metric is important qualitative data to gather in order to understand what factors are driving change in commercial fisheries. This will help to take inventory of the possible drivers as well as corroborate what researchers may be seeing in the data. It may also help to isolate what may be an effect of MPAs vs. other economic and ecological drivers. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Perceptions of ecological and economic MPA effects
    - This metric is important qualitative data to gather in order to understand what commercial fishermen perceive to be the impact of MPAs to be and which MPAs they perceive are impacting them. These can be both negative and/or positive impacts. These observations from commercial fishermen can provide important contextual data, corroborate research findings, and help research gain a user-centered perspective to inform research and monitoring efforts. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Attitudes towards MPAs and management
    - This metric is important qualitative data to gather as changes in attitudes can be indicators towards successful management outreach, education, and awareness efforts. This will be key to monitor over time as state agencies engage fishing communities in the long-term management of California's marine resources.
- Well-being/Quality of life
    - This metric is important to gather as economic data along does not fully represent the socio-economic health of commercial fishermen. Capturing responses to well-being and quality of life questions will provide a fuller understanding of how well commercial fishermen are doing overall. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.

It is important to mention that obtaining adequate representative participation and a time series of these data are vital in order to properly evaluate these data and make any statements that could be understood as representative of the entire commercial fishing fleet or adequate at measuring change over time.

3.2.2. CPFV Fisheries

CPFV Logbook

Our primary Tier 2 recommendation for CPFV logbooks is to record harvest location using 1x1nm mile blocks (instead of 10x10 nm blocks) which are already being utilized by the recreational fishing sector. CPFV logbooks should also allow for the entry of multiple 1x1nm blocks and allow for the entry of 10x10nm blocks for fisheries that are more expansive such as salmon and tuna fishing.

Capture of Spatial Fishing Data

As mentioned in the Tier 2 commercial fishing recommendations, the accurate capture of spatial fishing data is vital in providing data that is trustworthy, reliable, and robust enough to be utilized in long term MPA monitoring efforts. There is great need for fine scale human use data as often times biological data is captured using a fine-scale site specific methodology. In order for human use data to be integrated with biological monitoring data it is important to gather spatial data at a resolution that allows for relational linkages to be made.

That said, in baseline MPA monitoring efforts, in-person survey efforts were conducted to map commercial fishing grounds. These maps where then reviewed with the commercial fishing community overall to verify their accuracy. This type of effort was an effective way to take a snapshot of spatial fishing patterns but were intensive in terms of the time and resource it took to conduct this data collection effort.

In Tier 1 the capture of harvest locations still remains self-reported and issues remain with capturing harvest location using a single or even multiple 10x10nm fishing blocks. In Tier 3 we discuss how technology could be utilized to more accurately gather harvest location data. However, if Tier 3 recommendations are not feasible to implement, we recommend under Tier 2 that the monitoring program continue to utilize in-person interviews and community engagement methods to both map and verify spatial patterns of CPFV activities.

The goal of these mapping efforts would be to capture the spatial fishing patterns of CPFV vessels so that it represents at least the majority of the fishing effort in a given port. Given the limited CPFV operators in California it is feasible to interview the entire CPFV fleet and should be the sample strategy assuming they all could be contacted (highlighting the importance of capturing contact data during license renewal).

We would like to note that if the primary objective of these in-person interviews is to map fishing patterns, that interviews would be significantly streamlined (and thus require less resources) from past in-person interview efforts, as much of the data that was gathered in those interviews is recommended to be gathered in other methods mentioned in this report (e.g. online survey).

Annual and Semi-Annual Surveys

As stated in Tier 1 above, a survey that is issued every 1-3 years of CPFV operators can provide additional information necessary to fully understand the socio-economic health of the CPFV fleet. Specifically, surveys can be conducted where more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

It is recommended that for an annual survey (could be every 2-3 years if resources are not available to conduct each year) that the survey be sent to all CPFV operators. Fishermen could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. The CDFW cannot require these surveys to be taken, however, efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the Tier 2 metrics that are additive to Tier 1 metrics that should be gathered using this method and the rationale for each key metric:

- Perceptions of drivers of economic and ecological changes
  - This metric is important qualitative data to gather in order to understand what factors are driving change in CPFV fisheries. This will help to take inventory of the possible drivers as well as corroborate what researchers may be seeing in the data. It may also help to isolate what may be an effect of MPAs vs. other economic and ecological drivers. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Perceptions of ecological and economic MPA effects
  - This metric is important qualitative data to gather in order to understand what CPFV operators perceive to be the impact of MPAs to be and which MPAs they perceive are impacting them. These can be both negative and/or positive impacts. These observations from commercial fishermen can provide important contextual data, corroborate research findings, and help research gain a user-centered perspective to inform research and monitoring efforts. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Attitudes towards MPAs and management
  - This metric is important qualitative data to gather as changes in attitudes can be indicators towards successful management outreach, education, and awareness efforts. This will be key to monitor over time as state agencies engage fishing communities in the long-term management of California's marine resources.
- Well-being/Quality of life
  - This metric is important to gather as economic data along does not fully represent the socio-economic health of CPFV operators. Capturing responses to well-being and quality of life questions will provide a fuller understanding of how well CPFV operators are doing overall. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.

It is important to mention that obtaining adequate representative participation and a time series of these data are vital in order to properly evaluate these data and make any statements that could be understood as representative of the entire commercial fishing fleet or adequate at measuring change over time.

3.2.3. Recreational Fisheries

License Purchase

As stated in Tier 1 - the purchase of recreational fishing permits is a key touch-point with recreational fishermen that CDFW should maximize. In addition to the contact information captured in Tier 1 recommendation, additional information/metrics could be captured. It might not be feasible to capture these data for one-day license purchasers but could be achieved for annual license purchasers who can already purchase their annual license online and thus could easily provide this information:

- Demographics (Age, gender, ethnicity, household income level, education level)
  - Understanding the demographic profile of California saltwater recreational anglers will allow researchers to better understand how the impacts of MPAs or fisheries management unfolds unevenly across the population. Furthermore, gathering demographic data over time will help to understand changes and trends in the composition of California's saltwater angler community.

- Population attribute data is key in developing sample designs when it is not feasible to survey the entire recreational fishing population. This will help ensure sampling efforts are representative of the larger population.

Accounting for Unlicensed Fishing Effort
As an additional Tier 2 recommendation - in order to estimate the total population engaged in saltwater, one must also account for the amount of fishing effort that is unlicensed. Thus, infraction/citation data from CDFW enforcement sector should be utilized to estimate the proportion of the recreational fishing population that have not purchased recreational fishing licenses. This is an important data point to capture in order to accurately estimate the total recreational saltwater fishing effort across California.

Capture of Spatial Fishing Data
As mentioned previously, the accurate capture of spatial fishing data is vital in providing data that is trustworthy, reliable, and robust enough to be utilized in long term MPA monitoring efforts. There is great need for fine scale human use data as often times biological data is captured using a fine-scale site specific methodology. In order for human use data to be integrated with biological monitoring data it is important to gather spatial data at a resolution that allows for relational linkages to be made.

That said, in baseline MPA monitoring efforts, in-person survey efforts were conducted to map recreational fishing grounds. These maps where then reviewed with the recreational fishing community overall to verify their accuracy. This type of effort was an effective way to take a snapshot of spatial fishing patterns but were intensive in terms of the time and resource it took to conduct this data collection effort.

In Tier 1 the capture of harvest locations is captured through intercept surveys - however, it is unclear if these are representative of the larger recreational fishing patterns across California. In Tier 3 we discuss how technology could be utilized to more accurately gather harvest location data. However, if Tier 3 recommendations are not feasible to implement we would as a Tier 2 recommendation, that the monitoring program continue to utilize in-person and/or focus group type interviews and community engagement methods to both map and verify spatial patterns of recreational fishing activities.

The goal of these mapping efforts would be to capture the spatial fishing patterns of specific recreational fishing modes (private vessels, beach/bank, and man-made structure such as pier and jetties). Based on the experience of the authors of this report - a focus group type methodology may serve as the most efficient and effective method as often times the location of recreational fishing effort does not vary significantly from fisherman to fisherman. This is due to the fact that recreational fishing trips typically are only day-trips and thus limit the options of fishing location to certain habitat (e.g. rocky reef) that is close by or to specific locations (beach of piers). A focus group that convenes recreational fishermen who have deep knowledge of the recreational fishing grounds in their port could sufficiently represent the recreational fishing patterns of that port community.

We would like to note that if the primary objective of these in-person interviews or focus groups is to map the intensity of fishing patterns that interviews would be significantly streamlined (and thus require less resources) from past in-person interview efforts as much of the data that were gathered in those interviews are recommended to be gathered in other methods mentioned in this report (e.g. online survey).

Annual and Semi-Annual Surveys and/or Focus Groups
As stated in Tier 1 above, a survey that is issued every 1-3 years of saltwater recreational fishermen can provide additional information necessary to fully understand the socio-economic health of recreational fisheries. Specifically, surveys can be conducted where more in-depth information needs to be gathered that

cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

It is recommended that for an annual survey (could be every 2-3 years if resources are not available to conduct each year) that the survey be sent to strategic sample of saltwater recreational fishermen. Fishermen could be contacted via phone, email, or physical mail -- all directing them to a web-based survey. The CDFW cannot require these surveys to be taken, however, efforts should be made to incentivize response rate such as entry into a series of prizes/giveaway (perhaps donated) or discounts on license fees, etc.

Below we provide the Tier 2 metrics that are additive to Tier 1 metrics that should be gathered using this method and the rationale for each key metric. These metrics could be gathered by adding this information to the **annual or semi-annual survey effort** or by utilizing recreational fishing **focus groups** in each port community to gain the perspective of fishermen who are more fully engaged in recreational fishing efforts. Focus groups could be convened through the help of local and state recreational fishing associations.

- Perceptions of drivers of economic and ecological changes
    - This metric is important qualitative data to gather in order to understand what factors are driving change in recreational saltwater fisheries. This will help to take inventory of the possible drivers as well as corroborate what researchers may be seeing in the data. It may also help to isolate what may be an effect of MPAs vs. other economic and ecological drivers. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Perceptions of ecological and economic MPA effects
    - This metric is important qualitative data to gather in order to understand what commercial fishermen perceive to be the impact of MPAs to be and which MPAs they perceive are impacting them. These can be both negative and/or positive impacts. These observations from commercial fishermen can provide important contextual data, corroborate research findings, and help research gain a user-centered perspective to inform research and monitoring efforts. To help reduce data analysis time, these data could be captured as a series of categorical response questions as well as open-ended questions.
- Attitudes towards MPAs and management
    - This metric is important qualitative data to gather as changes in attitudes can be indicators towards successful management outreach, education, and awareness efforts. This will be key to monitor over time as state agencies engage fishing communities in the long-term management of California's marine resources.
- Demographics (Age, gender, ethnicity, household income level, education level)
    - Understanding the demographic profile of California saltwater recreational anglers will allow researchers to better understand how the impacts of MPAs or fisheries management unfolds unevenly across the population. Furthermore, gathering demographic data over time will help to understand changes and trends in the composition of California's saltwater angler community.
    - Population attribute data is key in developing sample designs when it is not feasible to survey the entire recreational fishing population. This will help ensure sampling efforts are representative of the larger population.

3.2.4. Coastal Recreation and Tourism

General Online Surveys

Online surveys can be an important data source for estimating econometric models of MPA impact. Section 3.1.4 above outlines the basics of online surveys, their sampling strategy and the benefits of conducting them regularly to derive summary statistics about coastal recreation at the state, regional, or local levels. Below we discuss two important econometric models and identify the variables that must be collected to estimate them: contingent valuation and travel cost.

Contingent Valuation: Willingness to Pay (WTP) and Willingness to Accept (WTA)

A contingent valuation study is a survey-based study in which participants are asked to state their willingness to pay (WTP), or accept payment (WTA), for well-defined changes in the levels of specific environmental attributes, such as air quality, water quality, or scenic views. Contingent valuation has been used by U.S. government agencies to measure public preferences for changes in water quality, biodiversity, and salmon populations.

Contingent valuation is relatively easy and low-cost to administer, which explains its wide adoption and use by government agencies. However, the method has been roundly critiqued by academics to the point where a prominent MIT economist declared it to be hopeless (Hausman 2012). The primary critiques of contingent valuation are as follows: (1) answers to hypothetical willingness-to-pay questions are consistently higher than actual revealed willingness-to-pay (hypothetical response bias); (2) large differences between WTP and WTA; and (3) lack of stable public preferences due to the "embedding effect". In regard to the embedding effect: behavioral economists Daniel Kahneman and Jack Knetsch have found that individuals' preferences for goods, services, or states of the world are dependent on the overall package of attributes in which the goods, services, and attributes are embedded. For example, survey respondents stated WTP for restoring a single stream, river, or lake, has been shown to depend strongly on the additional components of the restoration project queried in the contingent valuation study. In short, people have evinced the same WTP for restoring one lake as for restoring five lakes! As a result, adding or subtracting contextual information or scenario components from a contingent valuation study leads to dramatically different results in asking for WTP or WTA for the same changes in the levels of the same environmental attributes.

Any attempt to develop a contingent valuation study should be undertaken with the above caveats in mind. With the above caveats, contingent valuation studies may be useful as registers of public opinion on the topic of environmental changes. They cannot, however, be relied upon as plausible estimates of real-world preferences or economic behavior.

Travel Cost Models

Travel cost models are econometric (statistically based) models that use data on recreational visitation behavior to estimate the economic value that coastal recreational visitors place on recreational sites, or attributes of recreational sites such as water quality and wildlife. The theory behind travel cost models holds that recreational visitors will be willing to travel longer distances, at higher monetary and/or time cost, in order to visit more valuable recreational site attributes. Estimating a travel cost model thus requires collecting variables on the distance, time, and money spent in the course of traveling from the recreational visitor's residence to the chosen coastal recreation site. Many travel cost models estimate the value of site attributes based on a visitor's choice to visit one site among a large number of possible sites. These models are usually estimated using a discrete choice modeling framework such as logit (or sometimes probit). For more information about travel cost models, please see the Economic Models section below.

Variables

- **Transportation Variables.** The implementation of travel cost models requires the collection of transportation variables. Knowing the distance traveled, time involved in traveling, and mode of transportation chosen by the visitor allows the analyst to estimate total travel cost based on plausible assumptions. Collecting these variables thus allows researchers to identify and measure users' preferences for various attributes of recreational sites, and ultimately derive measures of the non-market economic value that users place on specific recreational sites or site attributes. The transportation-related variables that should be collected for a travel cost modeling study include:

- Mode of Transport
- Vehicle Type (e.g. sedan, SUV, truck, public bus, private bus, etc.)
- Miles Traveled
- # of Total Passengers - including vehicle driver, unless the driver was hired

- **Targeting Specific User Groups.** A general coastal recreation online survey is designed to capture the coastal recreation activities that the majority of coastal users engage in. However, at times this method does not gather enough of a sample of specific user groups who state agencies may want to specifically engage due to their interest and significant economic contribution to the coastal economy.

  For example, private boaters, SCUBA divers, surfers, and other specialize coastal recreation activities require a more targeted survey effort to adequately capture and represent their use patterns and the economic contribution of their recreation activities. The same general coastal recreation survey could be given to these user groups; however, specific efforts must be conducted to target and recruit respondents from these user groups.

  This could be done by engaging local user group association such as boating clubs, SCUBA diving clubs and association, surfing advocate organization such as Surfrider Foundation, etc. Targeting these specific user groups an engaging them in an online survey will be key to representing the use patterns and economic value of these user groups. Thus, we recommend in Tier 2 to apply resources to engage and survey these groups.

- **Citizen Science Programs**
  In Tier 2, a more elaborate citizen science data collection program may consider adding a survey module on recreational visitors' travel behavior. A citizen science volunteer may be instructed to survey a randomly chosen portion of recreational visitors she encounters in the course of surveying a transect. For example, a volunteer may be instructed to survey every third or every fifth visitor encountered. Citizen science volunteers may survey recreational visitors using such questions as:
  - What city do you live in?
  - What mode of transportation did you use to get to this site?
    - (If a motor vehicle) What kind of motor vehicle did you use? Did the vehicle belong to you or to someone else? How many passengers were aboard the vehicle for this trip?
    - (If a public or privately hired transit vehicle) How much money did you spend to get from your home to this site?
  - How long did it take you to get from your home to this site?
  - Why did you choose to visit this site over all the other sites in this region?
    - This question can be used to validate or refine the results of travel cost models, including checking for the presence of omitted variables.
  - What is the primary purpose of your trip to the coast?
  - What activities are you most interested in engaging in at the coast today?

  Adding a travel module to a citizen-science survey can allow for additional observations on travel costs, which may be used to develop a parallel set of travel cost studies. Collecting supplemental data for coastal recreational visitors' stated reasons for visiting specific sites can also validate, refine, or qualify the results of quantitative travel-cost model estimates. These data can assist in identifying potentially omitted variables from travel cost model estimates, as well as probing non-economic motivations or reasons for coastal visitation behavior.

3.3. TIER 3

In Tier 3 we focus on how technology can help advance data collection efforts in not only streamlining data collection but also help to gather more accurate data.

3.3.1. Commercial Fisheries

Digital Mobile Based Landing Receipts
Many advances are being made in fisheries electronic reporting which include the development of digital landing receipt mobile applications. California would greatly benefit from a digital landing receipt system in several ways that addresses current weaknesses in its paper-based system. Digital landing receipts would:

- Automatically digitize data for entry into the CDFW databases making data available in a much quicker timeframe and available to managers and researchers
- Allow for the more accurate capture of spatial fishing location by utilizing a Google Maps type view for fishermen to indicate which CDFW 1x1nm fishing blocks they harvested their catch. Just this feature alone would improve the capture of spatial fishing information significantly compared to the current method of asking fishermen to provide only one fishing block number and remember the fishing block number from memory.
- Allow for a quick and easy way to link across data collection methods. For example, if digital logbooks existed - a simple scan of a digital logbook QR code would link fishermen fishery logbooks to landing receipts enabling a more robust and integrated analysis of both data sets. Similarly, if fisherman licenses number could be scanned as a QR code - a digital landing receipt could link automatically to a fisherman's license record removing possible manual data entry errors.
- Automate data entry such as automatically capturing date, time and landing location using the smartphone/tablet built in GPS features.

Digital Mobile Based Logbooks
Similar to digital landing receipts - many advances have been made to develop digital logbooks that work both online and offline and utilize the GPS enabled technology that are now ubiquitous in smartphones and tablets. Digital logbooks offer the opportunity for fishermen to provide more detailed information on their fishing activities that are too cumbersome to capture at landing through a landing receipt.

Specifically, digital logbooks can:

- Capture information for each fishing event including location, effort, and estimated catch size.
    - Location: Automatically capture a fishing location through capturing the GPS location of the vessel and remove manual entry error or reduce the likelihood of false location information being captured. Capturing fine scale harvest location data is essential for MPA monitoring efforts.
    - Effort: Self-reported but more efficiently captured in a digital application
    - Estimated catch size: Self-reported and estimated - however if digital logbooks could be linked to digital landing receipts as mentioned above the self-reported data could then be verified or replace in lieu of the more accurate landing receipt data.
- Automatically digitize data for entry into the CDFW databases making data available in a much quicker timeframe and available to managers and researchers
- Allow a platform for CDFW to engage fishermen. For example, important news can be sent to fishers through the digital logbook application, reminders to upload their logbook data, reminders

of important management meetings, or short surveys can be sent to fishermen as well on an as needed basis. These are just some of the possibilities that utilizing a technology platform could open up.

3.3.2. CPFV Fisheries

Digital Mobile Based CPFV Logbooks

Similar to reasons stated above for developing commercial fishing logbook mobile applications--digital CPFV logbooks would enable the more accurate and robust capture of CPFV trip level information.

Specifically, digital mobile based CPFV logbooks would enable to the more accurate capture of spatial fishing location data. Currently CPFV logbook are design to capture information about a fishing trip as a whole. However, fishing trips likely consist of multiple fishing events where the boat is moved on to different fishing spots throughout the trip.

A mobile-based CPFV logbook could accommodate the capture of data for each fishing event such as:

- Location: GPS location of fishing event (could be the selection of a 1x1 nm block on a Google Map interface as well is fishing by trolling that covers an area vs. fishing at a specific location)
- Harvest Size: Number and pounds of fish caught by species
- Effort: Amount of time spent at fishing location

Web-Based Angler Survey

It was recommended in Tier 1 that CPFV logbooks be modified to capture the average price paid per anglers on a CPFV trip in order to roughly estimate gross revenue from CPFV operations. However, this only capture a portion of the economic value that CPFV anglers contribute to the coastal economy. Often there are significant trip expenditures associated with taking a fishing trip on a CPFV vessel and it is important to capture those expenditures in order to fully value the economic contribution of the CPFV sector.

It is recommended that a web-based survey is developed for CPFV anglers. Survey participants could be recruited from CPFV trips by CPFV operators. Incentives could be put in place to reward CPFV operators for securing a certain percentage of their customers. Incentives could also be put in place to entice CPFV anglers to participate in the survey such as entry into a lottery for prizes or discounts. CPFV angers could be given a specific trip code in order to tie their survey response to the specific trip information captured in the logbook.

Key metrics to be collected in this web-based angler survey include:

- Location of residence
- Demographics
- Trip expenditures (e.g. transportation, food, accommodations, gear, etc.)
- Primary purpose of trip (if other than fishing)

3.3.3. Recreational Fisheries

Digital Mobile Based Report Card Data Apps

A key challenge to capturing recreational fishing data is that recreational fishing is practiced by a large population and is dispersed unevenly across California's coastline both in both space and time. This makes for intercept survey time and resource intensive.

To help address this key challenge, the use of mobile application technology could provide targeted ways to engage key recreational fishing user groups (e.g. spiny lobster, abalone, spearfishing, etc.) in capturing and submitting key fisheries harvest data.

As mentioned before the key metrics to be gathered in fishery specific recreational fishing report cards are: 1) Location of harvest; 2) harvest effort; and 3) catch amount. If fishery report cards were submitted via a smartphone application the location of harvest could automatically be captured and easily submitted to CDFW - address two key issues with the current paper-based report card system.

As mentioned earlier, current report cards have fishermen indicate the location name of where they harvested their catch. However, these locations do not have defined boundaries are subject to the fisherman's interpretation. Capturing the exact geo-location of harvest via a mobile application will provide more accurate and precise harvest location data bringing the granularity needed to compare socioeconomic human use data to site specific biological monitoring data.

3.3.4. Coastal Recreation and Tourism

Online Surveys

Online surveys have been discussed in the above two sections 3.1.4 and 3.2.4 as effective ways of capturing demographically representative, geographically broad, and detailed information regarding coastal recreational visitation behavior. A more elaborate online survey may contain additional modules covering the following topics:

Overnight or Multi-Day Visits

The basic survey questionnaire in Section 3.1.4 above included a question on duration of visit, in order to identify overnight or multi-day visits to the coast. A more elaborate survey would include a separate module for overnight or multi-day visitors, asking questions on topics including:

- The temporal and spatial pattern of recreational activities: which activities the visitor/s engaged in, on what days, at what times of day, and in what locations
- Additional information about non-recreational components of multi-day visits such as family reunions, business or work trips, including:
    - What proportion of each day spent with family/working/engaging in recreation
    - Overlap between recreation and family activities, or recreation and work activities (e.g. recreation with colleagues, recreation as part of work retreats or family reunions)
    - Location and type of lodging: hotel, motel, Airbnb, family/friend's residence, retreat center
    - Tourist activities not typically associated with coastal recreation and not covered by previous coastal recreation questions, including visiting historical sites, architecture tours, wineries, museums, coastal sporting events (e.g. sailing, beach volleyball) or entertainment (e.g. concerts, dance parties/raves, etc.).

Out-of-State Visitors

Researchers may consider expanding the online survey sample to include residents of adjacent states; residents of all West Coast states; residents of all U.S. West states including the interior West, Alaska, and Hawaii; or residents of the entire U.S. With more comprehensive data, researchers may develop geographically broader summaries of participation rates, chosen activities, trip lengths, trip expenditures, and preferences of coastal recreational visitors.

Choice Experiments

In addition to the uses identified above, online surveys can be used to conduct more sophisticated forms of stated-preference studies, such as **choice experiments.** Choice experiments are a form of stated preference study wherein the analyst asks members of a population to choose their most preferred alternative from a series of bundles of attributes, provided at varying levels, and associated with varying prices. Estimating the results of choice experiments requires the use of a discrete choice modeling framework, such as logit. For more information about choice experiments, please see Section 4, Economic Modeling, below.

Implementing a choice experiment involves adding an additional module to an online survey that walks the survey respondent through a series of questions regarding her/his most preferred bundle of attributes/levels, as referenced above. Choice experiments often add several minutes to the time required to complete a survey, since they require that the respondents read and understand a *preamble* which explains the purpose and structure of the questions that will follow. Analyzing the results of choice experiments also involves additional time spent by the researcher, in estimation and interpretation.

Choice experiments are subject to many of the same weaknesses as all stated preference studies: hypothetical response bias, in other words the gap between people's stated preferences for various states of the world, and people's revealed preferences through their behaviors such as market purchases, voting patterns, and investing decisions. Their results, therefore, should be interpreted with caution.

Citizen Science Programs

Utilizing Mobile Applications

Citizen science volunteer programs can engage volunteers to collect spatially explicit data using mobile phones or tablets. Collecting spatially explicit data can allow for more sophisticated forms of data collection, whether ecological in nature such as phenology data (see below) or social scientific, such as place attachment and place identity (see below). With spatially enabled mobile application - the geo-location of human use data can be automatically captured and digitized on the spot removing the need for manual data entry. Digital data collection forms vis a mobile application would also enable more uniform and consistent data collection forms to be developed and shared across citizen science programs.

Furthermore, by utilizing a mobile application - additional survey modules can easily be added to data collection protocols such as the additions we detail below:

Tracking Phenology

Phenology is the aspect of ecology that studies temporal changes: when flowers bloom, when leaves fall, when birds build their nests, etc. Citizen science can be mobilized to collect phenological data at coastal sites inside or adjacent to MPAs. Citizen science volunteers can collect spatial data, using iPhones or iPads (or other similar devices) on the location and timing of coastal patterns including bird and mammal migrations, flowering plants, and other visible indicators of coastal and marine life. This data could be integrated with biological monitoring data to corroborate or provide more contextual evidence for trends observed in biological datasets.

Place Attachment and Place Identity

To supplement these data further, survey designers may also choose to include open-ended questions to elicit statements from coastal visitors regarding non-economic motivations for specific coastal visitation patterns, including **place attachment** and **place identity.** Place attachment can be defined as "an affective bond that people establish with specific areas where they prefer to remain and where they feel comfortable and safe". Place identity, by contrast, refers to "a process by which, through interaction with places, people describe themselves in terms of belonging to a specific place".

Surveys can test for the intensity of place attachment and place identity through Likert-scale questions such as the following examples:

- Place identity: To what degree do you agree with the following statements (0 = Not at all, … , 5 = Completely)
    - (Site name) is a part of me
    - I would not be who I am today without (Site name)
- Place attachment: To what degree do you agree with the following statements (0 = Not at all, … , 5 = Completely)
    - (Site name) is my favorite place to visit
    - Doing (activity name) at (site name) is better than doing (activity name) anywhere else

Place identity and place attachment can also be mapped, by eliciting survey respondents to drop markers or pins on digital (GIS-based) maps to identify locations or sites of exceptional personal significance, beauty, meaning, or identity formation. These are important to capture in order to understand the relationship coastal users have with coastal areas they recreation within. Understanding this will help managers better design how to engage coastal recreation users in management measures and raise awareness and educate on local issues.

4. ECONOMIC MODELING

In this section we discuss economic modeling methods in order to better understand how economic data may be utilized (and thus why it should be collected) to evaluate the value of human uses and thus the marine resources of California.

4.1 Economic models

The economic models that are applicable to the socio-economic monitoring of marine protected areas are of two major types. The first, Input-Output Models, allow the analyst to estimate the short-run regional impact of a given pattern of expenditures. The second, Non-Market Valuation, allow the analyst to estimate the value that residents and the broader public place on specific attributes of coastal and marine sites and locations, as well as specific activities associated with those sites and locations. Below we provide an overview and critique of these models in more depth.

4.2 Input-Output Models

Input-output models capture the production structure of an economy based on the relationships between inputs to the production of goods and services and the quantity of the final goods and services produced. The most commonly used input-output model is the IMPLAN model, available for purchase through MIG, Inc. The foundation of the IMPLAN model is the Input-Output tables published by the U.S. Department of Commerce. IMPLAN uses a range of datasets from the Bureau of Labor Statistics and Bureau of Economic Analysis to incorporate employment, labor income, and taxation into the model.

The Bureau of Economic Analysis also publishes its own input-output model called RIMS, which is simpler than IMPLAN. RIMS is essentially a set of multipliers that indicates the direct, indirect, and induced impacts of an investment on employment and output/economic activity. Unlike IMPLAN, RIMS does not provide estimates of the breakdown of jobs and/or output by economic sector.

Input-output models allow for results that are directly comparable to one another. A model such as IMPLAN estimates job creation, value added, output, labor income, and federal, state, and local tax revenue by sector. The primary data requirement for successful input-output modeling is a robust and validated set of data on expenditures by currency, economic sector, location, and year. The location specified can be as fine-grained as ZIP code or as coarse as state level.

IMPLAN and other input-output models estimate direct, indirect, and induced impacts. The **direct impact** of an expenditure pattern is simply its impact without taking into account additional resulting purchases. For instance, a purchase of building construction services will give rise directly to a certain number of jobs, without taking into account additional purchases of materials or supplies. The **indirect impact** of an expenditure consists of the effect of the purchase and/or rental of production inputs, raw materials, equipment, and rent or amortized ownership costs of land or building real estate involved in producing a good or service (but not the real estate of the business owners' or workers' residences). The **induced impact** consists of the effect of consumption expenditure patterns, including food, housing, and other personal consumption items, by the businesses directly and indirectly involved in producing the good or service.

The weaknesses of input-output models are several. First, they are **static,** meaning that they take the structure of the economy as a given and do not incorporate potential changes in the use of inputs, equipment, or labor as a result of changes in technology or business practices. Second, they are **short-run**; they cannot trace the impacts of the initial pattern of expenditures beyond the event year during which they occur. Third, the number of economic sectors into which one can categorize expenditures is limited: the IMPLAN model consists of 440 sectors, which is a far cry from the thousands of economic sectors classified under the 6-digit NAICS (North American Industry Classification System).

4.3 Non-Market Valuation Techniques

Non-market valuation techniques are attempts, through careful survey design and econometric analysis, to infer the dollar value that a population places on a given attribute of a good or service that is not directly for sale. For instance, the value of an unimpeded ocean view can be inferred through the econometric analysis of the contribution of such views to the price of residential properties that possess them. Non-market valuation techniques are frequently used to estimate the economic benefits from the conservation, protection, or restoration of natural ecosystems. Such conservation or restoration efforts can benefit local and regional economies through attracting tourism, promoting local recreational industries, increasing property prices, or promoting overall health and well-being. The full value of the restoration activities cannot be captured entirely through analyzing directly related expenditures, such as park user fees or local spending on recreational goods and services. Thus, non-market valuation is an important tool for measuring impacts.

Non-market valuations are of two major types: **stated preference** and **revealed preference. Stated preference** studies involve direct queries of willingness-to-pay for either a single attribute or a package of attributes. There are two major types of stated preference studies currently in wide use: **contingent valuation** and **choice experiments.**

Contingent valuation studies involve directly asking members of a population their willingness-to-pay (WTP) for specific increases in the provision of a given non-market good or service. An alternative approach involves asking respondents for their willingness-to-accept (WTA) payment for decreases of the provision of the good or service.

Contingent valuation may have value in estimating the socioeconomic impact of MPAs. An example would be a study in which respondents are asked their willingness to pay for an increase in the population of marine mammals, an increase in water quality, or any other attribute associated with the implementation of MPAs. Since MPAs involve increased (rather than decreased) levels of a range of environmental attributes, the WTP (rather than WTA) formulation is appropriate.

There are two major weaknesses of contingent valuation studies. First, in studies that involve both stated and revealed preference (see below), respondents' stated willingness to pay for increases in the levels of environmental attributes often does not match their revealed pattern of market behavior. Second, in studies that include both WTP and WTA, the two measures often fail to match: respondents' willingness to pay for a given increase in the level of an attribute do not equal their willingness to accept payment for an equivalent decrease in the level of the same attribute. This discrepancy may be due to the psychological characteristic of *loss aversion* in which losses are felt more strongly than equivalent gains.

Choice experiments are a form of stated preference study wherein the analyst asks members of a population to choose their most preferred alternative from a series of bundles of attributes, provided at differing levels, and associated with differing prices. Choice experiments were invented for the field of marketing economics, wherein analysts were interested in consumers' willingness to pay for individual attributes comprising a product. For example, in the case of a personal computer, relevant attributes might include hard drive capacity, RAM, and screen size. Applied to a non-market environmental "good" such as a beach, relevant attributes might include beach width, water quality, and the presence or absence of wildlife (such as birds or marine mammals).

The design of the choice experiment allows the analyst to isolate the implicit price, or marginal willingness-to-pay, of respondents for changes in the levels of provision of each attribute. In the case of the beach referenced above, the choice experiment would allow an analyst to answer the question, "How much would the average beach visitor be willing to pay for an increase in beach width of 100 feet?"

Choice experiments allow for significant flexibility in the definition of attributes. Attributes and levels can be defined through photographs, videos, physical descriptions, or other means such as sounds. The analyst can label the levels of attributes using relative ranking or scoring rubrics (e.g. Low, Medium, and High, or 1, 2, and 3); however, experiments are more effective when both attributes and levels are carefully defined through precise language and/or other media of communication. A typical choice experiment consists of three to five attributes, each taking three to five different levels. Adding more attributes or more levels creates additional complexity - and therefore requires additional computing power - in experimental design, estimation, and interpretation of results.

One of the primary strengths of choice experiments is that they allow the analyst to measure responses to changes that have not occurred, or that the survey respondent has not experienced directly. This property of choice experiments allows analysts to measure a much wider array of possible changes in ecological management regimes.

Choice experiments have several weaknesses. One weakness, similar to that of contingent valuation, is that stated preferences often diverge from observed choice behavior. Another weakness is that combinations of attributes may be difficult to understand, open to interpretation, or understood differently by different user groups. A third weakness is the omission of salient attributes whose inclusion would affect the survey respondent's choices systematically.

4.4 Revealed Preference Studies

The main alternative to a stated preference study, such as contingent valuation or a choice experiment, is a revealed preference study. Revealed preference studies use observed market behavior to identify and measure implicit values of the attributes of goods and services. Hedonic price studies are the most common forms of revealed preference studies. A hedonic price study measures statistically the relationship between the market prices of goods/services and the attributes of those goods/services. For instance, a study might measure the relationship between the price of a house and attributes such as floor space, heating source, roof condition, and/or the quality of local schools, parks, and amenities. Hedonic price studies can also be applied to environmental goods or services that are not for sale, such as local air quality or water quality. For environmental goods with multiple attributes, however - such as recreation sites - the appropriate revealed preference framework is the *travel cost model,* which is discussed below.

4.5 Travel Cost Models

Travel cost models allow the analyst to identify and measure the implicit dollar value that the average coastal recreational visitor places on the attributes of one or more coastal recreational sites, based on the cost that the visitor is willing to pay to travel to that site or sites. Travel cost models can cover either single sites or multiple sites. In a single site model, the analyst collects data on the number of visits that individual users pay to a given recreational site over the course of the study period (e.g. one year). Different recreational visitors will pay different "costs" to visit the site under study, depending on the distance necessary to travel from the visitor's residence to the recreation site. The analyst estimates a "demand curve" for the site based on the number of visits that visitors engage in, dependent upon distance/cost.

The primary limitation of the single site model is that the analyst cannot estimate the value of the individual attributes of the site, only the value of the site as a whole. In order to estimate the value of each of the component attributes of the site, a choice model covering multiple sites is necessary. The *random utility model* is the most common multi-site travel cost model, and we discuss that model next.

4.6 Random Utility Models (RUMs)

Random utility models (RUMs) are the most common framework used to estimate the implicit economic value of the attributes of recreational sites. A RUM models the recreational visitor's choice or decision to visit one particular site from a set of multiple sites on a single occasion. The model assumes that site choice is dependent on the characteristics of the site. For example, a beach visitor may choose to visit a specific beach for its high water quality, surf break, proximity to bathrooms or concession stands, and/or scenic vistas. The model is called *random utility* because it assumes that site choice is a function of a set of variables, such as site characteristics and travel cost, as well as a random component or error term. RUMs are estimated using a discrete choice model framework, usually a logit.

The primary strength of revealed preference models, such as travel cost/RUMs, is that they use recreational visitors' observed market behavior as data in estimating the value of site attributes. The discrepancy between stated preferences and observed behavior does not come into play. There are several weaknesses of these models, however, including the possibility of omitted variables. The models also rest on the assumption that travel time itself has an economic value that can be measured, and is usually linked to the visitor's salary or hourly wage rate. Finally, recreational users may choose sites for reasons other than the observable attributes of the sites; for example, a family history of visiting the site. These non-economic reasons for site choice cannot be analyzed using RUMs and will be captured in the error term of the model.

4.7 Other Frameworks

Input-output analysis and non-market valuation are the two most common frameworks for assessing the impact of an intervention that changes patterns of economic behavior, such as the establishment of MPAs. They are not the only two frameworks for making such an assessment. The field of evaluation has developed a range of techniques for measuring the impact of a program or intervention on a population. While randomized, controlled experiments remain the ideal, evaluators and economists have developed a range of techniques of rigorous analysis in their absence. The family of evaluation studies called comparison group evaluations provides the most reliable quantitative methods for this task.

4.8 Comparison Group Evaluations

A comparison group evaluation of the impact of MPAs would estimate the impact of MPAs on either whole coastal communities located inside or adjacent to them, or individual fishermen or groups of fishermen whose preferred fishing grounds are located either inside or adjacent to them. These studies would create robust impact estimates by constructing *comparison groups* of communities (or individual fishermen) located outside or distant from MPAs that share as many characteristics as possible with the communities (or individuals) located inside or adjacent to them.

Propensity Score Matching (PSM) is a good method to implement comparison group studies. In a PSM study, the analyst identifies a set of control variables (or covariates) that predict whether the nonrandom "treatment" is likely to occur. For instance, the case of MPAs, the ecological characteristics of a coastal/marine site can be used as covariates to predict whether that site is likely to be included in an MPA. The PSM approach makes two important assumptions: (1) that the probability of treatment (MPA inclusion) is solely dependent on characteristics that can be observed and measured, and (2) that the characteristics in question do not perfectly predict or sort the population into treated and non-treated groups.

To develop a PSM study, the analyst chooses a set of covariates that s/he believes accurately predicts treatment. The analyst then chooses a function, called the *matching algorithm*, to estimate the probability that the treatment (MPA inclusion) will occur, conditional on these covariates. PSM studies usually use either logit or probit models in estimating probabilities. Finally, the analyst estimates the effect of treatment conditional on the probability (or propensity score) generated from the previous step.

4.9 Data Considerations

In developing a robust socio-economic monitoring and indicators system for MPAs, the primary consideration for the effective use of economic models will be the collection and validation of consistent, comprehensive economic data. As stated above, collecting good expenditure data is critical for the successful application of input-output models. Collecting high-quality data on travel behavior is essential for non-market valuation. If the CA Ocean Protection Council creates consistent and robust large-sample datasets, then they will find no shortage of analysts ready to work with them. The most attractive datasets would follow a large number of individuals from the same population over multiple time periods (longitudinal data).

4.10 Additional Research Questions

Economists are increasingly employing more sophisticated models of human behavior in the design and implementation of studies. For instance, economists increasingly study the way that heuristics or cognitive biases, such as loss aversion or hyperbolic discounting, lead to human economic behavior that departs from perfect rationality. As an application of this thinking to MPAs, future studies might examine the impact of heuristics and biases on coastal resource users' economic behavior in the presence of MPAs. For instance, does the anticipation of establishment of an MPA in the future affect present commercial fishing behavior?

5. CONCLUDING REMARKS

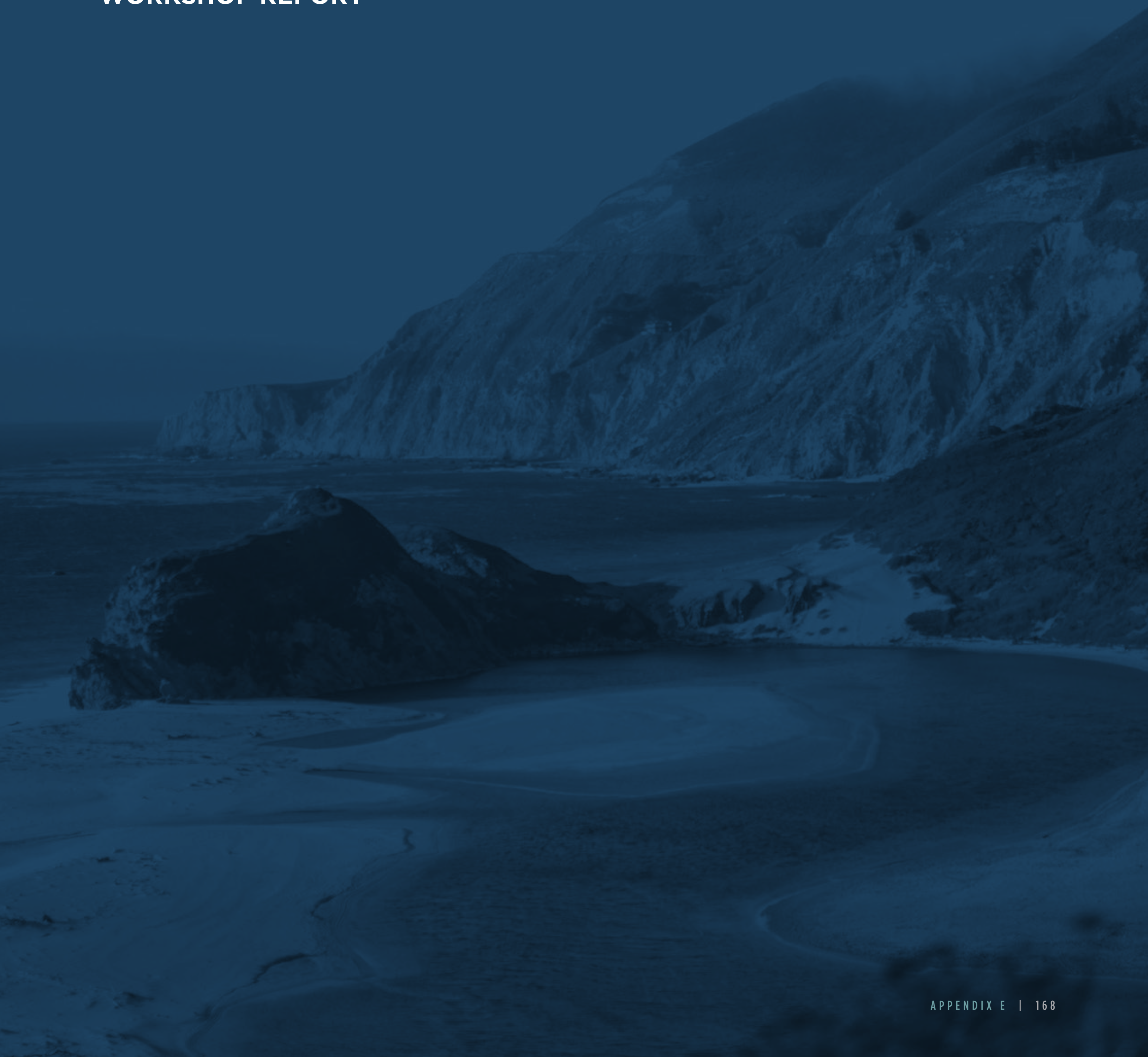
State agencies are faced with the mandate to manage MPAs using ecosystem-based and adaptive management measures to ensure the ecological and economic sustainability of coastal communities into the future. To do so, requires cost-effective and innovative approaches to collecting robust, fine-scale, and spatially explicit socioeconomic human use data that will better enable managers to design, monitor, and adapt the targeted management measures needed to effectively reach sustainability goals.

It is our hope that with this report we have provided a tiered approach as to what are the key metrics to monitor in each human use sector (commercial fishing, commercial passenger fishing vessels, recreational fishing, and coastal recreation) and how methods to monitor the socioeconomic dimensions of MPAs could scale up as resources become available. Given this, we attempted to leverage existing data collection efforts as much as possible and how both changes and additions to these existing efforts can as a whole provide a comprehensive monitoring program that is robust and aligns data across human use sectors.

We want to emphasize that utilizing and investing in technology will be a key aspect in enabling state agencies to cost-effectively scale up and adaptively manage their monitoring efforts over time. Not only will technology enable more effective and reliable gathering of data but utilizing technology will also enable managers and researchers to change data collection instruments as necessary which will be key in continually improving monitoring efforts into the long term.

Appendix E:

DEEPWATER WORKSHOP REPORT



California Ocean Protection Council
California Department of Fish and Wildlife
Moss Landing Marine Laboratories

Meeting Summary

Deep-Water Marine Protected Area Monitoring Workshop

April 19, 2017; 10:00 AM – 6:00 PM
April 20, 2017; 8:00 AM – 2:00 PM
Seminar Room
Moss Landing Marine Laboratories
8272 Moss Landing Drive, Moss Landing, CA 95039

WORKSHOP ATTENDEES

Name	Organization	Attendance
Carrie Bretz	**California State University Monterey Bay**	Wed
Rachel Brooks	**MLML**	Wed/Thurs
Mark Carr	**Department of Ecology and Evolutionary Biology - Long Marine Laboratory**	Wed/Thurs
Jenn Caselle	**Marine Science Institute - University of California, Santa Barbara**	Wed/Thurs
Cyndi Dawson	**Ocean Protection Council**	Wed/Thurs
E.J. Dick	**NOAA NMFS SWFSC - Santa Cruz Laboratory**	--
Ryan Fields	**MLML**	Wed/Thurs
Mary Gleason	**TNC**	Wed/Thurs
Kristen Green	**Stanford University**	Wed
Scott Hamilton	**MLML**	Wed/Thurs
Katie Kaplan	**OPC**	Wed/Thurs
Tom Laidig	**NOAA NMFS SWFSC - Santa Cruz Laboratory**	Wed/Thurs
Andy Lauerman	**MARE**	Wed/Thurs
James Lindholm	**California State University Monterey Bay**	Wed/Thurs
Melissa Monk	**NMFS - Santa Cruz Laboratory**	Wed/Thurs
Steven Morgan	**UCD - Bodega Marine Laboratory**	Wed/Thurs
Becky Ota	**CDFW Marine Region**	Wed/Thurs
Nick Perkins	**OPC**	Wed/Thurs

Mike Prall	**CDFW**	Wed/Thurs
Dirk Rosen	**MARE**	Wed/Thurs
Ben Ruttenberg	**Cal Poly**	Wed/Thurs
Rick Starr	**MLML**	Wed/Thurs
Brian Tissot	**Humboldt State University**	--
Jessica Watson	**ODFW**	Wed/Thurs
Steven Wertz	**CDFW**	Wed/Thurs
Lauren Yamane	**OPC - UC Davis**	Wed/Thurs
Eric Poncelet	**Kearns & West (facilitator)**	Wed/Thurs
Zach Barr	**Kearns & West (facilitator)**	Wed/Thurs

INTRODUCTION

The California Ocean Protection Council, the California Department of Fish and Wildlife, and Moss Landing Marine Laboratories convened a two-day workshop in Moss landing on April 19-20, 2017 engaging deep water ecosystem monitoring experts in discussions around developing a deep-water ecosystem monitoring framework to support statewide marine protected area (MPA) monitoring, including monitoring of both individual MPAs and California's MPA Network.

The objectives of the workshop were to: 1) discuss and identify the most important MPA monitoring questions to address, including adaptive management questions; 2) identify which taxa and habitats are most important to monitor to address the monitoring questions; and 3) limit the range of possible objectives related to monitoring.

The workshop was structured into discussions of the following four main topic areas (see Appendix A for the full agenda):

1. Structure, function, and integrity of ecosystems
2. Taxa
3. Metrics
4. Adaptive management

The sections below capture the key outcomes of the workshop's breakout session and plenary discussions.

KEY OUTCOMES

Topic 1: What does "Protecting the structure, function, and integrity of ecosystems" mean with respect to MPA monitoring?

1. *In individual MPAs across the network, do focal and/or protected species inside of MPAs stay the same or increase in size, density, and biomass relative to areas of similar habitat adjacent to and distant from MPAs?*

- Our primary task is to determine if this question is sufficient to address the goals of the MLPA
- Abundance and size of species can be measured in a reasonable way and are of interest. However, productivity is really important for ecosystem function/services
- How we define habitat and function is important
    - Important to be able to justify species importance
- Need to be able to answer stakeholder questions about MPA goals, is it more about what's inside or outside?
    - Effectiveness of MPAs is related to species abundance outside MPAs
- Need a discussion on community metrics vs. focal species – Do we measure community level responses (e.g. diversity), or do we have focal species that we monitor through time as representative of the entire community
- **Summary questions from South Coast Monitoring Plan (Jenn Caselle)**
    - ***"What is the current condition or state of communities inside and out of MPAs?"***
        - Use of focal species and ecosystem level patterns
    - ***"How does the baseline state of communities change over time?"***
        - Need for the use of the same metrics over time in order to monitor change
    - ***"Are there changes in community level dynamics inside and out of MPAs?"***
        - Important to look at how density and/ or mean are changing over time, or increasing/decreasing variance through time
        - Changes in focal species densities can relate to the ecosystem function that might change over time
    - **ULTIMATELY:** ***"What is it like now? How are things changing over time, and can we look at other metrics other than density or mean counts"***

2. *Do species richness and/or diversity stay the same or increase in MPAs relative to areas of similar habitat adjacent to and distant from MPAs?*

- **Key question**: ***Should we focus on focal species or species composition?***
    - Target focal species but collect additional community data, habitat data, etc. secondarily
    - If the right sample design is chosen, can approximate a full community study without having to invest in one
        - Video surveys provide the opportunity to go back and get more information when new questions come up
    - Functional diversity and functional richness provides a better means of assessing ecosystem health compared to taxonomic diversity
    - Need to have the capacity to capture unanticipated environmental stressors (long term) as well as fishing pressure (short term)

- Need to collect info on additional species beyond fisheries species –design study to collect a variety of data
  - Size and density are tractable, measureable, and more likely to see a change-so should be included

3. Can we monitor a series of MPAs (distributed along the coast) and consider results to be representative of the overall MPA network performance?

- Sampling intensity in a few MPAs vs. sampling less intensively in lots of MPAs?
- Instead of sampling each MPA individually selectively sample and then characterize regions as a whole
- Look at change over time and space – in/out differences should be detectable
- Target habitat focus → rocky reefs, justification: concerns with fishing, state guidelines prioritize rock, however, context of habitat around any rocky reef is important
  - Secondary habitat focus include sandy bottoms

4. What other ways can the state determine if MPAs are protecting the structure, function, and integrity of ecosystems?

- Need to come up with approximate measure of fishing pressure and human impact → compare MPAs to areas outside MPAs
  - Important to estimate local F (fishing mortality) – can help with site section in terms of where we would see the greatest response
  - Match ROMS modeling with MPA sampling – better understand fish recruitment data (paucity of recruitment data in deep water habitats)

Topic 2: Which taxa are best used to assess the performance of the CA MPA Network at protecting marine wildlife, rebuilding depleted populations and protecting the structure, function, and integrity of ecosystem?

Breakout Group Discussion:

Region 1 North Coast Participants: ***Cyndi Dawson, Katie Kaplan, Andy Lauerman, Nick Perkins, Jess Watson, Steven Morgan, Melissa Monk***

Region 2 Central Coast Participants: ***James Lindholm, Scott Hamilton, Becky Ota, Kristin Green, Mary Gleason, Steven Wertz, Mike Prall, Rick Starr***

Region 3 Southern Coast Participants: ***Carrie Bretz, Jenn Caselle, Ben Ruttenberg, Steve Wertz, Lauren Yamane***

1. Which taxa are sufficiently abundant to enable statistically significant estimates of changes in the metrics identified in Appendix 1?

Region 1 North Coast:

- Suggested taxa (with rationale):
    - Metridium and hydrocorals, seawhips – Structure/function species, some are groups of multiple species but fill the same functional role
    - **Commercially important species**:
        1) Gopher Rockfish
        2) Lingcod
        3) Quillback Rockfish
        4) Vermilion Rockfish
        5) Canary Rockfish
        6) Yelloweye Rockfish
    - Avoid destructive sampling (trawl, hook-and-line) instead use video survey tools

Region 2 Central Coast:

- **Exclude black corals** – *not sufficiently present, mostly in southern habitats*
- **Soft Bottom Habitat:**
    1) Sea whips
    2) Sea pens
    3) Brittle stars
    4) Sea cucumbers
    5) Halibut
    6) Starry flounder
    7) Sanddabs
- **Hard Bottom Habitat**:
    1) Large sponges – fish habitat
    2) Large solitary – fish habitat
    3) Sea cucumbers
    4) Rockfishes – Vermillion, Canary, Olive, Yellowtail, Blue, Kelp, Rosy, Boccacio, Dwarf Rockfishes, Greenspotted, Greenstriped, Brown
    5) Ratfish
    6) Spot prawns
    7) Thornyheads
    8) Long nose skates

Region 3 Southern Coast:

- **Developed a criteria for high priority fish:**
    - Fished (1)
    - Non-fished (2)
    - Threatened/endangered (3)
    - Ecosystem engineers/habitat forming (4)
    - Important prey species (5)
    - Trophic function (6)
    - Aggregations (7)

- Cross depth (8)
- Climate change sentinels (9)
- Abundant enough to statistically assess (10)
- Identifiable on video (11)
- Keystone (12)
- Large range (13)

- **Assigned species to different tiers**
  - ***Tier 1 (T1)*** – high importance, contribute economically
  - ***Tier 2 (T2)*** – secondarily captured, wouldn't necessarily design a monitoring project around them
- **Hard Bottom Species:**
  1) CA Sheephead (1,8,10,11,12) T1
  2) Lingcod (1,8,10,11,13) T1
  3) Gopher/Copper Rockfish (1,5,8,10,11,13) T1
  4) Vermillion/Canary/Yelloweye Rockfish (1,10,11,13, Canary and Yelloweye also 3) T1
  5) Halfbanded and Squarespot Rockfish (2,5,10,11,13) T1
  6) Aurora/Splitnose Rockfish (1,13,10,11) T1
  7) Cowcod/Bocaccio (1,3,11,13) T2
  8) Abalone (3) T3
  9) Sea cucumber (1,8,10,11) T1
  10) Lophelia (coral) (9,4,11) T2 not habitat forming, limited MPA effects
  11) Habitat forming inverts (sponges, anemones, etc)(4,10,9,8,11 at least to group,13) T1
  12) Box crabs (1) T2
  13) Sheep crab (1,10) T2
  14) Rock crab (1) T2
  15) Lytechinus (urchin) (5, Sheephead prey) T2
  16) Brittle stars (4) T2
  17) Sea stars (Pycnopodia, Arastia, Bat star, Henricia, Solaster)(12, Pycnopodia is 8) T2
  18) Black seabass (3) T2
  19) Ocean whitefish (1,11) T2
  20) Scorpionfish
  21) Elk kelp T2
- **Soft Bottom Species:**
  1) Barred sandbass T1
  2) Sanddabs T2
  3) Pink surfperch
  4) Angel shark T2
  5) Ridgeback prawns
  6) Angel sharks

2. *Which taxa are not sufficiently abundant but should be monitored anyway, and why?*

Region 1 North Coast:

- Response nested in question one

Region 2 Central Coast:

- **Hard Bottom Habitat*:***
    1) Yelloweye Rockfish
    2) Cowcod

Region 3 Southern Coast

- Response nested in question one

3. *Which of the above taxa can be used to aid in fisheries management?*

Region 1 North Coast:

- Large commercially important Rockfish and Lingcod
    - These are fished species that are most likely to be impacted by spatial closures

Region 2 Central Coast:

- Everything listed above as a targeted species – *Especially* species that lack a stock assessment

Region 3 Southern Coast:

- No response

4. *What other taxa will be surveyed in the process of monitoring the focal species?*

Region 1 North Coast:

- Habitat forming species (gorgonians, hydrocorals, metridium or other invertebrates (sea stars)
- All small fishes that are not focal species – most likely observed

Region 2 Central Coast:

- Criteria for species selection (assuming the use of a video tool)
    - **Primary target –** Species that are in high enough abundances to be valid under all statistical tests and are economically important
    - **Secondary target –** Species that are rare and patchy enough leading statistical analysis to be difficult
        - "*Secondary*" means sampled opportunistically as an environmental indicator, not of direct importance
    1) Sheephead – Secondary target
    2) Wolfeel – Secondary target
    3) Sablefish – secondary target

4) Dungeness crab – secondary target
5) Basket stars and crinoids – secondary target
6) Colonial anemones – secondary target

Region 3 Southern Coast:

- No response

5. *Are there specific taxa that occur in all parts of the MPA network and that should be monitored to enable an understanding of differences in MPA response across the state?*

Region 1 North Coast:

- Habitat invert metrics: Counted for density only, no sizing – using categorical approach to measure large groups of inverts
- Rockfish metrics: Density and size
- What are the criteria for choosing fish?
  - Targeted/overfished and depleted species
  - Abundant
  - Expected response to MPA
- Invertebrate criteria:
  - Indicator of structure and function
  - Sensitive to environmental changes
  - Abundant and widespread
- **OVERALL:**
  - Focusing on a few particular commercially and recreationally important rockfish species, we would be able to collect data on many of the other species in the surveyed areas (smaller species and inverts.
  - How about greater than 100 meters? Deeper Canyons were agreed to be difficult to survey. Many people thought they possibly should be avoided by these surveys.
  - Hard to justify direct sampling effort for soft bottom species. Soft bottom species move around so much – and soft bottom habitat shifts too. The power of a soft bottom study would be low.

Region 2 Central Coast:

- Suggested taxa:
  1) Lingcod
  2) Bocaccio
  3) Widow Rockfish
  4) Kelp Greenling
  5) Black Rockfish

6) Vermillion Rockfish
7) Canary Rockfish
8) Sanddabs
9) Slender Sole
10) Dover Sole
11) Rex Sole
12) Dwarf Rockfish
13) Sea Cucumber
14) Metridium

- Include functional groups that persist across the whole state, even if the members of that group change over time

Region 3 Southern Coast:

- No response

Overall Group Report:

***Summary*: A consensus was that rocky reef should be the focus, with the possibility of some soft bottom sampling. The way to adequately sample soft bottom was not decided upon – because soft bottom habitats are highly variable and may require multiple approaches. The group agreed that monitoring could be conducted using a tiered approach, which focuses primarily on benthic groundfish species such as key Rockfishes and Lingcod. Dwarf Rockfish species were included to measure overall ecosystem health, and some large invertebrates were included as critical habitat forming species. It was assumed that a visual tool would be used so that research teams could go back at a later date and pull out additional information on other species if needed.**

Tier 1 Species List Species with statewide distribution that are of particular interest around which sampling methodology is designed for all regions
Yelloweye Rockfish
Vermillion Rockfish
Canary Rockfish
Copper Rockfish
Dwarf Rockfishes
Aurora/Splitnose Rockfish (Deeper sampling required)
Lingcod
CA Sheephead (Regional importance – Southern CA)

Barred Sandbass (Regional importance – Southern CA)
Sea Cucumbers (Southern CA fishery)
Structure/Habitat forming invertebrates (Large solitary anemones and sponges)

Tier 2 Species List Species that will be opportunistically surveyed when designing sampling for Tier 1 species (This is not a complete list of possible species).
Bocaccio
Cowcod (May require higher rates of sampling to adequately survey)
All other Rockfishes (Brown, Gopher, Quillback, Green Spotted, Green Stripped, Widow Rockfish, etc.)
Sablefish
Ratfishes
Long nose skate
Black Seabass
Ocean whitefish
Scorpionfish
Sanddabs
Angel Shark
Starry flounder
Halibut
Mobile invertebrates (Sea stars, Crinoids, Urchins, Ridgeback prawns, Rock crab, Sheep crab, Box crab)
Sessile invertebrates (Lophelia corals, brittle stars)

Topic 3: Metrics

Breakout Group Discussion:

Group 1: ***Ben Ruttenberg, Cyndi Dawson, Rick Starr, Andy Lauerman, Steven Morgan, Mary Gleason, Mike Prall, Tom Laidig, Mark Carr, Ryan Fields, Jimmy Williamson***

Group 2: ***Nick Perkins, Jenn Caselle, Scott Hamilton, James Lindholm, Becky Ota, Dirk Rosen, Jessica Watson, Lauren Yamane, Katie Kaplan, Melissa Monk, Christian Denny, Rachel Brooks***

1. *Assuming some kind of visual tool is used, what metrics (e.g., density, abundance, percent cover, length, biomass, recruitment events, invasive species, marine debris) allow the state to assess the performance of the MPA Network?*

Group 1:

- **Suggested metrics ranked by importance:**
  1) Density
  2) Biomass
  3) Length distribution
  4) Geospatial location (varying degree of resolution dependent upon tool)
  5) Percent cover and categorical data (Invertebrate and biogenic habitat data)

Group 2:

- **Suggested metrics ranked by importance:**
  1) Biomass – Assess response or lack of response
  2) Percent cover – Sessile invertebrates
  3) Relief – Physical and biogenic (quantitatively/categorically)
  4) Position – animal relative to habitat
    - Secondary metric, indicative of density changes
  5) Invasive species
    - Secondary information
  6) Marine debris
    - Secondary information
  7) Recruit estimates – Counting number of Young-Of-Year (YOY)
    - Secondary metric – opportunistically

2. *What level of accuracy of sizing of individuals is needed?*

Group 1:

- Strive for 1cm resolution – functionally as close as possible to real life
- Bin later for higher groups
- 1cm resolution needed for newer models

Group 2:

- No definitive answer
- Need to know precision and error of size measurements
- Transparency of tools limitations when presenting results

3. *Should recruitment be measured?*

Group 1:

- Identify YOY's whenever possible
    - Secondary measurement – return to video recording later

Group 2:

- Measure YOY clouds and attempt to count individuals
    - Secondary measurement – return to video recording later

4. What analytical/statistical approaches to handling the data provide the highest likelihood of detecting change?

Group 1:

- **Two conflicting issues:**
    1) Need statistically rigorous design that may require long timelines to collect data, but will be the most defensible (rigorous regional study every few years)
    2) Political tension to have data quickly in order to show stakeholder that there is progress being made and that the MPAs are having some effect
- **Solution:**
    - Start sampling sites that have time series data – subset those by which sites we will see MPA effects
        - Most likely sites closer to ports and easier to sample
        - Less likely to see responses up North – potentially allocate less resources

Group 2:

- Randomly sample quadrats along transect
- Aggregate analysis across species
- Habitat suitability analysis – Model habitat associations and perhaps look at how particular MPA's are likely to impact fish populations based on available habitat

5. What is an effective yet cost efficient, frequency of sampling needed to detect significant changes over time?

Group 1:

- Start sampling sites that have time series data – subset those by which sites we will see MPA effects
    - Most likely sites closer to ports and easier to sample
    - Less likely to see responses up North – potentially allocate less resources

Group 2:

- Subregion approach to sampling: Rotate sites within the subregion
    - Core sites – sample multiple times and consistently (not every year)
    - Ancillary sites – rotating between sites (sampled less frequently)

- All MPA's would eventually be sampled – Fisherman less likely to be angry

Topic 4: Adaptive Management questions to address in a long-term monitoring plan: which questions would require specific studies, and which ones could be answered by any monitoring design?

1. ***What is the minimum number of MPAs that should be monitored?***
   - **Two different models proposed, based on $500,000 budget:**
     1) 6 core sites spread across regions
        - Use similar tools across all 6 sites
     2) Separate coast into two regions
        - Core sites sampled each year alternating between the two regions
          - 8 sites per region
          - Use cheaper tools to sample other sites within region

   Note: these numbers were based on the assumption of limited available funds for monitoring, the group agreed that more funding is needed and warranted for deep-water surveys and $500,000 is not enough to survey the entire coast annually.

2. ***Are there differences in ecosystem responses based on clusters of MPAs vs. stand-alone MPAs?***
   - Do clusters vs. non-clusters react differently? (A cluster of MPA's here is defined as two MPA's paired together like an SMR and SMCA next to each other)
   - Won't be able to answer this question in deep water ecosystem – Doesn't make sense to design long-term study for this question

3. ***What are the population effects of siting MPAs in larval source or sink locations and what are the implications for MPA siting?***
   - Yes, there will be effects—need to wait for ROMS model results before discussion
     - Secondary consideration

4. ***How do size, biogeographic location, the degree of protection (i.e., no-take or limited take), the life history characteristics of target species, habitat, fishing intensity outside MPAs, and environmental factors such as complex oceanographic patterns or other indirect effects affect MPA success?***
   - Question Tabled – Too many components to adequately address

5. ***How do ecosystem structure and function change through time and space?***
   - Potentially not enough variation within biogeographic area to answer

6. ***Can we design the monitoring program to monitor a wide variety of MPA sizes to evaluate the question of size vs. value? If so, what are the categories and what is the minimum replicate number to do so?***
   - MPA system not designed to answer this question, not enough variation

7. ***Can we design the monitoring program to sample a collection of MPAs with a range of habitat complexities and areas to evaluate the question of the value of habitat patch size? If so, what are the categories and what is the minimum replicate number to do so?***
   - Habitat complexity is going to fall into place, no need to design monitoring program around habitat but rather collect data opportunistically

8. ***Can we design the monitoring program to specifically answer questions about the type, amount, and reasons for spillover from MPAs to adjacent areas?***
   - Separate study design/program would have better results – but could design if needed to answer question
     - Tagging provides good estimate of spillover

9. ***What types of monitoring information can be used for other resource management needs (e.g., fisheries, water quality)?***
   - Additional sensors applied to ROVs (ex: CTDs, etc.)
   - Opportunistically collect other data to go along with primary objectives

Closing Remarks and Timeline:

- Next workshop (late June) – Talk methods, tools, details of the two different design models
- Shooting to have draft of action plan complete by midyear next year (12 months away)
  - RFPs, RFQs, etc. due next Fall
- Need narrative around decision points made – all tradeoffs

APPENDIX A

California Ocean Protection Council
California Department of Fish and Wildlife
Moss Landing Marine Labs

Agenda

Deep-Water Marine Protected Area Monitoring Workshop

April 19, 2017; 10:00 AM – 6:00 PM
April 20, 2017; 8:00 AM – 2:00 PM
Seminar Room
Moss Landing Marine Laboratories
8272 Moss Landing Drive, Moss Landing, CA 95039

Meeting Purpose/Objectives:

- Inform the development of an appropriate deep-water ecosystem monitoring framework to support statewide MPA monitoring, including monitoring of both individual MPAs and California's MPA network. To this effect:
  - Discuss and identify the most important monitoring questions to address, including adaptive management questions
  - Identify which taxa and habitats are most important to monitor to address the monitoring questions
  - Limit the range of possible objectives related to monitoring

Day 1: April 19, 2017

TIME	ITEM	PRESENTER/ MATERIALS
9:30 AM	*Arrivals*	
10:00	**Welcome, Objectives, and Introductions** ● Welcome by MLML ● Introductions ● Review of meeting objectives, agenda, and ground rules	● Rick Starr ● Eric Poncelet *Materials: Agenda, Participant Roster*
10:15	**Background and Orientation** ● Status of MPA monitoring in CA ○ Shift from regional plans to statewide program ● What has been accomplished to date?	● Cyndi Dawson, Becky Ota ● Steve Wertz *Material: PPT*
10:30	**Topic 1:** What does "Protecting the structure, function, and integrity of ecosystems" mean with respect to MPA monitoring? A. Identify questions to address in a long-term monitoring plan 1. Proposed questions (discuss and confirm)	● All (plenary)

	a. In individual MPAs across the network, do focal and/or protected species inside of MPAs stay the same or increase in size, density, and biomass relative to areas of similar habitat adjacent to and distant from MPAs? b. Do species richness and/or diversity stay the same or increase in MPAs relative to areas of similar habitat adjacent to and distant from MPAs? c. Can we monitor a series of MPAs (distributed along the coast) and consider results to be representative of the overall MPA network performance? 2. What other ways can the state determine if MPAs are protecting the structure, function, and integrity of ecosystems?	
12:15	*Lunch (sandwiches will be brought in)*	
1:15	**Topic 2:** Which taxa are best used to assess the performance of the CA MPA Network at protecting marine wildlife, rebuilding depleted populations and protecting the structure, function, and integrity of ecosystems? A. Breakout groups discuss the following questions: 1. Which taxa are sufficiently abundant to enable statistically significant estimates of changes in the metrics identified in Appendix 1? 2. Which taxa are not sufficiently abundant but should be monitored anyway, and why? 3. Which of the above taxa can be used to aid in fisheries management? 4. What other taxa will be surveyed in the process of monitoring the focal species? 5. Are there specific taxa that occur in all parts of the MPA network and that should be monitored to enable an understanding of differences in MPA response across the state?	• All (three breakout groups, by region) *Materials:* *List of deep-water species for all regions*
3:15	*Break*	
3:30	**Topic 2:** cont. B. Breakout group reports back C. Plenary discussion: identify common themes	
5:15	**Wrap Up and Preview of Day 2**	
5:30 PM	*Adjourn; no-host dinner at The Whole Enchilada*	

Day 2: April 20, 2017

TIME	ITEM	PRESENTER
8:00 AM	**Overview and Reflections on Day 1**	
8:10	**Topic 3:** Metrics	• All (two breakout

	A. Breakout groups discuss the following questions (90 min): 1. Assuming some kind of visual tool is used, what metrics (e.g., density, abundance, percent cover, length, biomass, recruitment events, invasive species, marine debris) allow the state to assess the performance of the MPA Network? 2. What level of accuracy of sizing of individuals is needed? 3. Should recruitment be measured? 4. What analytical/statistical approaches to handling the data provide the highest likelihood of detecting change? 5. What is an effective, yet cost-efficient, frequency of sampling needed to detect significant changes over time? B. Breakout group reports back C. Plenary discussion: identify common themes	groups) *Materials: Proceedings of the Marine Protected Areas and Fisheries Integration Workshop*
10:30	*Break*	
10:45	**Topic 4:** Adaptive management questions to address in a long-term monitoring plan: Which questions would require specific studies, and which ones could be answered by any monitoring design? A. Discuss possible adaptive management questions: 1. What is the minimum number of MPAs that should be monitored? 2. Are there differences in ecosystem responses based on clusters of MPAs vs. stand-alone MPAs? 3. What are the population effects of siting MPAs in larval source or sink locations and what are the implications for MPA siting? 4. How do size, biogeographic location, the degree of protection (i.e., no-take or limited take), the life history characteristics of target species, habitat, fishing intensity outside MPAs, and environmental factors such as complex oceanographic patterns or other indirect effects affect MPA success? 5. How do ecosystem structure and function change through time and space? 6. Can we design the monitoring program to monitor a wide variety of MPA sizes to evaluate the question of size vs. value? If so, what are the categories and what is the minimum replicate number to do so? 7. Can we design the monitoring program to sample a collection of MPAs with a range of habitat complexities and areas to evaluate the question of the value of habitat patch size? If so, what are the categories and what is the minimum replicate number to do so? 8. Can we design the monitoring program to specifically answer questions about the type, amount, and reasons for spillover from MPAs to adjacent areas? 9. What types of monitoring information can be used for other resource management needs (e.g., fisheries, water quality)? B. Overarching reflections	• All (plenary) *Materials: Master Plan for MPAs*

12:45	**Wrap Up and Next Steps**	
1:00 PM	*Adjourn*	

Meeting Materials:
1. Agenda
2. Roster of participants
3. List of deep-water species for all regions
4. Master Plan for MPAs (key sections: Chapter 4, Appendix A, pp A32-A37)
5. Proceedings of the Marine Protected Areas and Fisheries Integration Workshop, 2011 (key sections: tables on pp. 20-52)

California Ocean Protection Council
California Department of Fish and Wildlife
Moss Landing Marine Laboratories

Meeting Summary

Deep-Water Marine Protected Area Monitoring Workshop

June 26, 2017; 10:00 AM – 6:00 PM
June 27th, 2017; 8:00 AM – 2:00 PM
Seminar Room
Moss Landing Marine Laboratories
8272 Moss Landing Drive, Moss Landing, CA 95039

WORKSHOP ATTENDEES:

Mark Carr	UCSC
Cyndi Dawson	OPC
Christian Denney	MLML
E.J. Dick	NMFS
Ryan Fields	MLML
Mary Gleason	TNC
Katie Kaplan	OPC
Andy Lauermann	MARE
James Lindholm	CSUMB
Steven Morgan	UCD
Nick Perkins	OPC
Eric Poncelet	Kearns & West
Michael Prall	CDFW
Dirk Rosen	MARE
Rick Starr	MLML
Brian Tissot	HSU
Vicky Vasquez	MLML
Jimmy Williamson	MLML
Lauren Yamane	OPC

Table of Contents

Introduction and Overview

The California Ocean Protection Council (OPC), the California Department of Fish and Wildlife (CDFW), and Moss Landing Marine Laboratories (MLML) hosted a two-day workshop in Moss Landing on June 26th – 27th to continue developing a strategy for the long-term monitoring of deep-water marine protected areas (MPA) in California. Experts from across the state were involved in discussions and breakout sessions to identify viable tools and sample designs that would meet the State's objectives.

The state of California is shifting from short-term MPA baseline monitoring projects to long-term MPA monitoring programs across the entire MPA network. While no funding has been guaranteed for this program, OPC staff has indicated there is a maximum $4 million funding that could be available from the State to survey all habitat types along the California MPA network. In order to maximize the effectiveness of available funding, the OPC asked MLML to set up two workshops to inform the development of an appropriate deep-water ecosystem monitoring framework to support statewide MPA monitoring, including monitoring of both individual MPAs and California's MPA network. The objectives of the first workshop were to a) discuss and identify the most important monitoring questions to address (including adaptive management questions) and b) to identify which taxa and habitats are most important to monitor to address the monitoring.

The objectives of this second workshop were to a) discuss various tool and analytical technique combinations for conducting deep-water MPA monitoring b) articulate the tradeoffs between different approaches, and c) provide the State with tool and MPA recommendations for long-term monitoring of deep-water habitats. Similar to the first workshop, both plenary and break-out sessions were established and facilitated by Eric Poncelet (Appendix 1). After a recap of the first workshop, there were two presentations about sampling statistics based on baseline ROV monitoring data and a study comparing data from a ROV and a video lander. The first two breakout sessions included discussions of various tool and study design technique combinations for conducting deep-water MPA monitoring. A third breakout session was scheduled to discuss "various image analysis, data analysis and statistical techniques for evaluating spatial and temporal changes in deep water MPAs". This discussion was largely postponed for another workshop, however, as attendees agreed that it would be more important topic to discuss and recommend specific MPAs along the coast for long-term monitoring.

Summary of Day 1 Discussions

Presentations:

Nick Perkins (OPC/CDFW): Spatial Point Process Modeling.

Spatial Point Process modeling techniques allows spatial structures for individual fish to be modeled for a given location and provides a powerful way to explore sampling designs. This technique also allows spatial-autocorrelation to be explicitly accounted for within the model. By using baseline ROV data collected by CDFW for three species (Brown, Canary, and Yelloweye Rockfish) near Bodega Bay, Nick demonstrated how the coefficient of variation (CV) was reduced with increased sample size (number of ROV transects). A fixed transect width was used, but future modeling could be developed into a more sophisticated model (e.g., distance sampling). Similarly, environmental covariates can be included in the model to understand statistical associations between fish density and habitat variables. While a scarcity of data associated with some species can lead to high model uncertainty, spatial point process models may be useful as a power analysis to decide final sampling design for the deep water MPA monitoring program.

Christian Denny (MLML): Live-feed Video Lander vs. Remotely Operated Vehicle (ROV)

ROVs transects may survey large areas, but often have relatively few replicates. Drop cameras on the other hand survey much smaller areas, but can achieve higher sample sizes due to ease of deployment. There is an order of magnitude difference in the average area surveyed between the live-feed, drop camera tool (Stereo Video Lander) and MARE's ROV "Beagle", which has implications on sampling effort needed. Analysis revealed that the Lander did not obtain significantly different density estimates for species groups than the ROV tool. This indicates that the Lander may be a viable survey tool for the long-term deep water MPA program and may only require moderate sampling effort to achieve low CV. Because ROVs can cover a much broader area, they may be more appropriate in locations where habitats are patchy or poorly mapped in MPAs. Conversely, where substrates are well mapped and relatively uniform, Video Lander tools can do a good job of quickly and accurately surveying large areas.

Breakout Session 1

- Identify how alternative tool and technique combinations fit the deep-water monitoring goals articulated in workshop #1
- Describe the tradeoffs between different tool-technique combinations
- Discuss best practices for
  - Tools: **Mini-ROV, ROV, and HOV**
  - Techniques: Strip transects, line transects, photo quadrats

Mini-ROV

There was as strong consensus that Mini-ROVs (e.g., Seabotix) would be an inappropriate tool for answering primary questions and monitoring objectives. These small ROVs are a 'glorified drop camera' and are severely limited by depth (~70 m) and ocean currents. Because of these limitations, standardization and replication would be difficult with the mini-ROV across a broad range of typical oceanographic conditions. This tool theoretically could obtain the desired metrics across a variety of study designs; however, data are likely to be coarse compared with tools like ROVs or stereo drop cameras. Due to their small size, mini-ROVs have significant constraints in their instrumentation payload, and are unlikely to be equipped with stereo-cameras. Current iterations of this tool do not have any sizing capabilities, making area-swept and fish density estimates extremely difficult or impossible. Despite these shortcomings, the mini-ROV is relatively cheap, can be deployed from any vessel, provides high sample sizes, and only requires a car battery for power. Therefore this tool may have some use as an opportunistic sampling tool.

Remotely operated vehicle (ROV)

Discussion was limited to mid-sized, observation-class ROVs like the Phantom or Beagle. ROVs are well equipped to conduct any of the survey types outlined (strip transect, line transect, point counts, and photo quadrats) and collect all desired metrics agreed on at the first workshop (biomass, density, length, percent cover). ROVs are capable of depths to 1000 m, and are stable in a variety of oceanographic conditions. Because typical cruising speed is 1.5 – 2 kt, ROVs are capable of covering much larger areas and will better detect rare species compared with a point count survey. Video collected by ROVs could be archived and allow for detailed post-processing. Additionally, archived video may allow future state research objectives to be met post-hoc. Each ROV transect will cover a greater area compared with drop-camera techniques, but this comes at the cost of fewer replicate transects, and possibly less of the overall MPA being surveyed. While fixed transects may be possible with an ROV, there was a consensus that a randomized survey design be implemented. Nonetheless, a relatively short transect length and multiple transects may be important to increase statistical power. Line transects methods are possible with ROVs, however there was agreement that if ROVs are chosen for monitoring, they would be better used to conduct strip transect surveys because that would provide more information for a greater number of species.

There was a discussion of extrapolating ROV densities to abundance estimates. The consensus was that there will need to be an agreed-upon method to define the survey area to accurately extrapolate to abundance. This may mean defined transect lengths, or an agreed-upon method of subsampling a longer transect. Similarly, it will be important to decide a consistent instrumentation (stereo-cameras, altimeter, depth etc.) for the ROV tools used along the coast.

The main drawbacks to using an ROV are: cost for ship time, costs for post processing of video and greater personnel and training needs to operate. If there are time or financial constraints, archived video can always be randomly subsampled. Observation-class ROVs would require vessels at least 50 ft in length, which limits number of available ships along the coast. There was some concern about fish attraction and/or avoidance to ROVs, though this would not be a concern if the State was interested in relative indexes of abundance. If point counts were the desired survey technique, then ROVs would be an impractical tool. Similarly, while photo-quadrat type data could be extracted from HD video, the ROV is possibly 'overkill' for a photo-quadrat study and there are no practical means to have fixed photo quadrats for repeated sampling. There were also some concerns that if canyons were selected for surveys, a separate set of protocols would be needed to operate the ROV in those steep environments.

Two main techniques for operating ROVs were discussed: 'High-and-Fast' vs 'Low-and-Slow'.

- High-and-Fast surveys are conducted approximately 1 m off the bottom, and at a maximum speed of 1.5-2 kt. This speed allows much larger areas to be surveyed per each transect. Traveling fast is in some cases easier for the boat operator, but may not be possible in low-visibility conditions. High-and-Fast will allow more ground to be covered in a day. Video ID will contain greater proportions of unidentified rockfishes when traveling fast – compromising the overall quality of data.
- Low-and-Slow is conducted ~20 cm off the bottom and slower (~0.5 kt). This technique may have larger operating windows environmentally because operators will be able to avoid obstacles in turbid water conditions. The Low-and-Slow design will capture the same data that was captured using 'High-and-Fast', and may lead to higher proportions of fish ID'd. A continuous transect design with Low-and-Slow piloting could also cover a large area within a day.
- Note that a third technique that has been used in submersible surveys was not discussed for ROVs. In submersible surveys that have occurred in California, the vehicle has been operated ~0.5-1 m off the bottom and has been driven at a speed of 0.5-1 kt. This technique has been used with randomly located transects of about 200-300 m in length.

Human Operate Vehicle (HOV)

HOVs were considered slightly better, but similar to ROVs with respect to the type and quality of data obtained. HOVs have the benefit of a human observer, who can annotate all video collected and better ID small fish. Because small fish are not the focus of this long-term monitoring program, this difference may not be important. HOVs require specialized training, can have limited availability, and require larger vessels to carry and deploy than ROVs. HOVs are more expensive to operate than ROVs and cover less distance – limiting sample size (number of transects). If this tool were selected, a strip-transect design would be implemented, and distance-sampling techniques would facilitate more accurate estimates of density and biomass. Line-transect and photo-quadrat surveys could be obtained from archived video as was the case with the ROV. This tool has proven itself capable of collecting excellent data, but financial constraints and limited availability of HOVs may favor the use of ROVs.

ROV Sample Design Considerations

After discussing the merits and shortcomings of available tools, workshop attendees focused on the questions "*How will we design a study with an ROV?*" and "*What will our sample unit be?*"
It was agreed that a strip transect method would be used with the ROV because this technique would collect the most data for a given effort. Archived high-definition (HD) video would allow other sampling designs (e.g., random photo quadrats) to be conducted post-hoc. Stereo-video should be used to make length measurements because a relatively small number of fish (several hundred) need to be sized in order to characterize the population size structure. Additionally, lengths estimated by lasers have been shown to be biased at the smallest and largest size classes of fishes. The costs associated with stereo-

camera equipment and post-processing are not prohibitive and are comparable to the effort expended using lasers.

There was disagreement on whether the sample unit should be a transect or a sub-sample of a transect, such as in non-overlapping photo quadrats. Some attendees felt it may be inappropriate to use small quadrats to sample fish counts in deep-water, rocky reef habitats because they may result in a high number of zero counts. Existing statistical methods to deal with zero-inflated data are imperfect; therefore, it is important that sample unit be at the scale of the distribution of the target organism. Photo quadrats may be most appropriate for quantifying habitat across a survey area. The final sample design should be evenly applied to all MPAs surveyed along the CA coastline under the assumption that the data will be post stratified during analysis.

A typical ROV survey considers the sample unit to be each transect. Fixed-length transects are randomly placed across the study area. One recent study (Lindholm et al. 2015) had success in flat, soft-bottom habitat using a continuous ROV transect design. These long transects were subsequently subsampled post-hoc (as photo quadrats) to increase both sample size and statistical power. A long transect could be logistically favorable as it minimizes the number of ROV retrievals and deployments needed for a given survey, thereby maximizing sampling effort in a given day. Some workshop attendees objected that subsampling a long transect this way was arbitrary and may amount to 'pseudo-replication', and thus not properly address the issue of spatial autocorrelation. Although spatial-autocorrelation is unlikely to be eliminated from any study, some sample designs will better minimize spatial autocorrelation. Similarly, some modeling techniques may be able to account for some spatial-autocorrelation in the data, but likely do not capture the true scale of auto-correlation present.

Ultimately, the State is interested in a robust sample design along the entire network of MPAs. Tradeoffs likely exist between sampling a single MPA with a long transect versus spreading smaller randomly placed transects across a greater number of MPAs. It was unclear what additional benefits would be gained by using the long transect sample design. Ultimately the group did not agree on what an appropriate ROV sample unit should be. A proposal was made to review previous ROV sampling methods and layout 2-3 methods that have been used successfully.

Breakout Session 2

Discuss second set of tool and study design technique combinations for conducting deep water MPA monitoring.

- Identify how alternative tool and technique combinations fit the deep-water monitoring goals articulated in workshop #1
- Describe the tradeoffs between different tool-technique combinations
- Discuss best practices for
    - Tools: **Drift Camera, towed cameras, sled cameras, live-feed landers, drop cameras**
    - Techniques: Strip transects, line transects, photo quadrats

Towed Cameras

The use of a towed camera would be most appropriate for rapidly surveying habitat or geology types and less suitable for fish density estimates. Towed cameras have depth limits of approximately 200 m, but can be consistently operated across a range of current speeds. Tow speeds range between 1-3 kt allowing for larger survey areas in a given day compared with drift or drop cameras. Relatively small boats (20- 30 ft) can operate towed camera sleds. The cost of building and operating these tools is cheaper than a typical ROV, and towed cameras can be equipped with a similar array of sensors and instruments as a ROV. Strip transects and photo quadrat survey designs are attainable with towed cameras, though maintaining a consistent quadrat area would be challenging. Similarly this tool can be difficult to navigate in high-relief, rocky habitat – ultimately leading to sections of poor quality data. Newly developed towed camera systems have more sophisticated controls to navigate medium relief terrain, but these tools require more expertise to operate. Towed cameras also have coarse positional accuracy, which makes fine-scale habitat associations difficult. Additionally, it has been shown that some fish avoid the approaching cable of the towed camera system – a behavior that could compromise fish density estimates.

Drifting Cameras

A drift camera (e.g., Woods Hole Oceanographic Institute's SeaBOSS), is weighted and hangs below the vessel. Rather than being towed, it would drift with the boat passively, or with some small directional inputs from the vessel. As such, less area is surveyed than a towed camera system, though drifting cameras are much quieter and may have less fish avoidance issues. A simple winch system and live-feed video allows this tool to be hoisted over rugose habitat and maintain a constant distance from the seafloor. Drifting cameras would be compatible with stereo-camera systems and could attain the necessary precision in size estimates. Because this tool is approximately straight below the ship of operation, position could be easily triangulated with a pinger. Current implementations of drift camera tools are large in size and require vessels with an A-frame; however, future iterations could be built smaller to accommodate medium sized ships-of-opportunity.

Benthic Sled

While benthic sleds have been used successfully in previous studies of low-relief habitat, this tool was quickly decided against because contact with the seafloor may damage sensitive habitat. When bottom contact is not an issue, benthic sleds perform well in strong current conditions, and are not depth limited. Sleds are generally cheaper to build and operate than ROVs, but this can be variable depending on the instrument configuration. Vessel requirements are the same as towed cameras—allowing for a greater size range of vessels to be used. Replication is easily achieved with this tool; however, density estimates can be difficult to obtain accurately because maintaining a constant depth over rocky habitat is challenging. Altimeter sensors can alleviate this concern somewhat. Overall, this tool is best suited for soft bottom habitat.

Drop Cameras

Drop cameras have been used globally to successfully quantify relative indexes of fishes. When equipped with stereo-cameras, drop cameras can achieve accurate density and biomass estimates. Drop cameras are relatively cheap to build and maintain, and many are lightweight enough to be deployed off any vessel size class. Some have been deployed independent of the ship, while others remained tethered. This type of tool is suitable for photo quadrat and point count type surveys only. Because there is no live-feed to the surface, it is likely that a certain percentage of surveys would need to be excluded due misplacement of the drop camera, or the camera system tipping over in high-relief habitat. Additionally, there may be higher zero counts with a drop camera, in part because of the imprecise spatial deployment, and partially because the area surveyed is relatively small when compared with a towed camera, ROV, or HOV. Subsurface recording of video translates into greater top-side download times. Because these tools can be so quickly deployed over a large area, the cumulative benefits may out weight some of the logistical concerns and the cost of excluding a portion of the surveys.

Live-feed Drop Cameras

Live-feed drop cameras have the additional benefit of monitoring the survey in real time. These cameras can be placed with much greater positional accuracy on the bottom compared to blind drop cameras, and can be righted if tipped over – reducing the amount of data excluded post sampling. Additionally, the live-feed allows the operator to verify that the survey is being conducted in the targeted habitat type, further reducing wasted effort. To date, the live-feed camera systems have been approximately 200- 300 lb and require a medium-sized vessel and winch to deploy. While not depth limited for the purposes of this long-term monitoring project, the umbilical tether creates a logistical challenge, as it can be difficult for a vessel to hold station over the camera. Live-feed drop cameras are more expensive to build than their blind counter parts ($80-100K total cost), but are still considerably cheaper than ROV type tools. Live feed drop cameras are stereo-camera compatible and can be equipped with a broad array of additional sensors. Current iterations of this tool record video subsurface and require downloading at the surface. Future iterations of live-feed drop cameras will be designed to minimize time on bottom, allow HD topside recording, and alleviate other logistical concerns with deployment. Less area is surveyed per deployment of the drop camera, which may lead to zero inflated data; however, a greater spatial coverage of the MPA might be surveyed with this tool since replicates are easily obtained. Life-feed drop cameras would be used with a stratified random point survey to adequately cover all depths and habitats within each MPA of interest.

Summary of Day 2 Discussions

MPA Selection: Which MPAs should be sampled?

Attendees postponed the discussion of sample design, video analysis, and statistical methods until a future date. Instead, workshop attendees decided that their time was better-spent reviewing individual MPAs along the coast in order to recommend a short list of priority MPAs that should be monitored. Experts attending the workshop used personal experience and the general criteria listed below to select priority MPAs along the coast. Note that the moderators recommended that bolded items be weighed more heavily during the decision making process. The proposed long-term monitoring program should prioritize the representativeness of an MPA to the broader coastline over the availability of previous survey data for that MPA. Additionally, MPAs should also be selected to represent and span important biogeographic features along the coast. Because there are many definitions of biogeographic regions and the MLPA regions are not based strictly on biogeography, the group suggested that selection of MPAs to be monitored should not be constrained by the MLPA management regions as currently drawn on the map.

- **Representativeness** (depth, habitat, community composition, biogeographic region)
- **Focus on State Marine Reserves (SMR) or functional equivalent**
- **Feasibility and Practicality** (this includes cost)
- **Practicality**
- Species richness and diversity
- Historical fishing pressure data
- Existing time series of sample data
- Presence of appropriate reference area
- Expected recovery from fishing pressure
- Amount of rocky reef available

Selection of Priority MPAs

Nineteen MPAs were selected as being preferred for a robust sample design during the first part of the discussion. Thirteen of these MPAs were agreed upon as the minimum level of sampling that could be confidently recommended for the long-term deep water MPA monitoring program. Below the MPAs listed as "*Tier 1*" represents the minimum 13 MPAs recommended by the workshop attendees. The additional six MPAs listed as "*Tier 2*" make up the rest of the 19 MPAs that are the preferred coast-wide sample design.

Proposed high-priority Survey sites (North to South)

Pt. St George SMCA: *Tier 1*. This MPA is accessible and historically had instances of Yelloweye Rockfish (*Sebastes ruberrimus*) – a species of management concern.

Sea Lion Gulch SMR: *Tier 2.* This MPA has a high level of species richness and the largest continuous reef structure in the north, but is small and difficult to access.

Ten Mile SMR: *Tier 1*. This MPA is accessible and overlaps existing SCUBA survey sites which could be useful for comparison. Other survey data exists here.

Pt Arena SMCA/SMR: *Tier 2*. There is high species richness here, although this MPA is difficult to access (no nearby ports, rough conditions etc.). This site is of high interest since it neatly divides the north vs north-central regions of the California coastline. A time series of data exists for Pt. Arena. This site may be most appropriate to the north biogeographic region.

Bodega SMCA/SMR: *Tier 1*. Accessible. Large area of reef and historic time series of survey data.

SE Farallon Islands SMCA/SMR: *Tier 1*; This MPA contains abundant rocky reef habitat with high fish abundance and a large amount of data on both fish assemblages and fishing pressure in the area.

Portuguese Ledge SMCA: *Tier 2*. This MPA represents a unique rocky ledge feature in Monterey Bay, associated with the continental slope and historically has been a site of high fish abundance. Also, it has been studied extensively.

Pt Lobos SMCA/SMR: *Tier 1*. This MPA is relatively easy to access, representative of central coast species, contains unique geology, and has abundant deep rock habitat. There are lots of previous data from Point Lobos, and suitable reference sites.

Pt Sur SMCA/SMR: *Tier 1*. Relatively accessible and representative of central coast species. There is abundant deep rock habitat, lots of previous data, and suitable reference sites. Point Sur met the matrix criteria more strongly than Big Creek for this region of the coastline.

Piedras Blancas SMCA/SMR: *Tier 1.* Piedras Blancas contains extensive deep rocky habitat, has a high diversity of fish species, and may contribute more to connectivity than Point Buchon SMR.

Pt. Conception SMCA/SMR: *Tier 2*. Point Conception is an important biogeographic break that separates central and southern California. The rocky reefs here are small but very important to local species. Unusual tar seeps.

Harris Point SMR: *Tier 1*. Harris Point has abundant rocky reef habitat with high fish abundance, and is logistically more feasible to sample than Richardson Rock SMR on San Miguel Island. There are large amounts of data on fish assemblages and fishing pressure in the area.

South Point SMR: *Tier 2.* South Point SMR has ample rocky reef habitat with high fish abundance, large amount of data on fish assemblages and fishing pressure in the area.

Gull Island SMR: *Tier 1*. A good time series of data exists for Gull Island SMR, and this site is relatively protected from inclement weather. It may be more difficult to establish a representative reference area; however, heavy fishing in the areas adjacent to the SMR may lead to larger temporal differences inside/out of the MPA.

Anacapa Is. SMCA/SMR: *Tier 1*. Anacapa has plenty of deep rock habitat, lots of previous survey data, detailed benthic maps of the area, and a strong record of fishing pressure in the area.

Footprint SMR: *Tier 1*. Footprint SMR is similar to Anacapa but has rocky reef at greater depths (100+ m). There are lots of reference sites, and 10-15 years of historical data available from Milton Love.

Farnsworth SMCA: *Tier 2*. Farnsworth is the only MPA on Catalina Island with significant deep rocky reef, and has somewhat unique characteristics as an offshore bank with deep sea corals. It may be difficult to locate an adequate reference site for Farnsworth SMCA. Additionally, some pelagic fishing effort in this reserve may make future across-MPA comparisons statistically difficult

San Clemente Island: *Tier 1*. This area has been a de-facto reserve for ~40 years due to the US Navy's use of the island and water space.

S. La Jolla SMCA/SMR: *Tier 1*. This is one of the only MPAs suitable in the San Diego region. This MPA is representative of southern region habitat and fish assemblages and has plenty of reef available to survey.

How to Sample the MPAs?

Consistency in sample design will be needed so that data are comparable across the MPA network. This may not necessarily require the same tool to be used across the state, but the data must ultimately be comparable across MPAs. It was agreed that each MPA may require a different amount of sampling to adequately characterize fish populations and detect changes through time. This is in part due to inherent variability in both species abundances and habitat availability. Some reefs, such as those at Ten Mile SMR, will be sampled in their entirety, whereas other, larger MPAs will need to be stratified and subsampled for both habitat and depth. MPAs need to be surveyed across the range of depths that species are distributed with at least two samples from each depth strata. In order to extrapolate density and biomass estimate to a larger area (i.e., the entire reef structure or MPA), stratified sampling must be conducted over representative habitat. It is ok for random sampling to include non-rock features like sand channels so long as these are representative of the broader MPA, but large, non-representative soft bottom features should be avoided for this long-term program.

Although a final transect design was not agreed upon, it was suggested that transects start off the rocky reef habitat and move onto the reef in order to capture the important transition zone between sand and rock. Still to be decided was whether the entire reef within an MPA should be stratified and sampled, or whether smaller portions of the reef should be selected as representative of the entire MPA. The latter design would allow more intense sampling at smaller scales as opposed to spreading sampling over a larger area. The down side to this type of sampling is that spatial variation is not sampled, so differences observed over time can only be attributed to that site and not the entire MPA. Because the representativeness of a subsample is crucial to the extrapolation of density and biomass estimates, there was a consensus that accurate geo referencing of a tool is needed to match sample data with habitat data. It was therefore agreed that the accuracy and accuracy and precision of navigational equipment should be as accurate as possible. Finally, as technology improves through time after sampling begins, data will be collected according to lowest resolution capabilities. This will ensure data remains comparable throughout the duration of this long-term monitoring program.

Future Tasks

There were numerous statistical and sample design considerations that were not fully agreed upon. There was a consensus however that existing data should be used when possible to provide guidance with respect to a final sample design. Questions the group thought should be investigated included:

"Exactly how precise do we need our size estimates to be?" Existing data can be used to answer this question by looking at how biomass estimates are changed by grouping size estimates into coarser bins.

If there are cost/benefit tradeoffs between sizing with stereo cameras versus lasers, this analysis may help the final decision.

"How much sampling is needed, at a single MPA, to detect an effect through time?" There is concern that intense sampling may be required in each MPA to detect change through time, which may in turn severely limit the number of MPAs sampled along the coast. A simulation with existing data will help answer this question. This power analysis is needed in order to realistically set out a sampling design along the coast.

"How much sampling is needed by each tool to get the same CV for a given metric?" It may also be possible to evaluate the quality of baseline data to inform which tool will be most appropriate for a long-term study. It may be necessary to weigh the relative benefits of a tool that minimizes the CV of density estimates versus a tool that minimizes CV of length estimates. Length-weight ratios are a tight relationship, and it is likely that the variability in biomass estimates is most influenced by variability in the *density* estimates as opposed to length estimates. Another consideration is the relative amount of effort needed to reduce the CV of either density or length estimates. A cost-prohibitive amount of additional sampling may be needed to reduce density estimate CV, whereas only modest amount of sampling may be required to reduce associated CV in length measurements. This is a question that could also readily be explored with existing data.

Another workshop will likely be needed to decide final sample design and statistical considerations. The results from the analysis above will inform that workshop. Additionally, several other topics will need to be finalized. The final sample unit for an ROV study was not agreed upon during this workshop. A suggestion was made to review the literature and to discuss 2-3 previously used ROV techniques in more detail at a future workshop. It was agreed that previously used ROV techniques could be modified for this long-term program if necessary so long as the techniques were applied consistently across the state. A variety of additional statistical concerns will need to be fully addressed including spatial-autocorrelation and pseudo-replication. There also was no discussion comparing the results of the first breakout session (ROV was the preferred tool) with the final results of the second breakout session (live-feed drop camera was the preferred tool). There seemed to be a consensus was that ROV would ultimately be a tool used, but further discussion may be warranted on the feasibility of a hybrid study design with both ROV and live-feed drop cameras. The final sample-design recommendation could be presented as tiered stages based on funding availability. This would allow the State to evaluate the quality and scope of data it could expect given a set of budget restrictions.

Final Statement

Deep water rocky habitats are unique and more likely to show an MPA effect than some other habitats, such as beaches, and thus are key habitats to monitor. Surveying deep water MPAs will be cost intensive, but this is in part due to their expanse along the coastline. Shallow MPAs and areas closer to shore are much more likely to be taken advantage of by opportunistic sampling and citizen science programs, leaving the deep water habitat in need of more funding for experts, vessels, and use of visual survey tools.

There was a consensus that the 19 MPAs (Tier 1 and Tier 2) outlined are part of a preferred long-term monitoring program for deep water MPAs. These 19 MPAs span the important biogeographic features along the coast of California. The 13 MPAs listed as “Tier 1” represents the minimum number of MPAs that should be sampled in a long-term monitoring program. MPAs ultimately selected for the long-term program should be representative of the important biogeographic features along the coastline.

ROVs and/or live feed Video Landers equipped with stereo-cameras, or a combination of the two tools, are the preferred tools to use in a long-term program. A strip transect design or point counts would maximize data collection and facilitate the objectives of tracking changes in lengths, density, and biomasses of selected fishes though time. There was a consensus that stereo video should be used to collect length estimates within the precision guidelines, and that efforts should be made to reduce the CVs in density estimates.

Although final sample design logistics still need to be decided upon, it was agreed that consistent sampling techniques will need to be applied across the state. Additionally, habitat and depth should be stratified so that subsamples within an MPA represent the larger reef structure. Similarly at least two samples per depth/habitat strata are preferred. Because there will be a review of the MPA program in 2022, it is recommended that sampling be conducted annually, as soon as possible. Each MPA should be paired with an adjacent reference site and sampled annually.

Appendix 1

California Ocean Protection Council
California Department of Fish and Wildlife
Moss Landing Marine Labs

Agenda

Deep-Water Marine Protected Area Monitoring Workshop 2

June 26, 2017; 10:00 AM – 5:30 PM
June 27, 2017; 9:00 AM – 12:00 PM
Moss Landing Marine Laboratories
8272 Moss Landing Drive, Moss Landing, CA 95039

Meeting Purpose/Objectives:

- Discuss various tool and analytical technique combinations for conducting deep-water MPA monitoring
  - Identify benefits and drawbacks
  - Articulate the tradeoffs between different approaches
- Describe the implications of using different tool and technical combinations for study design
- Describe how particular data gathering approaches are related to analytical approach

Day 1: June 26, 2017

TIME	ITEM	PRESENTER/ MATERIALS
9:30 AM	*Arrivals*	
10:00	**Welcome, Objectives, and Introductions** • Welcome by MLML • Introductions • Review of meeting objectives, agenda, and ground rules	• Rick Starr • Eric Poncelet *Materials: Agenda, Participant Roster*
10:15	**Background and Orientation** • 2015 MBARI Visual Tools Workshop • CBNMS 2016 Benthic Survey Workshop • Deepwater MPA Workshop #1 results • Spatial Point Process Model • Comparison of ROV and Video Lander approaches	• Rick Starr • Nick Perkins • Christian Denney *Materials: Workshop Reports, Tools Spreadsheet, Intro PPT*
11:00	**Breakout Session 1:** Discuss various tool and study design technique combinations for conducting deep-water MPA monitoring. Discussion topics: • Identify how alternative tool and technique combinations fit the deep-water monitoring goals articulated in Workshop #1 • Describe the tradeoffs between different tool-technique combinations Each group will discuss *best practices* for use of the following tools with the following techniques:	• 3 breakout groups (all with same assignment)

	• Tools: a) Mini-ROV, b) ROV, and c) HOV • Techniques: a) strip transects, b) line transects, c) photo quadrats	
12:30	*Lunch (sandwiches will be brought in)*	
1:30	**Reports Back and Discussion**	• All
2:30	*Break*	
2:45	**Breakout Session 2:** Discuss various tool and study design technique combinations for conducting deep-water MPA monitoring. Discussion topics: • Identify how alternative tool and technique combinations fit the deep-water monitoring goals articulated in Workshop #1 • Describe the tradeoffs between different tool-technique combinations Each group will discuss *best practices* for use of the following tools with the following techniques: • Tools: a) Towed cameras, b) Sleds, c) Live-feed Landers, and d) Drop Cameras • Techniques: a) Strip transects, b) Photo quadrats, c) Point counts	• Same 3 breakout groups
4:15	**Reports Back and Discussion**	• All
5:15	**Wrap Up and Preview of Day 2**	
5:30 PM	*Adjourn; no-host dinner at The Haut Enchilada*	

Day 2: June 27, 2017

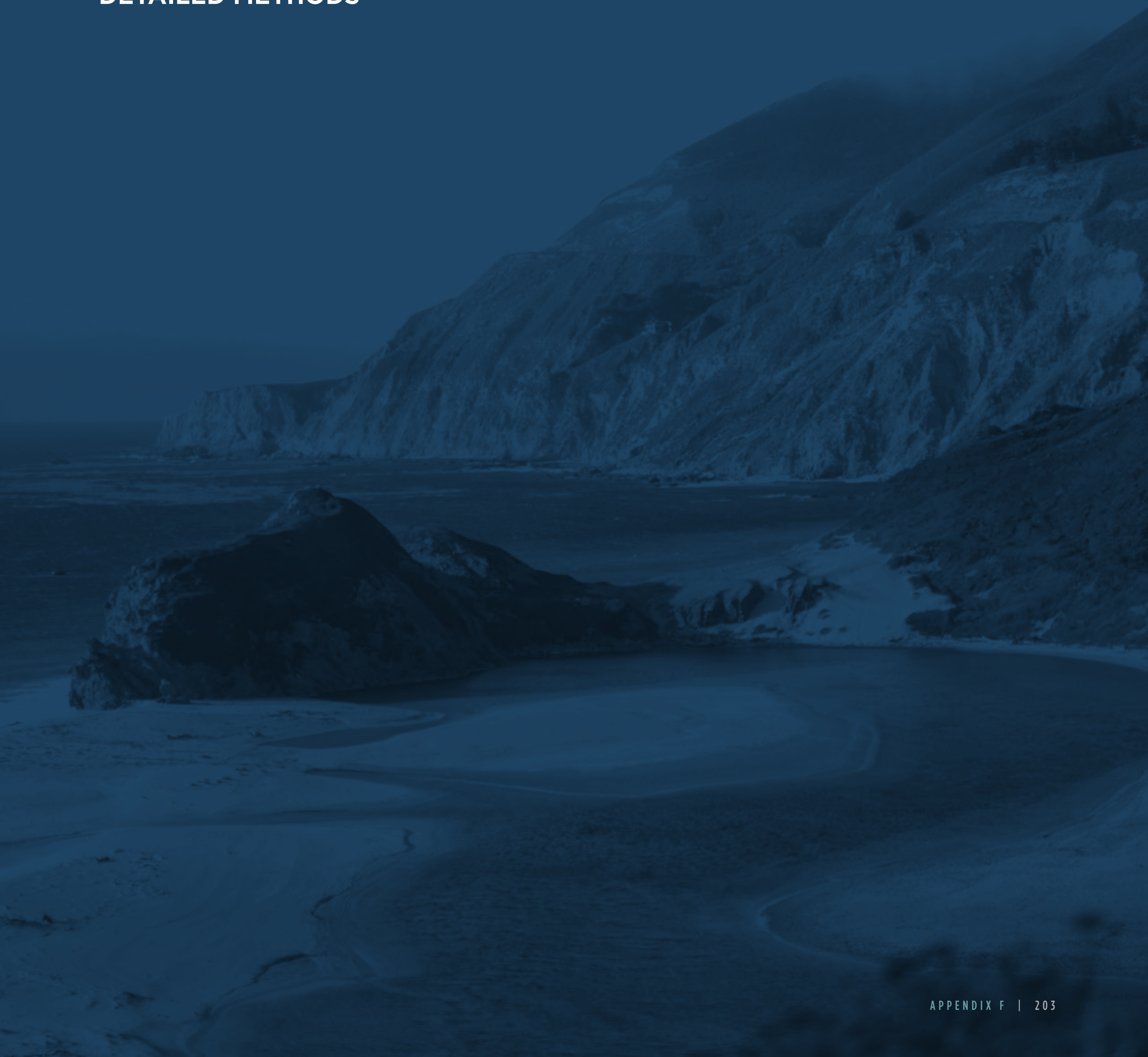
TIME	ITEM	PRESENTER
9:00 AM	**Overview and Reflections on Day 1**	• Eric Poncelet
9:15 AM	**Plenary discussion:** Discuss various image analysis, data analysis, and statistical techniques for evaluating spatial and temporal changes in deep-water MPAs 1. What is the best way to do image analysis? 2. What is the best way to do data analysis? 3. What are the best statistical techniques to allow change detection?	• All *Materials: CBNMS 2016 Benthic Survey Workshop, Intro PPT*
10:45	*Break*	
11:00	**Discuss trade-offs between monitoring a few MPAs intensively vs monitoring many MPAs less intensively**	• All (plenary)
11:45	**Wrap Up and Next Steps**	• Rick Starr • Eric Poncelet
Noon	*Adjourn*	

Meeting Materials

- Agenda
- Workshop Roster of Participants
- Deep-water MPA Monitoring Workshop 1 outcome: List of goals for deep-water MPA monitoring
- MBARI Visual Tools Workshop - spreadsheet of tools
- MBARI Visual Tools Workshop - Report
- Cordell Bank National Marine Sanctuary 2016 Benthic Survey Workshop – Report
- List of relevant academic studies/articles

Appendix F:

INDEX SITE SELECTION - DETAILED METHODS



Criteria 1: Marine protected area (MPA) design features

During the Marine Life Protection Act (MLPA) planning process, the MLPA Science Advisory Team (SAT) provided regional stakeholders with MPA science and design guidelines based on the best readily available science (CDFW 2008, MLPA SAT 2008, 2009, 2011). Regional stakeholder groups were advised to prioritize these guidelines in their design of MPAs; however, the MPAs proposed and eventually adopted vary in their level of compliance with SAT guidelines (Gleason et al. 2013, Saarman et al. 2013, CDFW 2016).

MPAs that meet scientific guidelines are expected to realize more significant conservation benefits, and therefore should be prioritized for long-term monitoring. To that end, coastal and island MPA sites were scored against SAT guidelines (MPA size, threshold of habitat representation and replication within and MPA), and overlap with Areas of Special Biological Significance (ASBS) and historically protected areas. For more information on methods for scoring estuary MPAs, see appendix F, page 220.

MPA size

The SAT recommended that "for an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns, MPAs should have an alongshore span of 5-10 kilometers (3-6 statute miles [sm]) of coastline, and preferably 10-20 km (6-12.5 sm)" (CDFW 2008). The SAT also recommended that MPAs extend from intertidal to offshore areas in order to a) protect the diversity of species that live at different depths and b) accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore. The recommended offshore span is from the mean high tide line to the offshore state waters boundary, generally a distance of 3.45 sm (three nautical miles), except in some areas such as offshore rocks where state boundaries may extend farther. Taking into account these two guidelines, the SAT recommended a minimum area of 9 square statute miles (sm^2) for each MPA, and preferably 18 sm^2 or larger.

Based on these recommendations, each MPA was scored for size as follows: two points if its size is greater than or equal to 18 sm^2; one point if its size is greater than or equal to nine sm^2 and less than 18 sm^2; zero points if its size is less than nine sm^2.

Threshold of habitat representation and replication within an MPA

The SAT recommended that "for an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every 'key' marine habitat should be represented in the MPA Network" (CDFW 2008). The key marine habitats described in the MLPA were subdivided by the SAT to reflect ecological differences at different depths. Twelve different habitats were classified and their spatial distribution within the MPAs was calculated. These habitat summaries include: rocky shores, hard bottom 0-30 meters (m), hard bottom 30-100 m, hard bottom 100-3000 m, beaches, soft bottom 0-30 m, soft bottom 30-100 m, soft bottom 100-3000 m, kelp, coastal marsh, eelgrass, and estuary.

The SAT also recommended that each of the above habitats be replicated within individual MPAs. To count as a replicate of any given habitat, an MPA must contain enough habitat to encompass 90% of the biodiversity associated with that habitat. The minimum size required to encompass 90% of the associated biodiversity varies by habitat and has been determined from biological surveys (CDFW 2008). A summary of the minimum size requirements for habitat replication, in linear miles or square miles, is provided in Table F1.

TABLE F1: The minimum size required to encompass 90% of biodiversity for key MPA habitats. Hard and soft bottom habitats include depth ranges in meters (m).

HABITAT	MEASUREMENT	MINIMUM SIZE
Rocky Shores	Linear miles	0.60
Hard 0 - 30m	Linear miles	1.10
Hard 30 - 100m	Square miles	0.20
Hard 100 - 3000m	Square miles	0.20
Beaches	Linear miles	1.10
Soft 0 - 30m	Linear miles	1.10
Soft 30 - 100m	Square miles	5.00
Soft 30 - 3000m	Square miles	7.00
Kelp	Linear miles	1.10
Coastal Marsh	Square miles	0.04
Eelgrass	Square miles	0.04
Estuary	Square miles	0.12

Based on these recommendations, each MPA was scored for habitat representation and replication as follows: one point per habitat type that met minimum size requirements, and zero points for habitat types that did not meet the minimum size requirement.

Level of protection (LOP) within an MPA

For comparisons among alternative MPA proposals, the SAT assigned a level of protection (LOP) to each MPA based on the proposed method of take within its boundaries. LOPs were based on the likely impacts of proposed activities to the ecosystems within an MPA. Conceptually, the SAT sought to answer the following question in assigning LOPs: "How much might an ecosystem differ from an unfished or unharvested ecosystem if one or more proposed activities are allowed (CDFW 2008, MLPA SAT 2008, 2009, 2011, Saarman et al. 2013)?"

The SAT assigned an LOP of "very high" to MPAs in which no take was permitted (SMRs and no-take SMCAs). MPAs that allowed extractive activities received LOPs ranging from "high" for low-impact activities to "low" for high-impact activities (e.g., habitat alteration). Both direct impacts (those resulting directly from the gear used or the removal of target or non-target species) and indirect impacts (ecosystem level effects of species removal) were considered in LOP assignments. For example, multiplier values ranged from 0 to 1 in increments of 0.2. A low LOP received a multiplier of 0, whereas, a very high LOP received a multiplier of 1 (Table F2).

TABLE F2: Possible levels of protection (LOPs) for each MPA type, corresponding LOP multiplier assigned for long-term monitoring site selection analysis, and examples of associated activities. SMR=State Marine Reserve, SMCA=State Marine Conservation Area.

LOP	MPA TYPES	MULTIPLIER	ASSOCIATED LOP ACTIVITIES
VERY-HIGH	SMR; SMCA (no-take)	1.0	No take
HIGH	SMCA	0.8	Salmon (hook and line [H&L] or troll in waters >50m depth); coastal pelagic finfish (H&L, round-haul net, dip net); white seabass and bonito (spear)
MOD-HIGH	SMCA	0.6	Dungeness crab (trap, hoop-net, diving); salmon (troll in water <50m depth); pier-based fishing (H&L, hoop net)
MODERATE	SMCA	0.4	Spot prawn (trap); sea cucumber (scuba/hookah); surfperch (H&L from shore); salmon (H&L in waters <50m depth)
MOD-LOW	SMCA	0.2	Lingcod, cabezon, rockfishes, sheephead, and greenlings (H&L, spearfishing, trap); red abalone (free-diving); urchin (diving)
LOW	SMCA	0.0	Rock scallop (scuba); giant kelp (mechanical harvest); ghost shrimp (hand harvest); mussels (hand harvest); bull kelp (hand harvest)

[1] Final North Coast LOPs: http://www.dfg.ca.gov/marine/pdfs/northcoastproposals/rec_description.pdf
[2] Final North Central Coast LOPs: http://www.dfg.ca.gov/marine/pdfs/ipa_description.pdf
[3] Final Central Coast LOPs: http://www.dfg.ca.gov/marine/pdfs/comparison_mpas.pdf
[4] Final South Coast LOPs: http://www.dfg.ca.gov/marine/pdfs/scsr_description_ipa.pdf

MPAs were scored for LOP by multiplying each MPA's habitat threshold points (described above) by its LOP multiplier.

MPA overlap with Areas of Special Biological Significance (ASBSs)

Although the MLPA does not specifically mandate water quality management within MPAs, marine life is known to be adversely affected by poor water quality. Ocean pollution has been linked to changes in marine population growth, reproduction, and mortality rates; decreased abundance of marine life; and shifts in community composition (e.g., decreased diversity and loss of sensitive species) (Pastorok & Bilyard 1985, Laist 1987, Derraik 2002, Echeveste et al. 2010). For MPA Network design, the SAT recommended that proposed MPAs avoid areas of poor water quality and be co-located with state water quality protection areas (e.g. ASBS) because they benefit from water quality protection beyond that offered by standard waste discharge restrictions (Fox et al. 2013). MPAs were scored for overlap with ASBSs by assigning a point value from 0 to 1 representing percent of area overlap with ASBS. For example, if an ASBS overlapped with 72% of the MPA's area, point value was 0.72.

MPA overlap with historically protected area

The MLPA mandated that the state redesign its existing MPAs to function as an interconnected statewide network. Prior to the MLPA, California's existing 63 MPAs were generally small and established in an ad hoc manner throughout the state over many decades and using at least nine different designations (McArdle 1997, 2002; Gleason et al. 2013). During the redesign process, several MPAs overlapped with historical MPA boundaries. To prioritize MPAs that include a portion of an MPA predating the MLPA, MPAs were scored by summing two different point values, defined as follows:

An MPA received historical MPA overlap credit equivalent to the percentage of area overlapping with the historically protected area. For example, if a historically protected area overlapped with 64% of the MPA's area, the overlap credit was 0.64.

In addition, similar to LOP scoring, a historical MPA protection credit was given. The MPA received one point if the historical MPA prohibited all take and zero points if the historical MPA allowed any type of take.

Total historical MPA points = historical MPA overlap credit + historical MPA protection credit

Calculating final design scores

Each MPA received a design score based on the following equation:

Design score = MPA size points + habitat threshold points + LOP points + ASBS points + historical MPA points

As an example, here are the points awarded to Point Lobos State Marine Reserve (SMR):

- MPA size points = 0
  - Point Lobos SMR is approximately 5.5 sm^2, which falls below the recommended minimum threshold of nine sm^2 as recommended by the SAT.

- Habitat threshold points = 6
  - Point Lobos SMR meets the minimum habitat thresholds for rocky shores, kelp, hard bottom habitat 0-30 m, hard bottom habitat 30-100 m, beaches, and soft bottom habitat 0-30 m.

- LOP points = 6
  - Point Lobos SMR was assigned an LOP of "very high" since it prohibits all take, therefore the MPA received a LOP "multiplier" of 1. LOP points were calculated by multiplying the LOP "multiplier" by the total sum of habitats protected, in this case 1*6 = 6.

- ASBS points = 0.2
  - Point Lobos SMR overlaps with the Carmel Bay/Point Lobos Ecological Reserve ASBS, with approximately 23.8% of the MPA overlapping with the ASBS.

- Historical MPA points = 1.3
  - The current Point Lobos SMR is an expansion of a historical MPA. Established in 1973, the historical Point Lobos SMR did not allow take (protection credit = 1 point) and comprised approximately 26% of the area encompassed by the new MPA (overlap credit = 0.3 points), so total historical MPA points = 1 + 0.3 = 1.3.

- Based on the above information, Point Lobos SMR receives a **final design score of 13.5.**

All final MPA design feature scores for each coastal and island MPA are in Table F3, and for each estuarine MPA are in Table F4.

Criteria 2: MPA historical monitoring

Responses of targeted fished species to MPA implementation can occur on the order of years to decades, and community responses tend to occur over longer time scales (Babcock et al. 2010, Caselle et al. 2015, Starr et al. 2015). **For a more informative and successful network evaluation, it is essential to prioritize MPAs with the longest possible time series of available data. This provides a more statistically robust before-after/control-impact analyses - in other words, a greater understanding of change over time.**

In order to offer an unbiased assessment of the statewide monitoring we used very specific criteria in order to include monitoring as part of "historical monitoring." Specifically, the monitoring had to occur consistently throughout the state both before and after MPA implementation. There are a multitude of programs that offer long-term monitoring data (see section 2.2 "Examples of Important Existing Programs"), but were ultimately not included due to either temporal or spatial limitations. The approach to only include historical monitoring consistently conducted statewide limited the analysis to only rocky substrate programs. However, data collected by spatially limited survey programs such as the National Park Service's KFMP at the Channel Islands will be integrated in future analyses.

Rocky intertidal monitoring: Multi-Agency Rocky Intertidal Network (MARINe) biodiversity and fixed plot surveys

MARINe has conducted surveys at a set of rocky intertidal monitoring sites for more than 15 years. MARINe conducts two types of intertidal monitoring surveys:

Biodiversity surveys are designed to gather detailed information about the diversity and community structure of rocky intertidal communities, and how these communities change over time across a large geographic area. During these surveys, researchers identify and count all algae and invertebrates in a wide swath of the intertidal; they also record topographical information in order to create three-dimensional species distribution maps. MARINe biodiversity surveys have been conducted in each bioregion every 2-5 years since 2001.

Fixed plot surveys are designed to measure population trends for important intertidal species such as sea stars and abalone. Each year, MARINe researchers survey a set of fixed plots, counting and measuring a subset of ecologically important species and recording percent cover of habitat-forming species such as mussels, rockweed, and barnacles. MARINe fixed plot surveys have been conducted in each bioregion every year since at least 2001, with the earliest surveys dating back to the 1980s.

Nearshore (0-30 m) subtidal kelp forest monitoring: Partnership for Interdisciplinary Study of Coastal Oceans (PISCO) and ReefCheck California (RCCA) SCUBA surveys

PISCO and RCCA collect data on kelp forest ecosystems including macroalgae, invertebrates, and fishes via SCUBA diver surveys. PISCO's sampling protocols and training methods are standardized across affiliated institutions and partners, including UC Santa Cruz and UC Santa Barbara, and have data dating back to 1999. Using protocols similar to PISCO, RCCA has trained volunteer recreational divers to conduct surveys statewide since 2006.

Mid-depth (30-100 m) remotely operated vehicle (ROV) monitoring: CDFW/Marine Applied Research and Exploration (MARE) surveys

CDFW and MARE have performed extensive ROV surveys inside and outside of MPAs since 2004. Data derived from ROV imagery is particularly powerful because all observations are precisely georeferenced, meaning that scientists can more effectively model species distributions and their habitat associations.

Calculating final historical monitoring points

All coastal and island MPAs were scored for level of historical monitoring according to the following rule: MPAs received a single point for each of the five surveys described above (MARINe biodiversity surveys, MARINe fixed plot surveys, PISCO surveys, RCCA surveys, and CDFW/MARE surveys) for each survey replicate that was conducted each year since the beginning of the survey program. As an example, here are the historical monitoring points awarded to Point Lobos SMR:

- MARINe biodiversity survey = 4
    - There is only one rocky intertidal site surveyed within Point Lobos. It has been surveyed for biodiversity by MARINe in 2001, 2005, 2014, and 2017, so receives a point value of 4.
- MARINe fixed plot survey = 19
    - There is only one rocky intertidal site surveyed within Point Lobos. It has been surveyed for fixed plot sampling every year from 1999-2017, so receives a point value of 19.
- Kelp forest monitoring, PISCO = 18
    - Within Point Lobos SMR, PISCO has three sites: Monastery (surveyed 1999-2016), Bluefish (surveyed 1999-2016), and Weston (surveyed 2001-2016). While multiple sites with years of survey data are available, Point Lobos only receives credit for the site with the greatest number of surveys. In this case two sites have 18 years of surveys, so 18 points are awarded.
- Kelp forest monitoring, RCCA = 12
    - Within Point Lobos SMR, RCCA has four sites: North Monastery (surveyed 2008, 2010-2017), South Monastery (surveyed 2007-2017), Middle Reef (surveyed 2006-2017), and Weston (surveyed 2006-2017). While multiple sites with years of survey data are available, Point Lobos only receives credit for the site with the greatest number of surveys. In this case two sites have 12 years of surveys, so 12 points are awarded.
- Mid-depth ROV monitoring = 2
    - Point Lobos SMR has been surveyed by ROV twice, once in 2008 and once in 2015, so receives a point value of 2.
- Total score: Based on this information,
  Point Lobos SMR receives a preliminary historical monitoring score of 55.

A multiplier was then applied as a filter to more highly weight MPAs that are capable of supporting multiple types of monitoring. The purpose of this filter was to determine which MPAs may be best suited for long-term monitoring across different habitat types. An MPA with a long survey history, but only one habitat monitored, is less likely to be of value in long-term monitoring than an MPA in which multiple habitats have been monitored. Therefore, for each of the monitoring habitats identified (rocky intertidal, kelp forest, and mid-depth rock) MPAs received a monitoring multiplier value of either 0, 1, 2, or 3 for each type of habitat surveyed by any method (i.e., if RCCA surveyed an MPA, but PISCO did not, the MPA still received credit for supporting kelp forest monitoring). Monitoring multipliers were then used in final historical monitoring scores as follows:

Historical monitoring score = (rocky intertidal biodiversity points + rocky intertidal fixed plot points + PISCO kelp forest monitoring points + RCCA kelp forest monitoring points + mid-depth ROV points) * monitoring multiplier

Based on the above information, Point Lobos SMR received a final historical monitoring score of 165 (all three types of habitats were surveyed, so monitoring multiplier = 3; 55*3 = 165); final historical monitoring scores for each coastal MPA are in Table F3.

Criteria 3: Habitat-based connectivity contribution modeling

California's MPAs were designed and are managed to function as an ecologically cohesive, statewide network, especially in terms of larval dispersal. For most nearshore marine species, planktonic larval transport is primarily driven by oceanographic factors such as currents and seasonal upwelling. Over the last decade, there have been significant advances in oceanographic modeling. One widely used approach is the Regional Oceanographic Modeling System (ROMS), which tracks particle movement in four dimensions (space over time) based on simulated nearshore oceanographic conditions (Moore et al. 2011).

ROMS was applied to examine the larval connectivity of key habitats in the MPA Network (rocky intertidal, kelp and rocky reef 0-30 m, rocky reef 30-100 m, sandy beach, soft bottom 0-30 m, and soft bottom 30-100 m). Particles representing larvae were "released" into the model and allowed to remain for a range of 30-60 days. This range represents the pelagic larval duration (PLD), or how long larvae remain in the water column before settling, for most nearshore species (Shanks 2009). The total larval output (i.e., donor, source) and settlement (i.e., recipient, sink) was assessed for all non-estuarine MPA sites in the network. Sites were then ranked based on their total contribution to the MPA Network as both source and sink.

General ROMS methods

- Simulated oceanographic conditions in ROMS were based on 15-year averages (1999-2013).
- General model expanse was U.S.-Mexican border to U.S.-Canadian border.
- Particles were released from 557 cells along the expanse. These cells included all coastal areas of California with one important exception – the Farallon Islands, located approximately 27 miles off San Francisco, were not included.
- Approximately 88,000 "larvae" were released from each cell (all releases through all years), with a total of 49 million larvae released. Total settlement depended on the PLD.
    - » There have been a series of sensitivity studies to determine the number of particles required to provide an accurate set of results (the number required such the further increases do not affect the results). The number used in this study (1000 larvae released per month per cell) is much more than needed, but the model output can and has been used for other questions where larvae number requirements are higher.
- Model results for 11 PLDs (5, 10, 15, 20, 30, 45, 60, 90, 120, 150, 180 days) were obtained.
- Larvae moved hourly, but with daily averaged currents. Every hour, the daily average currents from the ROMS model were interpolated in space and time to find the current at each particle location. Then each particle was moved with its appropriate current velocity at that location. Landward of a certain depth range (500 m), the larvae were also given a random "kick" simulating tidal currents of 5 cm/s. This kick was also given every hour in addition to the daily-averaged motion.
- Settlement could only occur within 10% of PLD (e.g., for PLD of 30 days: 27-33 days)
- The ROMS output can be considered a measure of connectivity among cells (locations) but should not be considered an estimate of one cell's contribution of larvae (propagules) to other cells. This is because cells in ROMS grids are only characterized by oceanographic factors. In order to estimate the level of larval contribution, propagule production for donor cell, and amount of suitable habitat for receiving cells, high resolution habitat information must be incorporated as a sub-model.

Habitat sub-models

The area or linear extent of key nearshore habitats was estimated for each ROMS cell in California, including those within MPAs, using a suite of data sources (e.g., seafloor mapping and existing GIS data layers). Linear extent was used for sandy beaches and rocky intertidal habitats, and area was used for all other habitats.

Integrating ROMS and the habitat sub-models

Habitat and ROMS sub-models were integrated as follows. Raw larval connectivity between locations (i.e. cells, MPAs) was measured based on suitable habitat in the donor and recipient locations.

- An equation was applied to ensure that donor locations without certain types of habitat could not contribute propagules from those habitats. It also ensured that propagules associated with habitats not found in a location could not settle in recipient locations lacking those habitats.
- For a given PLD, or set of PLDs, the sum of contributions was calculated for all location pairs by habitat. For most locations, this is the same as the actual value (no summation required). However, some MPAs are found in multiple ROMS cells so the separate values for each portion of the cells represented by the MPA was summed to produce an MPA value.
- This suite of values was then queried to produce contribution or connectivity (or both) estimates for all habitats. In addition, other contribution/connectivity attributes were calculated as follows:
    - » The number of links to and from all locations. For example – the number of other locations that contributed to a recipient location or the number of other locations a donor location contributed to. Here the links were restricted based on the level of contribution or connectivity, which removed links where contribution or connectivity were very low (<0.0001).
    - » The diversity of links. This was calculated using the Shannon-Weiner Index (H'). This index incorporates the number of links and also the contribution or connectivity values for each link. High values are driven by many links of relatively even contribution or connectivity.

Examples of other metrics that can be produced via these methods:

- The contribution, links, and diversity of links (calculated using the Shannon-Weiner Index [H']) of specific MPAs to all locations
- The contribution, links, and diversity of links of all locations to specific MPAs
- The contribution, links, and diversity of links of specific MPAs to other MPAs

The final combined connectivity value (number of links to and from all locations) for each coastal MPA are found in Table F3.

Criteria 4: High resolution mapping of recreational fishing effort

Recovery trajectories of fished populations following MPA implementation are highly dependent on the level of fishing mortality (F) to which those populations were subjected prior to protection (Micheli et. al 2004, White et al. 2013, Caselle et. al 2015, Starr et al. 2015, White et al. 2016). **In other words, more pronounced ecological change should be expected inside MPAs where F was once high, and these sites should be prioritized for long-term monitoring.**

In cases where there are not sufficient data to estimate direct mortality due to fishing, a related measure, fishing effort, can provide a proxy of relative historical fishing pressure and guidance for where long-term monitoring could be focused. In order to attribute fishing effort at a spatial scale appropriate for determining influence on specific MPAs, data must include spatial attributes recorded at resolutions that support linking fishing location with MPA boundaries. CDFW's California Recreational Fisheries Survey (CRFS) program began in 2004, and employs fisheries technicians to interview recreational anglers about their catch and fishing activities from private/rental boats, on chartered commercial passenger fishing vessels (CPFVs, or "party boats") led by hired boat captains, and from beaches and manmade structures that include piers and jetties. The private and rental boat survey data collected includes spatial and sampling effort attributes recorded at scales that support summation of records within relatively high resolution mapping units, which are one-minute latitude by one-minute longitude in size, excluding estuaries. Ideally, similar resolution data would be used for analogous synthesis of commercial fishing effort or catch; however, current commercial landing records for similar targeted species only support summation of effort and catch at a resolution of ten-minutes latitude by ten-minutes longitude, which is too coarse for this analysis. As such, Criteria 4 presents an index of historical recreational bottom fishing pressure on MPAs prior to implementation, independent of fishing pressure from other modes of fishing. While this does not describe the complete state of all fishing effort, it does identify sites that historically received high recreational effort and thus are expected to have a measurable (biotic) response to MPA treatment. Using CRFS interviews from 2006 to the last year prior to MPA implementation for each MLPA planning region (2011 for North, 2009 for North Central, 2006 for Central, 2011 for South), estimates of relative recreational ocean fishing effort by private/rental boats were mapped. A relative index of historical fishing effort was calculated by standardizing the sampled number of angler boat trips over time and area at sites now located within MPAs (Table F3). The analyses here focus on boat trips on which anglers targeted bottomfish, and exclude trips representing seasonally high effort on salmon and pelagic species that are not expected to stay within MPA boundaries. A one-mile buffer was applied around intersections of MPAs with the gridded blocks. Results indicated that relative fishing effort prior to MPA implementation was concentrated in coastal areas surrounding major ports and cities and surrounding island areas closest to these ports. Across California, relative fishing effort was highest in the southern bioregion (for bottomfish), although there were hotspots in all three bioregions (Figures F1, F2, and F3). The maximum relative fishing block effort in an MPA ranged from 0 to 139 trips/year across the different regions.

Historical recreational boat fishing hotspots for bottomfish emerged in the northern bioregion around Crescent City (Point St. George Reef Offshore State Marine Conservation Area [SMCA]), Reading Rock State Marine Reserve (SMR)/SMCA, and Fort Bragg (MacKerricher SMCA and Point Cabrillo SMR) (Figure F1). In the central bioregion, high relative fishing effort mapped to Point Buchon SMR/SMCA and MPAs between Halfmoon Bay and Santa Cruz (Montara SMR, Pillar Point SMCA, Año Nuevo SMR, Greyhound Rock SMCA) (Figure F2). Relatively high fishing effort prior to MPA implementation was also concentrated around Monterey (Pacific Grove Marine Gardens SMCA, and Asilomar SMR) (Figure F2). Along the southern bioregion mainland, Cabrillo SMR near San Diego had the highest relative fishing effort focused on bottomfish in the state. Dana Point SMCA, and the area around La Jolla (San Diego-Scripps Coastal SMCA, Matlahuayl SMR, and South La Jolla SMR/SMCA) were also important fishing grounds for bottomfish. In the Channel Islands, historical recreational hotspots targeting bottomfish were concentrated at Footprint SMR, Anacapa Island SMR/SMCA, and around Catalina

Island (Arrow Point to Lion Head Point SMCA, Long Point SMR, Casino Point SMCA, Lover's Cove SMCA, Blue Cavern Onshore/Offshore SMCAs, and Farnsworth Onshore/Offshore SMCAs) (Figure F3). The final relative fishing effort scores for each coastal MPA are found in Table F3.

[1] https://www.wildlife.ca.gov/Conservation/Marine/CRFS

[2] Units are a relative index of effort (i.e., a result of 2.0 indicates twice as much effort relative to a result of 1.0). Values do not represent any measure of total effort.

[3] All species listed in the PFMC Pacific Coast Groundfish Fishery Management Plan (PFMC 2016) except leopard shark, California skate, sand sole and starry flounder; all species listed in the California Nearshore Fishery Management Plan (CDFW 2002); and unidentified bottomfish or groundfish, blacksmith, black croaker, white seabass, other flounders, sea chubs, groupers, grunts, Pacific halibut, sea basses (except spotted sand bass), kelpfishes, sculpins, wrasses, ocean whitefish, some surfperches (black, kelp, pink, rainbow, reef, sharpnose and striped) and other flatfish and sharks found in the nearshore over hard bottoms and offshore.

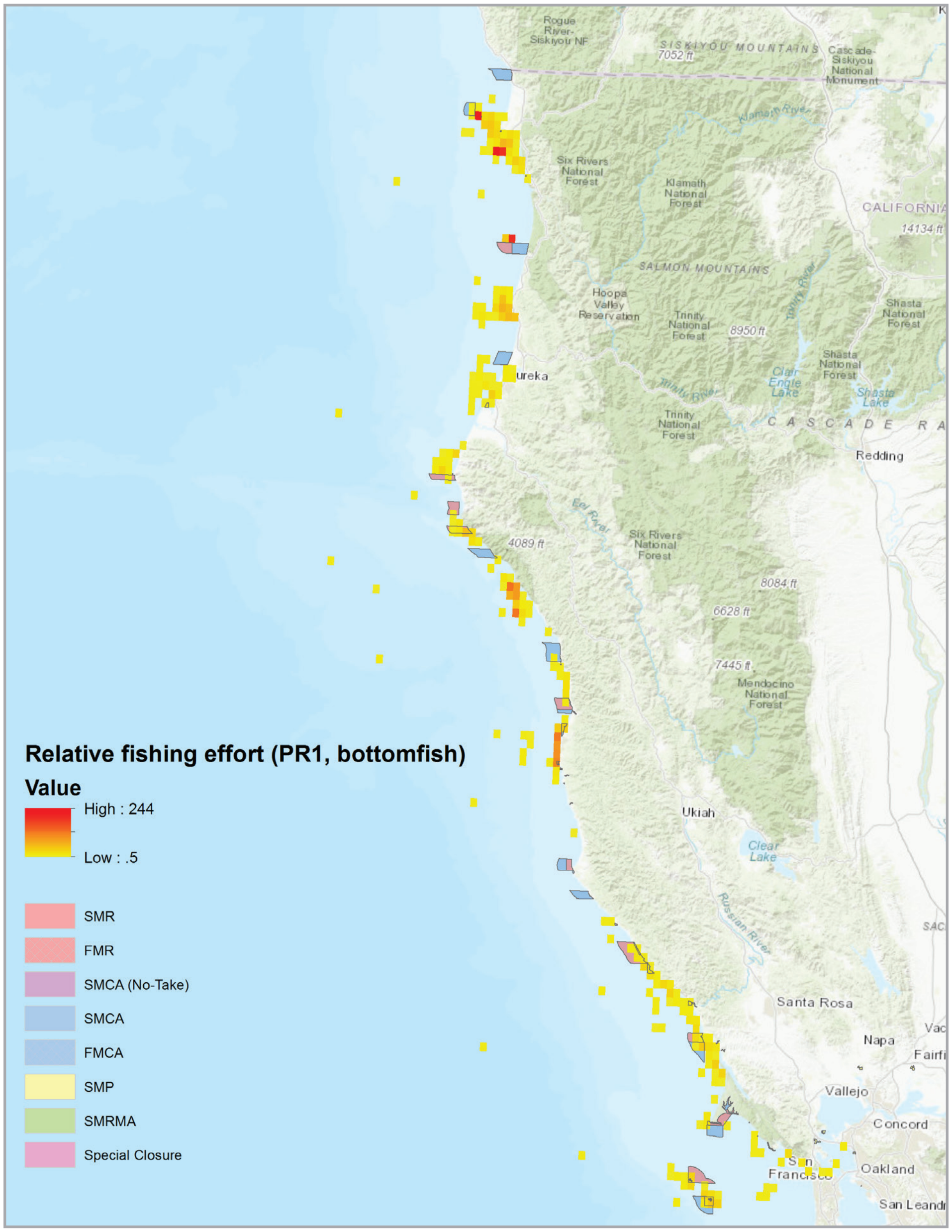


FIGURE F1: Distribution of maximum historical (pre-MPA) relative fishing effort by private/rental boat trips targeting bottomfish in the northern bioregion, based on California Recreational Fisheries Survey data. S[F]MR= state [federal] marine reserve, S[F]MCA=state [federal] marine conservation area, SMP=state marine park, SMRMA=state marine recreational management area.

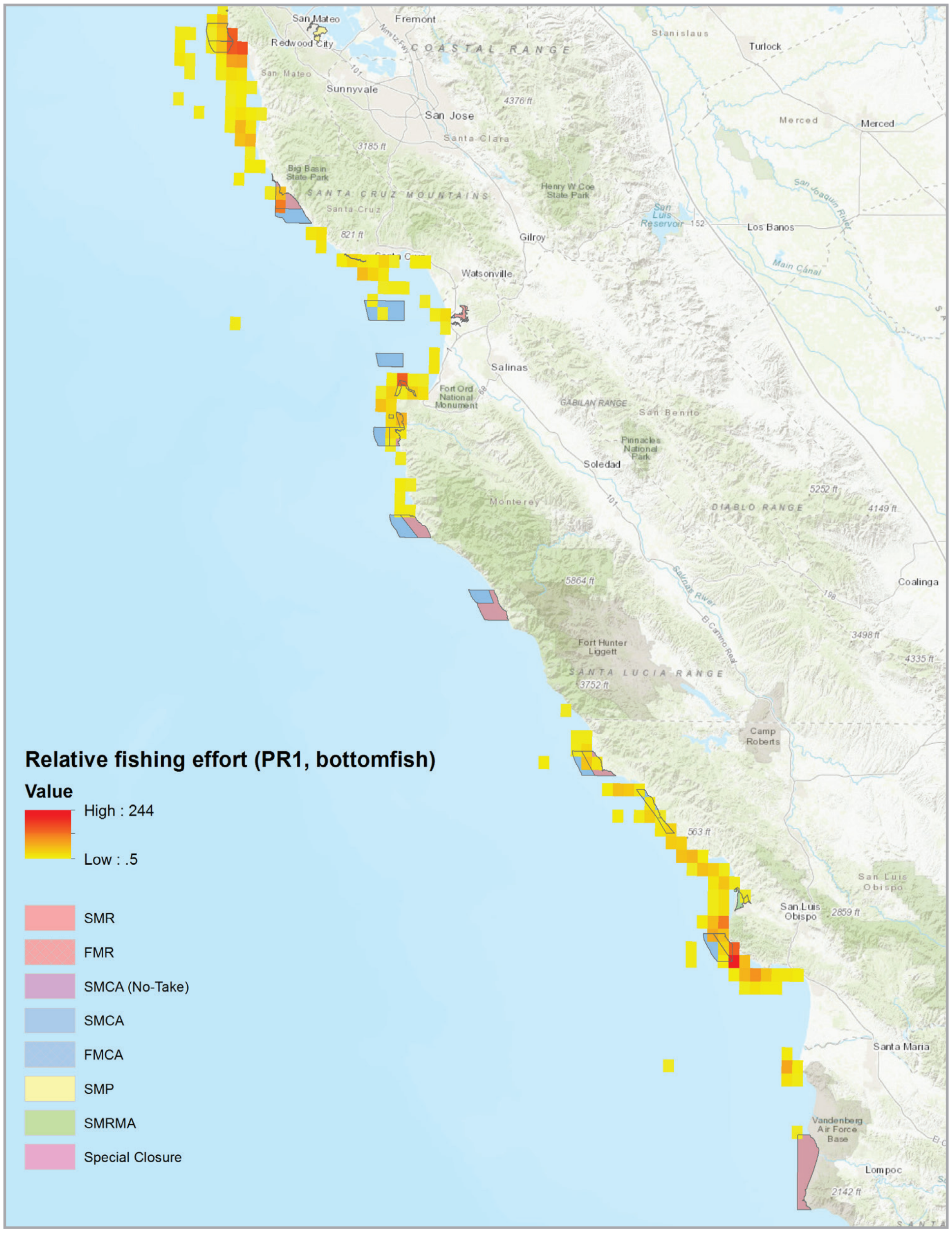


FIGURE F2: Distribution of maximum historical (pre-MPA) relative fishing effort by private/rental boat trips targeting bottomfish in the central bioregion, based on California Recreational Fisheries Survey data. S[F]MR= state [federal] marine reserve, S[F]MCA=state [federal] marine conservation area, SMP=state marine park, SMRMA=state marine recreational management area.

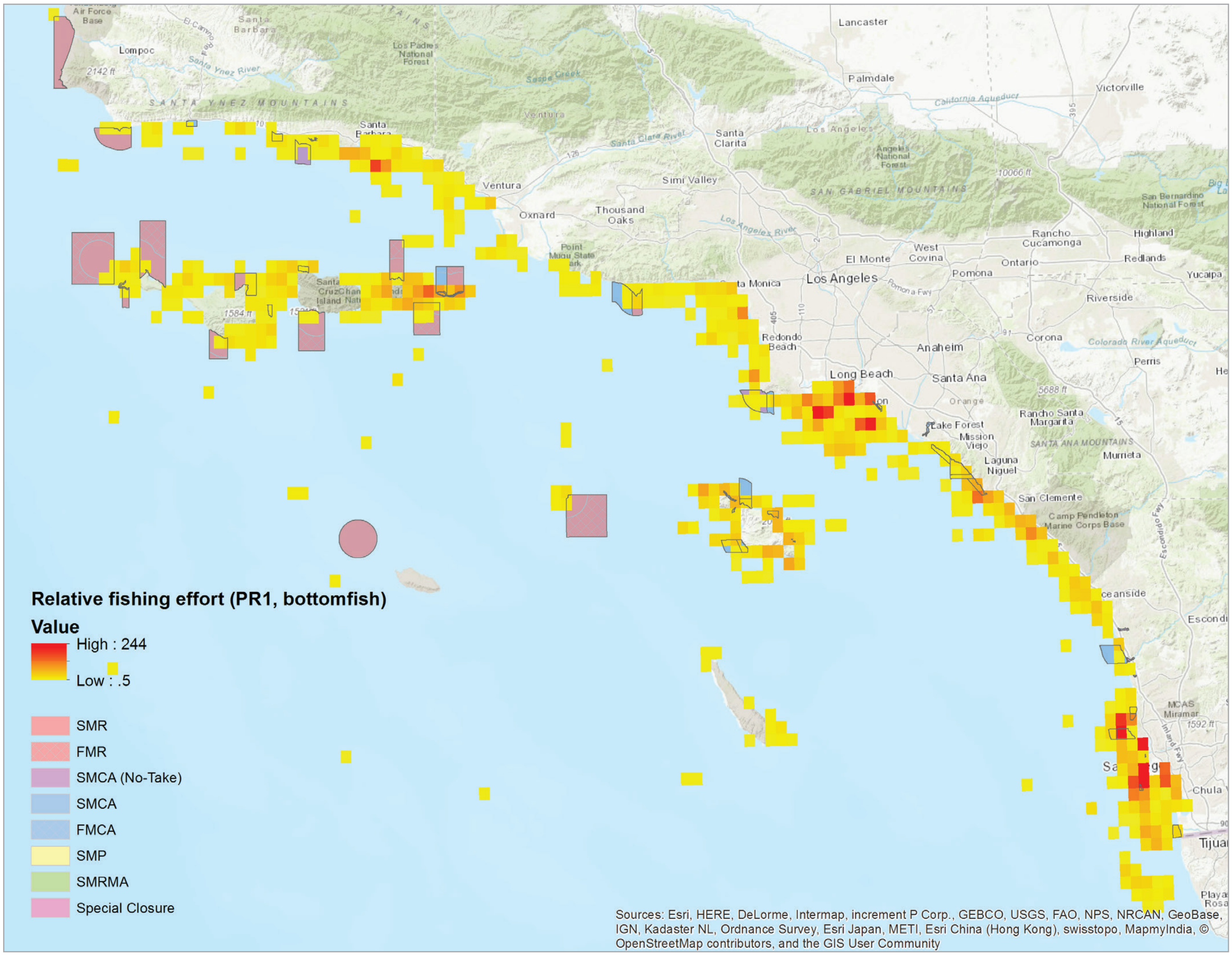


FIGURE F3: Distribution of maximum historical (pre-MPA) relative fishing effort by private/rental boat trips targeting bottomfish in the southern bioregion, based on California Recreational Fisheries Survey data. S[F]MR= state [federal] marine reserve, S[F]MCA=state [federal] marine conservation area, SMP=state marine park, SMRMA=state marine recreational management area.

MPA index site scores, rankings, and final tiered lists

Integrating Quantitative Criteria into Tiered Approach for Index Site Selection

For each of the four criteria listed above, a rank-order list of MPAs (excluding estuarine MPAs) within each bioregion was generated based on final scores. The four individual rank-order values were then averaged to generate a final integrated rank-order value. MPAs were sorted into tiers based on these values, with cutoffs for each tier varying by bioregion to ensure equal bioregional representation of the MPAs within each of the three tiers. For example, the 34 North Coast MPAs were sorted so that 11 MPAs fell into Tier I, 11 MPAs fell into Tier II, and 12 MPAs fell into Tier III (Table F3).

Tier I MPAs received the highest integrated rank-order values. They meet many of the design criteria needed for effective protection, are well connected components of the MPA Network, and may have long time series of monitoring data and/or experienced high historical recreational fishing effort, which make these MPAs good candidates for detecting the potential effects of protection over time. Many of the MPAs on the Tier I index site list are state marine reserves.

Tier II MPAs received the second-highest integrated rank-order values. Many of these MPAs ranked high in one or two of the quantitative methods and may be considered valuable index sites for more specific research questions. Tier II MPAs can be considered for long-term monitoring when funding permits, when an MPA cluster is split between tiers, or to help answer more regionally focused questions.

Tier III MPAs received the lowest integrated rank-order values. Many of these MPAs are small, represent fewer habitats, are difficult to access, have limited or no long-term monitoring data, or have more allowable take within their boundaries. Tier III MPAs are recommended for long-term monitoring only to answer very specific or localized research questions.

Raw points and rank for each method (design features, monitoring history, connectivity modeling, and historical fishing effort), as well as final rank, are reported in Table F3 below.

TABLE F3: Recommended coastal MPA tiers within each bioregion (MPAs listed north to south) based on final rank. MPAs are ranked regionally within each category based on points awarded. Abbreviations: SMR = state marine reserve, SMCA = state marine conservation area

MPA AND DESIGNATION	MPA DESIGN FEATURES		MONITORING HISTORY		CONNECTIVITY MODELING		HISTORICAL FISHING EFFORT		FINAL RANK (AVERAGE)
	Points	*Rank*	*Points*	*Rank*	*Points*	*Rank*	*Points*	*Rank*	
NORTH COAST									
TIER I									
READING ROCK SMCA	3.7	21	2.0	24	7.1	9	60.3	2	14.0
READING ROCK SMR	3.0	24	3.0	21	4.6	13	60.3	2	15.0
SEA LION GULCH SMR	11.3	4	3.0	21	5.2	12	15.5	6	10.8
TEN MILE SMR	15.0	1	6.0	12	7.2	8	2.7	23	11.0
MACKERRICHER SMCA	3.3	23	6.0	12	2.3	19	36.9	4	14.5
SAUNDERS REEF SMCA	8.3	9	24.0	5	5.9	10	0.0	27	12.8
STEWARTS POINT SMR	12.0	3	12.0	9	19.0	2	7.9	14	7.0
SALT POINT SMCA	5.5	15	12.0	9	2.3	20	7.9	14	14.5
BODEGA HEAD SMR	12.1	2	56.0	1	10.0	5	12.0	10	4.5
BODEGA HEAD SMCA	5.8	13	4.0	14	10.6	4	12.5	9	10.0
POINT REYES SMR	9.3	5	14.0	7	14.0	3	4.2	18	8.3
TIER II									
POINT ST. GEORGE REEF OFFSHORE SMCA	4.0	18	2.0	24	1.1	24	73.7	1	16.8
SOUTH CAPE MENDOCINO SMR	9.0	6	1.0	30	4.0	16	9.6	11	15.8
BIG FLAT SMCA	6.3	12	1.0	30	5.5	11	6.0	17	17.5
DOUBLE CONE ROCK SMCA	9.0	6	0.0	32	8.9	6	3.4	21	16.3
POINT CABRILLO SMR	2.5	28	4.0	14	0.8	25	32.6	5	18.0
POINT ARENA SMR	8.2	10	42.0	2	2.0	22	0.0	27	15.3
POINT REYES SMCA	2.6	27	3.0	21	21.7	1	4.2	18	16.8
DUXBURY REEF SMCA	4.6	16	15.0	6	3.0	18	0.0	27	16.8
NORTH FARALLON ISLANDS SMR	8.4	8	2.0	24	ND*	32	9.2	12	19.0
SOUTHEAST FARALLON ISLAND SMR	5.7	14	4.0	14	ND*	32	12.5	7	16.8
SOUTHEAST FARALLON ISLAND SMCA	4.6	17	4.0	14	ND*	32	12.5	7	17.5
TIER III									
PYRAMID POINT SMCA	3.0	24	4.0	14	4.6	14	0.0	27	19.8
SAMOA SMCA	4.0	18	0.0	32	8.1	7	0.0	27	21.0
MATTOLE CANYON SMR	7.0	11	2.0	24	3.4	17	1.4	26	19.5
TEN MILE BEACH SMCA	0.0	34	0.0	32	2.0	23	2.3	24	28.3
RUSSIAN GULCH SMCA	1.4	31	4.0	14	0.7	26	8.3	13	21.0
VAN DAMME SMCA	0.4	33	11.0	11	0.1	31	0.0	27	25.5
POINT ARENA SMCA	3.6	22	4.0	14	4.5	15	0.0	27	19.5
SEA LION COVE SMCA	1.2	32	40.0	3	0.5	27	0.0	27	22.3
DEL MAR LANDING SMR	2.8	26	14.0	7	0.3	29	1.8	25	21.8
STEWARTS POINT SMCA	4.0	18	2.0	24	2.2	21	3.9	20	20.8
GERSTLE COVE SMR	1.7	29	34.0	4	0.1	30	6.3	16	19.8
RUSSIAN RIVER SMCA	1.4	30	2.0	24	0.4	28	3.2	22	26.0

MPA AND DESIGNATION	MPA DESIGN FEATURES		MONITORING HISTORY		CONNECTIVITY MODELING		HISTORICAL FISHING EFFORT		FINAL RANK (AVERAGE)
	Points	*Rank*	*Points*	*Rank*	*Points*	*Rank*	*Points*	*Rank*	
CENTRAL COAST									
TIER I									
MONTARA SMR	11.1	7	27.0	17	15.5	3	46.4	3	7.5
AÑO NUEVO SMR	13.9	3	40.0	15	11.5	6	37.0	7	7.8
GREYHOUND ROCK SMCA	5.2	13	52.0	11	12.8	5	37.0	7	9.0
CARMEL BAY SMCA	6.9	9	165.0	1	3.7	18	20.0	9	9.3
POINT LOBOS SMR	13.5	4	165.0	1	10.3	8	20.0	9	5.5
PIEDRAS BLANCAS SMR	15.0	2	90.0	5	10.2	9	14.3	13	7.3
POINT BUCHON SMR	10.0	8	66.0	8	10.0	10	67.6	1	6.8
POINT BUCHON SMCA	6.4	11	3.0	19	13.2	4	67.6	1	8.8
VANDENBERG SMR	15.1	1	76.0	7	29.9	1	1.0	23	8.0
TIER II									
PILLAR POINT SMCA	3.2	23	3.0	19	9.2	13	46.4	3	14.5
NATURAL BRIDGES SMR	4.0	21	78.0	6	3.1	19	17.0	12	14.5
SOQUEL CANYON SMCA	6.2	12	1.0	23	20.8	2	1.9	22	14.8
PACIFIC GROVE MARINE GARDENS SMCA	4.0	20	46.0	13	2.8	20	45.8	5	14.5
ASILOMAR SMR	6.5	10	60.0	9	3.7	16	45.8	5	10.0
POINT SUR SMR	13.0	5	111.0	3	9.5	11	3.0	20	9.8
BIG CREEK SMR	12.2	6	46.0	13	7.0	14	0.0	24	14.3
CAMBRIA SMCA	5.0	14	50.0	12	4.5	15	10.5	16	14.3
TIER III									
PORTUGUESE LEDGE SMCA	4.6	17	1.0	23	3.7	17	0.0	24	20.3
EDWARD F. RICKETTS SMCA	2.0	26	30.0	16	0.5	24	10.4	17	20.8
LOVERS POINT - JULIA PLATT SMR	4.7	16	110.0	4	0.7	23	10.4	17	15.0
CARMEL PINNACLES SMR	2.9	24	4.0	18	0.2	26	20.0	9	19.3
POINT LOBOS SMCA	4.2	19	2.0	22	0.4	25	7.7	19	21.3
POINT SUR SMCA	4.6	17	3.0	19	11.1	7	3.0	20	15.8
BIG CREEK SMCA	2.4	25	1.0	23	1.4	22	0.0	24	23.5
PIEDRAS BLANCAS SMCA	3.6	22	1.0	23	9.2	12	14.3	13	17.5
WHITE ROCK SMCA	5.0	14	58.0	10	1.5	21	11.5	15	15.0

MPA AND DESIGNATION	MPA DESIGN FEATURES		MONITORING HISTORY		CONNECTIVITY MODELING		HISTORICAL FISHING EFFORT		FINAL RANK (AVERAGE)
	Points	*Rank*	*Points*	*Rank*	*Points*	*Rank*	*Points*	*Rank*	
SOUTH COAST									
TIER I									
POINT CONCEPTION SMR	18.0	2	108.0	7	24.3	2	2.5	41	13.0
CAMPUS POINT SMCA	15.0	5	141.0	3	12.6	10	3.5	36	13.5
HARRIS POINT SMR	22.2	1	165.0	2	33.8	1	6.0	34	9.5
CARRINGTON POINT SMR	13.0	6	28.0	22	15.7	7	10.0	26	15.3
SCORPION SMR	8.5	13	90.0	8	13.4	9	15.8	21	12.8
ANACAPA ISLAND SMCA	4.8	24	62.0	12	10.8	11	24.4	9	14.0
ANACAPA ISLAND SMR	11.0	10	225.0	1	16.0	6	28.5	8	6.3
POINT DUME SMCA	8.4	14	57.0	13	18.8	3	9.4	27	14.3
POINT DUME SMR	10.2	11	120.0	4	8.6	14	9.4	27	14.0
BLUE CAVERN ONSHORE SMCA	11.1	8	74.0	9	1.9	29	18.3	15	15.3
LAGUNA BEACH SMR	11.0	9	117.0	5	14.4	8	18.2	19	10.3
DANA POINT SMCA	5.0	22	64.0	11	9.2	13	38.8	5	12.8
SWAMI'S SMCA	11.9	7	1.0	31	17.0	4	12.1	24	16.5
SOUTH LA JOLLA SMR	8.0	16	36.0	20	5.8	15	69.5	2	13.3
TIER II									
SOUTH POINT SMR	16.4	3	50.0	15	4.7	19	7.0	32	17.3
GULL ISLAND SMR	15.3	4	46.0	19	5.4	16	3.8	35	18.5
BEGG ROCK SMR	8.4	15	0.0	35	16.5	5	0.0	42	24.3
SANTA BARBARA ISLAND SMR	4.4	26	117.0	5	3.0	24	7.0	31	21.5
POINT VICENTE SMCA	5.0	23	27.0	24	5.0	18	19.4	10	18.8
ABALONE COVE SMCA	5.4	21	28.0	22	5.2	17	19.4	10	17.5
ARROW POINT TO LION HEAD POINT SMCA	5.9	20	0.0	35	2.0	28	18.3	15	24.5
LONG POINT SMR	8.0	16	12.0	26	1.5	35	18.7	14	22.8
CRYSTAL COVE SMCA	4.6	25	74.0	9	9.9	12	7.4	30	19.0
LAGUNA BEACH SMCA	2.0	37	50.0	15	4.4	20	18.2	19	22.8
SAN DIEGO-SCRIPPS COASTAL SMCA	2.5	34	56.0	14	3.3	22	38.6	6	19.0
MATLAHUAYL SMR	7.5	18	48.0	17	2.5	27	38.6	6	17.0
SOUTH LA JOLLA SMCA	1.8	39	1.0	31	2.7	26	69.5	2	24.5
CABRILLO SMR	2.1	36	31.0	21	1.0	37	139.0	1	23.8

MPA AND DESIGNATION	MPA DESIGN FEATURES		MONITORING HISTORY		CONNECTIVITY MODELING		HISTORICAL FISHING EFFORT		FINAL RANK (AVERAGE)
	Points	Rank	Points	Rank	Points	Rank	Points	Rank	
SOUTH COAST									
TIER III									
KASHTAYIT SMCA	3.0	33	0.0	35	1.7	32	2.8	39	34.8
NAPLES SMCA	4.0	27	48.0	17	2.8	25	6.1	33	25.5
RICHARDSON ROCK SMR	3.6	30	0.0	35	0.8	38	2.7	40	35.8
JUDITH ROCK SMR	3.8	29	1.0	31	1.8	30	3.1	37	31.8
SKUNK POINT SMR	9.9	12	6.0	29	1.4	36	2.9	38	28.8
PAINTED CAVE SMCA	3.4	32	16.0	25	3.2	23	12.0	25	26.3
FOOTPRINT SMR	1.1	40	0.0	35	1.7	33	44.6	4	28.0
BLUE CAVERN OFFSHORE SMCA	1.8	38	0.0	35	0.0	41	18.3	15	32.3
CASINO POINT SMCA	0.0	42	12.0	26	0.0	42	18.9	12	30.5
LOVER'S COVE SMCA	0.3	41	0.0	35	0.1	40	18.9	12	32.0
FARNSWORTH ONSHORE SMCA	7.2	19	8.0	28	1.6	34	12.7	22	25.8
FARNSWORTH OFFSHORE SMCA	3.9	28	3.0	30	1.8	31	12.7	22	27.8
CAT HARBOR SMCA	2.4	35	1.0	31	0.7	39	18.3	15	30.0
TIJUANA RIVER MOUTH SMCA	3.6	31	0.0	35	3.4	21	8.2	29	29.0

* ROMS data from the Farallon Islands were not available due to spatial constraints.

In addition to the 102 new or redesigned coastal and island MPAs, the MPA design and siting process established 22 estuarine MPAs in California (see Action Plan, Section 2.3). Only one of the four quantitative methods (MPA Design Features) integrated into the tiered approach for index site selection could be applied to estuaries. Therefore, in order to assign estuarine MPAs into one of three tiers, they were separated from coastal MPAs and only evaluated on their ability to meet the SAT recommended MPA design features.

However, not all MPA design features evaluated by the SAT applied to estuaries. For example, estuarine MPAs were exempted from the size guidelines because MPA size was often constrained by estuarine boundaries, and spacing was not evaluated for the three estuarine habitats (Saarman et al. 2013). Additionally, ASBSs are only coastal features and do not apply to estuaries, and are therefore also excluded. Of the potential MPA design feature scores detailed earlier in this appendix, only habitat threshold points, LOP points, and historical MPA points apply to estuarine MPAs. Finally, since most estuaries are unique ecosystems, regardless of geographical location (see Action Plan, Section 2.3, Monitoring in Other Habitat Types, pages 41-42) estuarine MPAs were ranked relative to one another on a statewide rather than regional basis (Table F4).

TABLE F4: Recommended estuarine MPA tiers within each bioregion (MPAs listed north to south) based on final rank. MPAs are ranked statewide based on points awarded. Abbreviations: SMR = state marine reserve, SMCA = state marine conservation area, SMRMA = state marine recreational management area.

MPA and DESIGNATION	BIOREGION	MPA DESIGN FEATURES	
		Points	*Rank*
TIER I			
ESTERO DE LIMANTOUR SMR	North	10.5	1
DRAKES ESTERO SMCA	North	5.0	5
ELKHORN SLOUGH SMR	Central	5.5	4
GOLETA SLOUGH SMCA	South	4.9	7
BOLSA CHICA BASIN SMCA	South	6.2	2
BATIQUITOS LAGOON SMCA	South	6.2	3
SAN ELIJO LAGOON SMCA	South	4.9	6
TIER II			
SOUTH HUMBOLDT BAY SMRMA	North	3.0	11
NAVARRO RIVER ESTUARY SMCA	North	2.0	13
RUSSIAN RIVER SMRMA	North	4.0	8
MORO COJO SLOUGH SMR	Central	2.0	13
MORRO BAY SMRMA	Central	4.0	8
MORRO BAY SMR	Central	4.0	8
UPPER NEWPORT BAY SMCA	South	2.8	12
TIER III			
TEN MILE ESTUARY SMCA	North	1.0	15
BIG RIVER ESTUARY SMCA	North	1.0	15
ESTERO AMERICANO SMRMA	North	0.0	20
ESTERO DE SAN ANTONIO SMRMA	North	0.0	20
ELKHORN SLOUGH SMCA	Central	1.0	15
BOLSA BAY SMCA	South	0.9	19
SAN DIEGUITO LAGOON SMCA	South	1.0	18
FAMOSA SLOUGH SMCA	South	0.0	20

TABLE F5: Soft bottom habitats - area or linear extent of coastline and percentage of available habitats within each bioregion - Tier I MPA sites.

MPA	BIOREGION	TOTAL AREA (mi²)	BEACHES (linear mi)	%	SOFT SUBSTRATE 0-30M (linear mi)	%	SOFT SUBSTRATE 30-100M (area mi²)	%	SOFT SUBSTRATE 100 - 3000M (area mi²)	%	ESTUARY (area mi²)	%	EELGRASS (area mi²)	%	COASTAL MARSH (area mi²)	%
READING ROCK SMCA	NORTH	11.96	2.96	0.8%	2.82	1.2%	3.77	0.5%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
READING ROCK SMR	NORTH	9.60	0.00	0.0%	0.00	0.0%	9.43	1.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
SEA LION GULCH SMR	NORTH	10.42	2.42	0.6%	2.01	0.9%	3.86	0.5%	1.09	1.4%	0.00	0.0%	0.00	0.0%	0.00	0.0%
TEN MILE SMR	NORTH	11.95	2.63	0.7%	2.00	0.9%	8.13	1.0%	0.46	0.6%	0.00	0.0%	0.00	0.0%	0.01	0.0%
MACKERRICHER SMCA	NORTH	2.48	4.40	1.1%	0.00	0.0%	0.06	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.01	0.0%
SAUNDERS REEF SMCA	NORTH	9.36	1.83	0.5%	0.19	0.1%	5.25	0.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
STEWARTS POINT SMR	NORTH	24.06	0.89	0.2%	0.18	0.1%	21.89	2.7%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
SALT POINT SMCA	NORTH	1.84	0.59	0.1%	0.36	0.2%	0.37	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
BODEGA HEAD SMR	NORTH	9.34	1.32	0.3%	0.26	0.1%	5.38	0.7%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
BODEGA HEAD SMCA	NORTH	12.31	0.00	0.0%	0.00	0.0%	6.31	0.8%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
POINT REYES SMR	NORTH	9.55	8.38	2.1%	2.07	0.9%	1.20	0.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
MONTARA SMR	CENTRAL	11.81	2.14	0.8%	0.95	0.4%	7.75	1.3%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.01	0.0%
AÑO NUEVO SMR	CENTRAL	11.15	10.46	3.8%	3.34	1.4%	1.63	0.3%	0.00	0.0%	0.00	0.1%	0.00	0.0%	0.05	0.1%
GREYHOUND ROCK SMCA	CENTRAL	12.00	2.79	1.0%	0.70	0.3%	8.61	1.4%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
CARMEL BAY SMCA	CENTRAL	2.20	3.09	1.1%	1.58	0.7%	0.36	0.1%	0.07	0.0%	0.02	0.2%	0.00	0.0%	0.02	0.1%
POINT LOBOS SMR	CENTRAL	5.50	2.10	0.8%	1.36	0.6%	2.05	0.3%	0.33	0.2%	0.00	0.0%	0.00	0.0%	0.01	0.0%
PIEDRAS BLANCAS SMR	CENTRAL	10.44	5.48	2.0%	4.43	1.9%	2.25	0.4%	0.00	0.0%	0.01	0.2%	0.00	0.0%	0.06	0.1%
POINT BUCHON SMR	CENTRAL	6.68	1.46	0.5%	0.73	0.3%	4.56	0.8%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
POINT BUCHON SMCA	CENTRAL	12.19	0.00	0.0%	0.00	0.0%	8.11	1.3%	3.02	1.9%	0.00	0.0%	0.00	0.0%	0.00	0.0%
VANDENBERG SMR	CENTRAL	32.91	13.33	4.9%	12.82	5.5%	10.11	1.7%	0.00	0.0%	0.04	0.6%	0.00	0.0%	0.09	0.2%
POINT CONCEPTION SMR	SOUTH	22.52	2.73	0.6%	1.83	0.5%	15.79	2.4%	3.26	0.8%	0.00	0.0%	0.00	0.0%	0.01	0.0%
CAMPUS POINT SMCA	SOUTH	10.56	3.02	0.7%	1.21	0.3%	7.08	1.1%	1.48	0.4%	0.01	0.0%	0.00	0.0%	0.01	0.0%
HARRIS POINT SMR	SOUTH	25.40	2.71	0.6%	5.60	1.5%	15.93	2.4%	2.54	0.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%
CARRINGTON POINT SMR	SOUTH	12.78	0.82	0.2%	3.32	0.9%	3.82	0.6%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
SCORPION SMR	SOUTH	9.64	0.89	0.2%	2.28	0.6%	4.88	0.7%	0.18	0.0%	0.00	0.0%	0.01	0.0%	0.00	0.0%
ANACAPA ISLAND SMCA	SOUTH	7.30	0.19	0.0%	1.74	0.5%	6.21	0.9%	0.18	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
ANACAPA ISLAND SMR	SOUTH	11.55	1.12	0.3%	2.59	0.7%	7.25	1.1%	0.78	0.2%	0.00	0.0%	0.00	0.0%	0.00	0.0%
POINT DUME SMCA	SOUTH	15.92	4.09	0.9%	3.14	0.9%	5.95	0.9%	7.18	1.8%	0.00	0.0%	0.00	0.0%	0.00	0.0%
POINT DUME SMR	SOUTH	7.53	2.77	0.6%	1.81	0.5%	1.07	0.2%	4.30	1.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%
BLUE CAVERN ONSHORE SMCA	SOUTH	2.61	1.66	0.4%	1.89	0.5%	0.79	0.1%	1.43	0.4%	0.00	0.0%	0.00	0.0%	0.00	0.0%
LAGUNA BEACH SMR	SOUTH	6.72	3.48	0.8%	3.65	1.0%	2.82	0.4%	1.79	0.5%	0.00	0.0%	0.00	0.0%	0.00	0.0%
DANA POINT SMCA	SOUTH	3.47	3.60	0.8%	1.90	0.5%	0.79	0.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
SWAMI'S SMCA	SOUTH	12.71	3.77	0.9%	1.29	0.4%	3.85	0.6%	5.52	1.4%	0.00	0.0%	0.00	0.0%	0.00	0.0%
SOUTH LA JOLLA SMR	SOUTH	5.04	2.33	0.5%	0.07	0.0%	0.85	0.1%	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.00	0.0%
NORTH BIOREGION TOTAL		1618.90	391.45		227.31		820.08		75.93		60.84		13.31		136.88	
CENTRAL BIOREGION TOTAL		1317.84	272.90		231.37		602.63		158.19		7.02		1.94		45.02	
SOUTH BIOREGION TOTAL		2350.87	441.29		362.57		672.08		392.73		43.30		19.64		60.78	

*All miles are statute.

TABLE F6: Rocky habitats - area or linear extent of coastline and percentage of available habitats within each bioregion - Tier I MPA sites.

MPA	BIOREGION	TOTAL AREA (mi²)	ROCKY INTERTIDAL (linear mi)	%	KELP (linear mi)	%	HARD SUBSTRATE 0-30M (linear mi²)	%	HARD SUBSTRATE 30-100M (area mi²)	%	HARD SUBSTRATE 100-3000M (area mi²)	%
READING ROCK SMCA	NORTH	11.96	0.22	0.1%	0.00	0.0%	0.08	0.1%	0.00	0.0%	0.00	0.0%
READING ROCK SMR	NORTH	9.60	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.16	0.2%	0.00	0.0%
SEA LION GULCH SMR	NORTH	10.42	2.32	0.8%	0.19	0.2%	0.56	0.5%	2.86	3.6%	0.12	15.5%
TEN MILE SMR	NORTH	11.95	6.77	2.2%	2.43	2.3%	1.10	1.0%	0.50	0.6%	0.00	0.0%
MACKERRICHER SMCA	NORTH	2.48	3.91	1.3%	2.23	2.1%	0.00	0.0%	0.05	0.1%	0.00	0.0%
SAUNDERS REEF SMCA	NORTH	9.36	4.29	1.4%	1.11	1.1%	2.52	2.2%	1.65	2.1%	0.00	0.0%
STEWARTS POINT SMR	NORTH	24.06	4.57	1.5%	3.00	2.9%	3.03	2.6%	0.88	1.1%	0.00	0.0%
SALT POINT SMCA	NORTH	1.84	4.03	1.3%	3.84	3.7%	2.46	2.1%	0.54	0.7%	0.00	0.0%
BODEGA HEAD SMR	NORTH	9.34	2.74	0.9%	0.00	0.0%	2.27	2.0%	1.85	2.3%	0.00	0.0%
BODEGA HEAD SMCA	NORTH	12.31	0.29	0.1%	0.00	0.0%	1.33	1.2%	5.11	6.5%	0.00	0.0%
POINT REYES SMR	NORTH	9.55	5.37	1.8%	0.00	0.0%	1.49	1.3%	0.09	0.1%	0.00	0.0%
MONTARA SMR	CENTRAL	11.81	3.45	1.4%	0.55	0.4%	2.73	2.8%	0.72	1.6%	0.00	0.0%
AÑO NUEVO SMR	CENTRAL	11.15	6.86	2.9%	0.24	0.2%	1.83	1.9%	0.79	1.7%	0.00	0.0%
GREYHOUND ROCK SMCA	CENTRAL	12.00	3.39	1.4%	0.08	0.1%	2.38	2.5%	0.03	0.1%	0.00	0.0%
CARMEL BAY SMCA	CENTRAL	2.20	2.66	1.1%	2.57	1.7%	1.15	1.2%	0.12	0.3%	0.02	0.1%
POINT LOBOS SMR	CENTRAL	5.50	13.70	5.7%	4.61	3.1%	3.91	4.1%	1.38	3.0%	0.02	0.1%
PIEDRAS BLANCAS SMR	CENTRAL	10.44	6.09	2.5%	4.18	2.8%	2.10	2.2%	0.54	1.2%	0.00	0.0%
POINT BUCHON SMR	CENTRAL	6.68	2.71	1.1%	1.85	1.2%	2.59	2.7%	0.47	1.0%	0.00	0.0%
POINT BUCHON SMCA	CENTRAL	12.19	0.00	0.0%	0.00	0.0%	0.00	0.0%	0.32	0.7%	0.04	0.1%
VANDENBERG SMR	CENTRAL	32.91	10.21	4.3%	0.63	0.4%	1.45	1.5%	0.08	0.2%	0.00	0.0%
POINT CONCEPTION SMR	SOUTH	22.52	3.13	1.1%	1.29	0.5%	1.84	1.0%	0.32	0.7%	0.10	1.6%
CAMPUS POINT SMCA	SOUTH	10.56	1.37	0.5%	1.62	0.6%	1.85	1.0%	0.04	0.1%	0.00	0.0%
HARRIS POINT SMR	SOUTH	25.40	8.18	2.9%	2.30	0.9%	1.96	1.0%	2.40	5.0%	0.25	4.1%
CARRINGTON POINT SMR	SOUTH	12.78	5.35	1.9%	1.24	0.5%	1.97	1.0%	0.27	0.6%	0.00	0.0%
SCORPION SMR	SOUTH	9.64	4.07	1.4%	0.05	0.0%	0.69	0.4%	0.33	0.7%	0.01	0.1%
ANACAPA ISLAND SMCA	SOUTH	7.30	3.50	1.2%	0.00	0.0%	0.54	0.3%	0.03	0.1%	0.00	0.0%
ANACAPA ISLAND SMR	SOUTH	11.55	6.50	2.3%	0.65	0.3%	0.65	0.3%	0.10	0.2%	0.00	0.0%
POINT DUME SMCA	SOUTH	15.92	0.44	0.2%	0.85	0.3%	1.05	0.5%	0.00	0.0%	0.00	0.0%
POINT DUME SMR	SOUTH	7.53	1.54	0.5%	0.57	0.2%	0.47	0.2%	0.00	0.0%	0.89	14.7%
BLUE CAVERN ONSHORE SMCA	SOUTH	2.61	1.68	0.6%	1.40	0.6%	0.88	0.5%	0.01	0.0%	0.00	0.0%
LAGUNA BEACH SMR	SOUTH	6.72	2.48	0.9%	0.00	0.0%	1.13	0.6%	0.00	0.0%	0.00	0.0%
DANA POINT SMCA	SOUTH	3.47	2.06	0.7%	0.80	0.3%	1.67	0.9%	0.00	0.0%	0.00	0.0%
SWAMI'S SMCA	SOUTH	12.71	1.20	0.4%	1.44	0.6%	1.43	0.7%	0.02	0.0%	0.04	0.7%
SOUTH LA JOLLA SMR	SOUTH	5.04	1.45	0.5%	0.72	0.3%	1.95	1.0%	0.50	1.0%	0.00	0.0%
NORTH BIOREGION TOTAL		1618.90	301.58		104.23		114.65		79.24		0.76	
CENTRAL BIOREGION TOTAL		1317.84	238.83		151.07		95.97		46.60		29.98	
SOUTH BIOREGION TOTAL		2350.87	280.71		253.51		191.62		47.79		6.05	

*All miles are statute.

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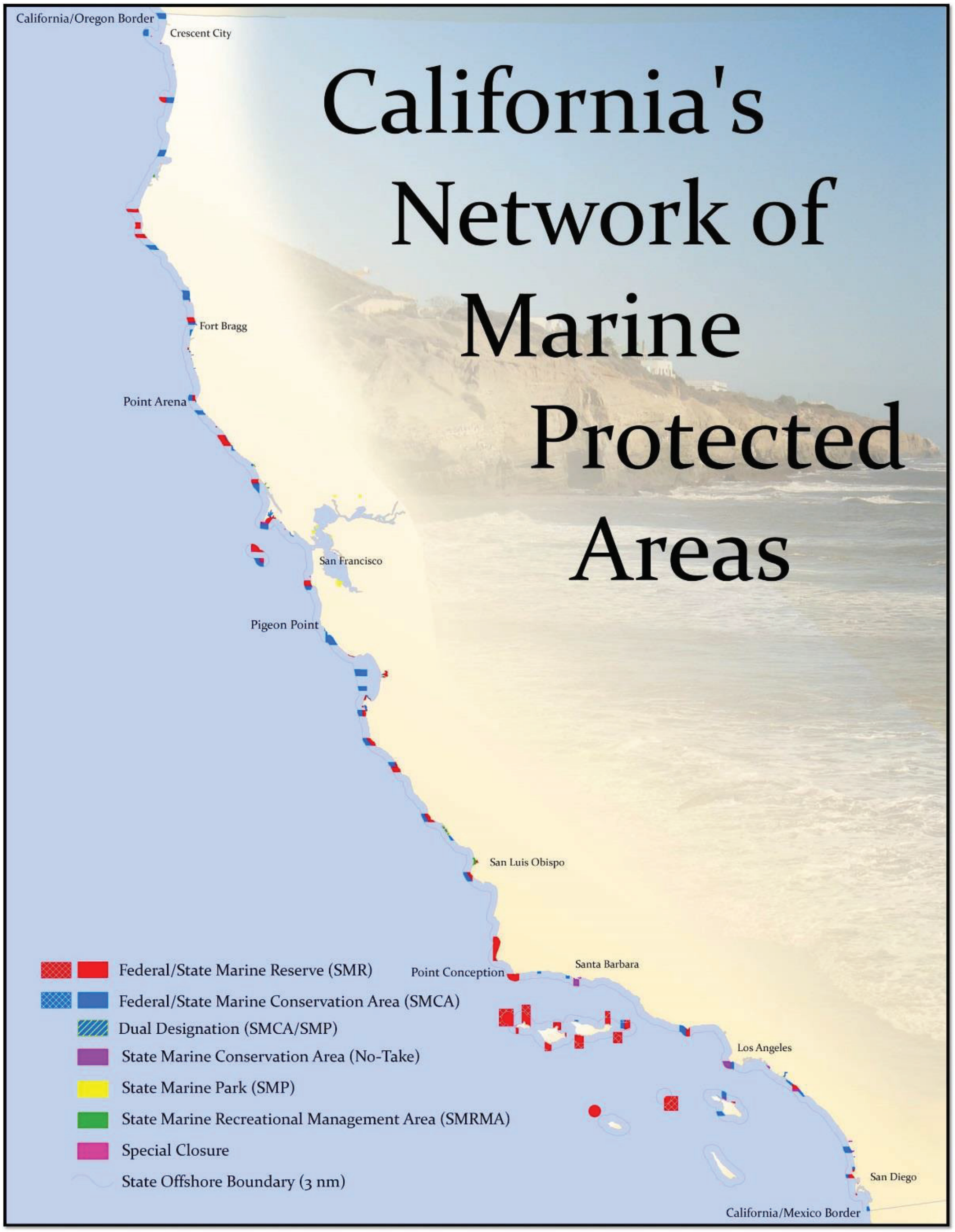
Appendix G:

PROCEEDINGS OF THE MARINE PROTECTED AREA SITE SELECTION WORKSHOP

Proceedings of the Marine Protected Area Site Selection Workshop

January 12, 2018

Long Marine Lab, University of California, Santa Cruz



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Executive Summary

California's marine protected areas (MPAs) were designed to function as a cohesive and ecologically connected network, pursuant to the Marine Life Protection Act (MLPA).[1] The MLPA also requires that the network be monitored to evaluate progress towards meeting the MLPA goals and to inform adaptive management.[2] As a first step, the state implemented Phase 1 of the Statewide MPA Monitoring Program (2007 – 2018) to conduct regional baseline monitoring near the time of MPA implementation. Baseline monitoring established a comprehensive benchmark of ecological and socioeconomic conditions across the state, and provided an important set of data against which future MPA performance can be measured.[3] Building on Phase 1, the California Department of Fish and Wildlife (CDFW) and California Ocean Protection Council (OPC) are developing priorities and strategies for Phase 2, statewide long-term monitoring. A Statewide MPA Monitoring Action Plan (Action Plan) is now under development by CDFW and OPC to prioritize MPA index sites, and ecological and socioeconomic indicators for long-term monitoring, and to help guide cost-effective spending and funding for future monitoring projects. The Action Plan will aggregate monitoring recommendations presented in Phase 1 regional MPA monitoring plans and technical reports with novel quantitative and expert informed approaches for long-term monitoring.

On January 12, 2018, CDFW and OPC convened a workshop titled "Marine Protected Area Site Selection" with collaborating researchers to discuss and develop recommendations and a shared understanding to inform the development of the Action Plan, including approaches for long-term monitoring design, detecting potential MPA effects, and predicting MPA effectiveness over time. Workshop participants identified core priorities for integrating discussed approaches to inform the Action Plan, and important next steps. Presentations and topics centered around:

1) Incorporating MPA design features and long-term monitoring datasets into site selection criteria
2) Monitoring that accounts for fisheries sustainability and ecosystem integrity goals
3) Using the state space integration projection model (SSIPM) to estimate fishing mortality rates to set expectations for population responses
4) Using spatial point process models for benthic visual survey and sampling design
5) Continued facilitation of a Regional Oceanographic Modeling System (ROMS) to estimate network connectivity

[1] California Fish and Game Code (FGC) §2850-2863.
[2] FGC §2853(c)(3). See also FGC §2852(a) and §2856(a)(2)(H).
[3] CDFW. (2016). California Marine Life Protection Act Master Plan for Marine Protected Areas. Adopted by the California Fish and Game Commission on August 24, 2016.

Overview

California has adopted a two-phase approach to MPA monitoring through the Statewide MPA Monitoring Program to track the ecological and socioeconomic conditions across the MPA network. Regional baseline monitoring (Phase 1) established a comprehensive benchmark of ecological and socioeconomic conditions at or near the time of MPA implementation in each of four regions across the state, including the central coast, north central coast, south coast, and north coast (Table 1). Phase 1 monitoring occurred from 2007 – 2018, and included 37 state-funded regional projects across the state (Table 1).

Table 1. Phase 1 regional baseline monitoring, including the number of regional projects, data collection period, analysis and sharing information period, and initial 5-year management review.

Coastal Region	Number of Projects	Collect Data	Analyze, Synthesize & Share Information	5-year Management Review
Central	5	2007 - 2010	2010 - 2013	2013
North Central	11	2010 - 2012	2012 - 2016	2016
South	10	2011 - 2013	2013 - 2017	2017
North	11	2014 - 2016	2016 - 2018	2018

Beginning in 2016, California is now designing and implementing statewide long-term monitoring (Phase 2) to reflect current priorities and management needs across agencies and mandates. Since it is unfeasible to monitor every one of California's MPAs each year, due to limitations of cost and time, the MLPA calls for "*monitoring, research, and evaluation at selected sites to facilitate adaptive management of MPAs…*".[4] Therefore, planning for Phase 2 includes drawing from Phase 1 to stitch together data and priorities on a statewide scale. Building long-term datasets at monitoring index sites using practical, cost-efficient, and standardized ecological indicators over sufficient time and geographic scale is necessary to evaluate MPA network performance, inform adaptive management decisions, and ensure that the MPA network is meeting the goals of the MLPA. To help further guide implementation of Phase 2 monitoring and cost-effective spending, CDFW and OPC are developing the Action Plan, beginning in early 2018 and anticipated for completion by Fall 2018 (Figure 1).

[4] FGC §2853(c)(3)

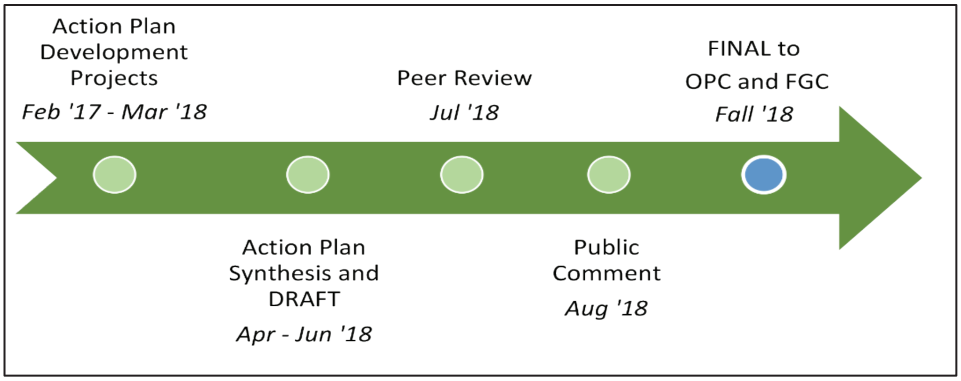

Figure 1. Draft timeline for Action Plan development and review.

The Action Plan will:

1) Be developed in a manner that is scientifically rigorous and builds on the local knowledge, capacity, and unique considerations from the MPA planning process and Phase 1 monitoring.
    a. E.g, MPA science design features, "State of the Region" summary reports[5,6,7,8] and CDFW's management recommendations regarding the first five years of regional MPA implementation,[9] and final technical reports for each of the 37 individual regional baseline projects.[10]
2) Incorporate quantitative and expert informed approaches to help prioritize MPA index sites, ecological and socioeconomic indicators, and other sampling design criteria for Phase 2.
    a. E.g., University of California, Santa Cruz (UCSC) ROMS to estimate network connectivity, and analyses by University of California, Davis (UCD)/CDFW post-doctoral researchers and California Ocean Science Trust (OST) science integration fellows
3) Guide cost-effective spending and funding for future monitoring projects.

Presentations and topics discussed at the January 12, 2018 "MPA Site Selection Workshop" included: [11]

- CDFW's MPA design features and monitoring matrices (Appendix B)
- Monitoring California's MPA network based on multiple objectives for adaptive management (Appendix C)
- Estimating values of local fishing mortality: Needed for both fisheries (Marine Life Management Act; MLMA) and MPAs (MLPA) (Appendix D)
- Spatial point process model for benthic visual survey and sampling design (Appendix E)
- Continued development of the UCSC ROMS to estimate network connectivity

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[5] OST and CDFW. (2013). *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*. California, USA. February 2013. 45 p.
[6] OST and CDFW. (2015). *State of the California North Central Coast: A Summary of the Marine Protected Area Monitoring Program 2010-2015*. California, USA. November 2015. 26 p.
[7] OST, CDFW, and OPC. (2017). *State of the California South Coast: Summary of Findings from Baseline Monitoring of Marine Protected Areas, 2011-2015*. California, USA. March 2017. 60 p.
[8] CDFW, OST, and OPC. (2017). *State of the California North Coast: Summary of Findings from Baseline Monitoring of Marine Protected Areas, 2013-2017*. California, USA. November 2017. 32 p.
[9] Available on CDFW's website: https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Research-And-Monitoring.
[10] Available on California Sea Grant's website: https://caseagrant.ucsd.edu/ongoing-projects/mpa-baseline-programs#ResearchSummaries.
[11] See Appendix A for a more complete list of presentations and topics discussed, and workshop purpose/objectives.

Presentations and Topics

1. CDFW's MPA Design Features and Monitoring Matrices

CDFW has developed matrices and an associated interactive mapping tool to facilitate the process of selecting and prioritizing long-term monitoring sites. Using a points-based system, CDFW demonstrated how priority MPAs were identified using key MPA design features (MPA Features Matrix) and information on historical monitoring conducted within MPAs prior to implementation (MPA Monitoring Matrix). The MPA Features Matrix includes criteria that were identified and evaluated during the MLPA Initiative public planning process such as core science design guidelines (e.g., size, habitat representation and replication, levels of protection, etc.;[12] as well as proximity to Areas of Special Biological Significance, and whether MPAs had a historical protected area within its boundaries) (Table 2).

Table 2. Example of records in the MPA Features Matrix. Abbreviations: level of protection (LOP), Areas of Special Biological Significance (ASBS).

MPA Name	MPA Size	MPA Size points	Rocky Shores-0.60 Linear Miles	Level of Protection	LoP Multiplier	ASBS % of MPA	ASBS points	Historic v. current size	Historic MPA LoP	TOTAL POINTS
Sea Lion Cove SMCA	0.2	0	1	mod low	0.2	0%	0.0	0.00	0	1.2
Saunders Reef SMCA	9.4	1	1	mod low	0.2	12%	0.1	0.00	0	2.3
Del Mar Landing SMR	0.2	0	1	very high	1	38%	0.4	0.41	0	2.8
Stewarts Point SMCA	1.2	0	1	low	0	0%	0.0	0.00	0	1.0
Stewarts Point SMR	24.1	2	1	very high	1	0%	0.0	0.00	0	4.0
Salt Point SMCA	1.8	0	1	mod low	0.2	0%	0.0	0.68	0	1.9
Gerstle Cove SMR	0.0	0	0	very high	1	84%	0.8	0.87	0	1.7
Russian River SMRMA	0.4	0	0	very high	1	0%	0.0	0.00	0	0.0
Russian River SMCA	0.8	0	0	mod	0.4	0%	0.0	0.00	0	0.0
Bodega Head SMR	9.3	1	1	very high	1	3%	0.0	0.05	1	4.1
Cluster - Bodega Head SMCA / Bodega Head SMR	21.7	2	1	mod high	0.6	1%	0.0	0.02	0.5	4.1
Bodega Head SMCA	12.3	1	0	mod high	0.6	0%	0.0	0.00	0	1.0
Estero Americano SMRMA	0.1	0	0	very high	1	0%	0.0	0.00	0	0.0

The MPA Monitoring Matrix includes sampling history for long-term monitoring efforts targeting specific ecosystems, that were uniformly and consistently conducted statewide prior to MLPA implementation, including:

- Rocky intertidal monitoring (Multi-Agency Rocky Intertidal Network biodiversity and fixed plot data),
- Nearshore (0-30 meter [m]) subtidal and kelp forest monitoring (PISCO and Reef Check California [RCCA] SCUBA data), and
- Mid-depth (30-100 m) remotely operated vehicle (ROV) monitoring (CDFW and Marine Applied Research and Monitoring [MARE])

The years of prior monitoring were tabulated as a time series for a single site within each MPA, and a multiplier was added to each MPA to account for the number of monitoring effort types occurring in each of the three target ecosystems (Table 3).

[12] See Appendix A, Section 4.3 of CDFW. (2016). California Marine Life Protection Act Master Plan for Marine Protected Areas. Adopted by the California Fish and Game Commission on August 24, 2016.

Table 3. Example of records in the MPA Monitoring Matrix. Abbreviations: rocky intertidal monitoring (RIM), kelp forest monitoring (KFM), mid-depth remotely operated vehicle monitoring (ROV).

MPA Name	RIM: PISCO Diversity	RIM: PISCO Fixed	KFM: RCCA	KFM: PISCO	ROV	Monitoring History Points	Monitoring Multiplier	TOTAL POINTS
Sea Lion Cove SMCA	3	12	3	2	0	20	2	40
Saunders Reef SMCA	2	2	0	3	1	8	3	24
Del Mar Landing SMR	2	3	0	2	0	7	2	14
Stewarts Point SMCA	0	0	0	2	0	2	1	2
Stewarts Point SMR	1	0	0	2	1	4	3	12
Salt Point SMCA	1	2	1	2	0	6	2	12
Gerstle Cove SMR	2	3	12	0	0	17	2	34
Russian River SMRMA	0	0	0	0	0	0	0	0
Russian River SMCA	1	1	0	0	0	2	1	2
Bodega Head SMR	7	17	0	0	4	28	2	56
Cluster - Bodega Head SMCA / Bodega Head SMR	3.5	8.5	0	0	4	16	2	32
Bodega Head SMCA	0	0	0	0	4	4	1	4
Estero Americano SMRMA	0	0	0	0	0	0	0	0

A third matrix (All Rankings Matrix) was presented which combines final scores from the MPA Features and MPA Monitoring Matrices. The All Rankings Matrix allows for sorting and filtering of either the MPA Features or Monitoring matrices individually and/or a combination of both to observe how MPAs compare against each other on both a regional and statewide basis (Table 4). Lastly, CDFW demonstrated a mapping tool designed to help visualize the matrices in a more user-friendly format. In conjunction with other quantitative tools and approaches presented at the workshop (described in the following topics), the matrices and mapping tool will help facilitate long-term MPA monitoring site selection and a likely probability of detecting an ecosystem response to protection over time.

Table 4. Example of records in the MPA Monitoring Matrix.

MPA Name	Statewide MPA Features	Statewide MPA Monitoring	Statewide Combo	Regional MPA Features	Regional MPA Monitoring	Regional Combo
Sea Lion Cove SMCA	Group 4	Group 4	Group 4	Group 4	Group 2	Group 3
Saunders Reef SMCA	Group 4	Group 4	Group 4	Group 3	Group 3	Group 3
Del Mar Landing SMR	Group 4	Group 4	Group 4	Group 4	Group 3	Group 4
Stewarts Point SMCA	Group 4	Group 4	Group 4	Group 4	Group 4	Group 4
Stewarts Point SMR	Group 2	Group 4	Group 3	Group 1	Group 3	Group 2
Salt Point SMCA	Group 4	Group 4	Group 4	Group 4	Group 3	Group 4
Gerstle Cove SMR	Group 4	Group 4	Group 4	Group 4	Group 2	Group 3
Russian River SMRMA	Group 4	Group 4	Group 4	Group 4	Group 4	Group 4
Russian River SMCA	Group 4	Group 4	Group 4	Group 4	Group 4	Group 4
Bodega Head SMR	Group 2	Group 3	Group 3	Group 1	Group 1	Group 1
Cluster - Bodega Head SMCA / Bodega Head SMR	Group 3	Group 4	Group 4	Group 3	Group 2	Group 3
Bodega Head SMCA	Group 4	Group 4	Group 4	Group 3	Group 4	Group 4
Estero Americano SMRMA	Group 4	Group 4	Group 4	Group 4	Group 4	Group 4

2. Monitoring California's MPA Network Based on Multiple Objectives for Adaptive Management

UCD/CDFW post-doctoral researcher Katie Kaplan is leading the collaborative development of an approach for:

a) <u>Timeline of expected fished population responses to California's MPAs</u>: To inform adaptive management, Kaplan et al. are setting expectations for species responses to MPAs and comparing those expectations to long-term monitoring data, in order to assess if MPAs are performing as expected. Determining a clear timeline for expectations can aid in the development of a monitoring program that evaluates expectations over realistic time frames for assessing populations responses to MPAs. Kaplan and Yamane et al. are working on projecting a timeline of fished population responses to MPAs, including 19 species to date (see Table 5 and Topic #3 below).

Table 5. Species selected to project a timeline of responses to MPAs.

Common name	Species name	Family	Maximum Age (years)[13]
Cabezon	*Scorpaenichthys marmoratus*	Cottidae	13
Kelp greenling	*Hexagrammos decagrammus*	Hexigrammidae	18
Kelp rockfish	*Sebastes atrovirens*	Scorpaenidae	20
California scorpionfish	*Scorpaena guttata*	Scorpaenidae	21
Black & yellow rockfish	*Sebastes chrysomelas*	Scorpaenidae	22
Lingcod	*Ophiodon elongatus*	Hexigrammidae	25
Gopher rockfish	*Sebastes carnatus*	Scorpaenidae	30
Olive rockfish	*Sebastes serranoides*	Scorpaenidae	30
Brown rockfish	*Sebastes auriculatus*	Scorpaenidae	34
Kelp bass	*Paralabrax clathratus*	Serranidae	34
Blue rockfish	*Sebastes mystinus*	Scorpaenidae	44
Black rockfish	*Sebastes melanops*	Scorpaenidae	50
Bocaccio	*Sebastes paucispinis*	Scorpaenidae	50
California sheephead	*Semicossyphus pulcher*	Labridae	53
Copper rockfish	*Sebastes caurinus*	Scorpaenidae	57
Vermillion rockfish	*Sebastes miniatus*	Scorpaenidae	60
Yellowtail rockfish	*Sebastes flavidus*	Scorpaenidae	64
China rockfish	*Sebastes nebulosus*	Scorpaenidae	79
Red sea urchin	*Mesocentrotus franciscanus*	Strongylocentrotidae	> 100 [14]

[13] Maximum reported age for the finfish species, according to FishBase (version 10/2017). http://www.fishbase.org.
[14] Tagging studies reveal that red sea urchins are long-lived, with large individuals possibly living beyond 100 years; according to Kalvass, P., Rogers-Bennett, L., Barsky, K., and C. Ryan. (2003). Red sea urchin. In: *Status of the Fisheries Report: An Update through* 2003 (Eds. Ryan, C. and M. Patyten). California Department of Fish and Game, Marine Region. p. 9-1 to 9-14.

Responses depend, in part, on the level of fishing mortality prior to MPA implementation. An age-structured population model was applied to assess the time required to reach final abundance (i.e., maximum MPA effect) for each fished species, and the length of time of a potential transient response was assessed using two different connectivity assumptions, an open and closed population model for each fished species. Additionally, populations with variable recruitment were assessed to provide a confidence interval around expected population responses with stochasticity considered. Preliminary estimated timelines are highly variable by species and their associated life history characteristics. For example, preliminary results indicate cabezon which have a maximum age of 13 years, may take 7 years to reach final abundance; while china rockfish which have a maximum lifespan of 79 years, may take 40 years to reach final abundance.

b) <u>Identifying community level metrics</u>: To identify indicators of community structure and function, a subsampling method was applied that correlates subsets of species to the full set of known species in the community. This method calculates the dissimilarities (using the Bray-Curtis dissimilarity index) for all pairs of sites sampled along the California coast for a given habitat monitored, and then determines the links between sites to assess relationships in space. The minimum number of species that correlate at 95% to the full set of species can then be selected as indicators of community structure (i.e., the minimum number of species to predict 95% of the full community effect). This minimum list of species can be subsequently compared with previous indicators identified from key MPA design aspects (e.g., species likely to benefit lists developed by the MLPA Science Advisory Team[15]) and supporting documents from Phase 1 baseline monitoring (e.g., regional MPA monitoring plans and baseline technical reports), to effectively learn and adapt on previous work moving forward.

c) <u>Integrated tiered approach to inform development of the Action Plan</u>: A tiered approach to identify indicator species can be based on (Figure 2):

- Level of harvest: Species that are directly targeted for harvest or commonly in bycatch or indirectly damaged by fishing methods,
- Life history traits and vulnerability to fishing pressure: Species that may be more vulnerable to fishing pressure and benefit more from protection based on life history traits such as limited adult home range, long life span, and low fecundity,
- Indicators of community structure and function: Species role in the ecosystem as ecological interactors, biogenic habitat, or level of trophic importance, and
- Broad-scale metrics from scientific literature and expert input (e.g., biodiversity and climate change indicators).

[15] See Appendix A, Section 4.3 of CDFW. (2016). California Marine Life Protection Act Master Plan for Marine Protected Areas. Adopted by the California Fish and Game Commission on August 24, 2016.

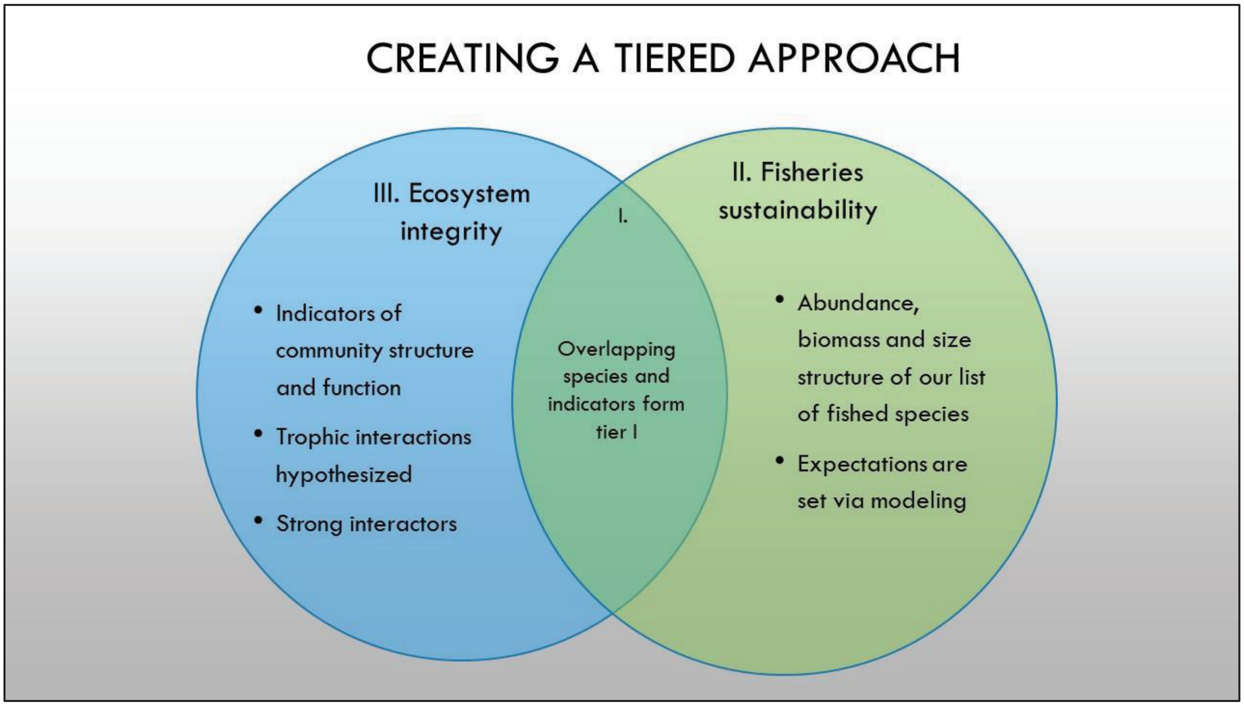


Figure 2. Conceptual schematic for creating an integrated tiered approach to identify indicator species. Tiers are defined in the "Key Outcomes and Next Steps" section.

3. Estimating Values of Local Fishing Mortality: Needed for Both Fisheries (MLMA) and MPAs (MLPA)

UCD/CDFW post-doctoral researcher Lauren Yamane is leading the collaborative development of an approach to estimate fishing pressure prior to MPA implementation to provide a better understanding of which species are likely to benefit from protection, and where MPA monitoring would most likely detect the greatest recovery due to protection. Original estimates used blue rockfish as the model indicator species at central coast sites,[16] while recent work has expanded to include south coast sites and more model species. A key challenge for this type of work is getting sufficiently large sample sizes and long data time-series lengths. The following tiered approach was used to determine fishing pressure and inform management decisions:

a) <u>Data-rich scenario</u>: This scenario applies to species and sites for which the SSIPM can be applied to estimate local fishing mortality rates (local F). Yamane et al. are estimating pre-MPA local F using the SSIPM applied to fisheries-independent data (e.g., PISCO, RCCA) for fished species (Table 5). This scenario is useful for identifying indicator species that may be appropriate for evaluation purposes. In general, it is expected that areas with greater historic fishing pressure would yield the highest biomass increases in response to MPAs. Higher local F generally correlates to increased truncation of size structure and therefore an increased ability to detect the filling in of size structure (Figure 3). Species characteristics resulting in the most precise estimates of local F include lower natural mortality (M) rates

[16] Blue rockfish is the most abundant monitored species, and has a long data time-series length of 9 years pre-MPA implementation.

(higher M can lead to underestimates of local F and greater error), a growth rate (k) exceeding M (e.g., k>M), and fished in early life history stages.

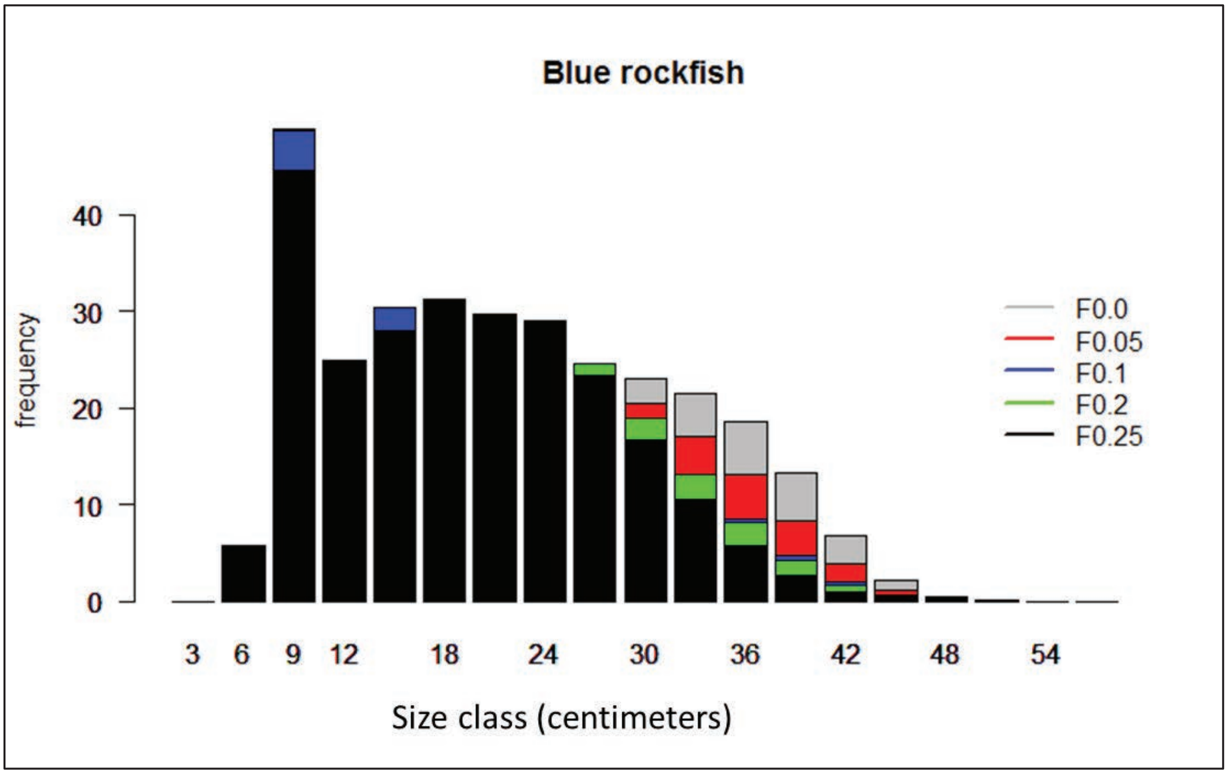


Figure 3. An example of the filling in of size structure for blue rockfish as local F increases.

Preliminary results indicate data-rich species with the most reliable estimates of local F based on biological characteristics include rockfishes (blue, vermillion, copper, yellowtail, kelp, china) and red sea urchin; and those with the least reliable estimates of local F are California scorpionfish, lingcod, cabezon, and kelp greenling. In addition, sites with larger sample sizes (i.e., number of fish lengths recorded per MPA and time step) and longer data time-series lengths lead to greater precision of local F estimates.

b) Data-moderate scenario: For those species and datasets which are not conducive for use with the SSIPM (e.g., important recreational species such as lingcod, cabezon, California scorpionfish, and kelp bass), Yamane et al. are estimating more general historical fishing effort across the state with fisheries-dependent data at relatively fine spatial scales. A primary example was presented by Olivia Rhoades, OST fellow, who is completing an analysis of relative historical fishing effort of private and rental skiff fisheries at a one minute of latitude by one minute of longitude scale using CDFW California Recreational Fisheries Survey data. The project will describe the level of relative fishing effort applied by recreational fishing boats throughout California from 2006 to 2011. This scenario is useful for informing site selection that may be appropriate for evaluation purposes.

c) Data-poor scenario: This scenario applies to sites where data-rich or data-moderate information is not available (e.g., the California north coast). Yamane et al. are estimating regional proxies for historical fishing (e.g., proxies such as distance to port, and using data-rich cases to understand data-poor cases), which is potentially useful for informing site selection.

4. Spatial Point Process Model for Benthic Visual Survey and Sampling Design

UCD/CDFW post-doctoral researcher Nick Perkins is leading the collaborative development of approaches to analyze and integrate an extensive ROV dataset collected by CDFW and MARE, including:

a) <u>Methods for analyzing ROV data</u>: Statistical analysis of ROV data is challenging due to data collection along transects and not accounting for spatial autocorrelation, which can lead to bias and errors. However, analysis approaches are rapidly evolving which may lead to robust estimates of species abundance. For example, Perkins et al. are exploring the use of spatial point process models to estimate species abundances within ROV sites and across subtidal rocky reef habitats (e.g., Bodega Head, Año Nuevo, and Pillar Point being developed as case studies). These models incorporate bathymetry-derived covariates (e.g., depth, slope, curvature, rugosity, and other substrate and habitat complexity layers at varying scales) combined with species presence/absence data (Figure 4). This approach can be compared with outputs from other approaches such as design-based estimates, non-spatial generalized linear models and generalized additive models.

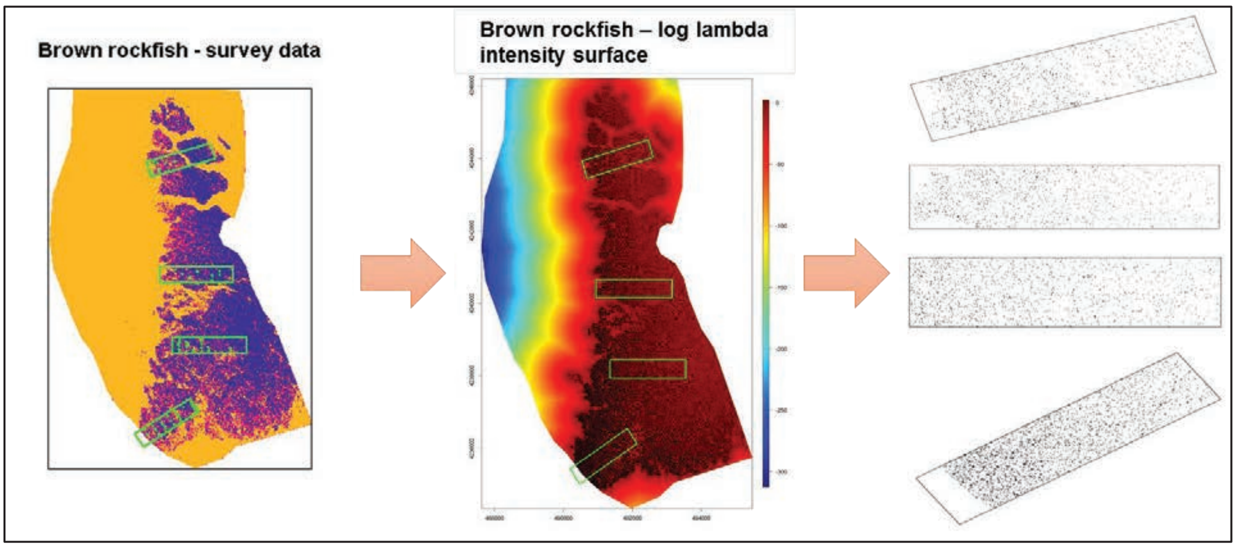


Figure 4. An example of using a spatial point process model to account for the occurrence of brown rockfish individuals in the Bodega Head area (left image), the intensity (i.e., number) of brown rockfish expected to occur in the area given the weighting of covariates (middle image), and predicted abundance across the area (right image).

b) <u>ROV sampling and survey design:</u> To ensure ROV sampling designs provide high enough statistical power to detect changes, Perkins et al. are incorporating outputs from spatial point process models (see Topic #4a above) to simulate species distributions across sites. These simulations will allow testing of the various sampling designs and levels of effort to evaluate and improve precision of surveys. Also, simulations of changing abundance and/or size distributions through time (e.g., using model species and data time-series of expected MPA recovery being worked on by Kaplan and Yamane et al.) will allow exploration of the interaction between sampling design and the statistical power needed to detect change. This will allow the trade-offs between sampling effort and an expected timeline to detect predicted changes to be explored.

c) <u>Eco-regionalization of subtidal communities:</u> Previous work has demonstrated that incorporating bioregions into analyses can improve estimates of species recovery, such as providing higher statistical power to detect MPA effects. By using ROV and SCUBA datasets, oceanographic (e.g., sea surface temperatures and indices, fronts, chlorophyll a, etc), and habitat data (1 kilometer cells); Perkins et al. are developing a regions of common profile (RCP) model to identify which species contribute most out of species groupings and important environmental drivers. The RCP model may be potentially useful for informing site selection by incorporating sampling effects, deriving data-driven maps of eco-regions across the state, and placing MPAs and reference sites in a broader environmental context. For example, the RCP model may aid developing expectations for whether bioregions with similar species assemblages and environmental drivers have similar MPA responses, and whether there is potential to link changes in communities and environmental conditions over time (and ensure MPA and reference sites are comparable over time).

5. Continued Development of a Regional Oceanographic Modeling System to Estimate Network Connectivity

UCSC researchers Pete Raimondi and Mark Carr are tailoring a ROMS to evaluate larval connectivity of rocky intertidal, shallow rocky reef/kelp forest (0-30m), and deep rock (30-100 m) habitats. The ROMS simulates the movement of planktonic larvae from each 5 kilometer cell under different temporal scenarios with respect to dispersal times (planktonic larval durations [PLDs]) and oceanographic conditions, and can be used to determine the effect of PLD on source-sink dynamics, including the relative contribution of larval production and degree of connectivity (Figure 5).

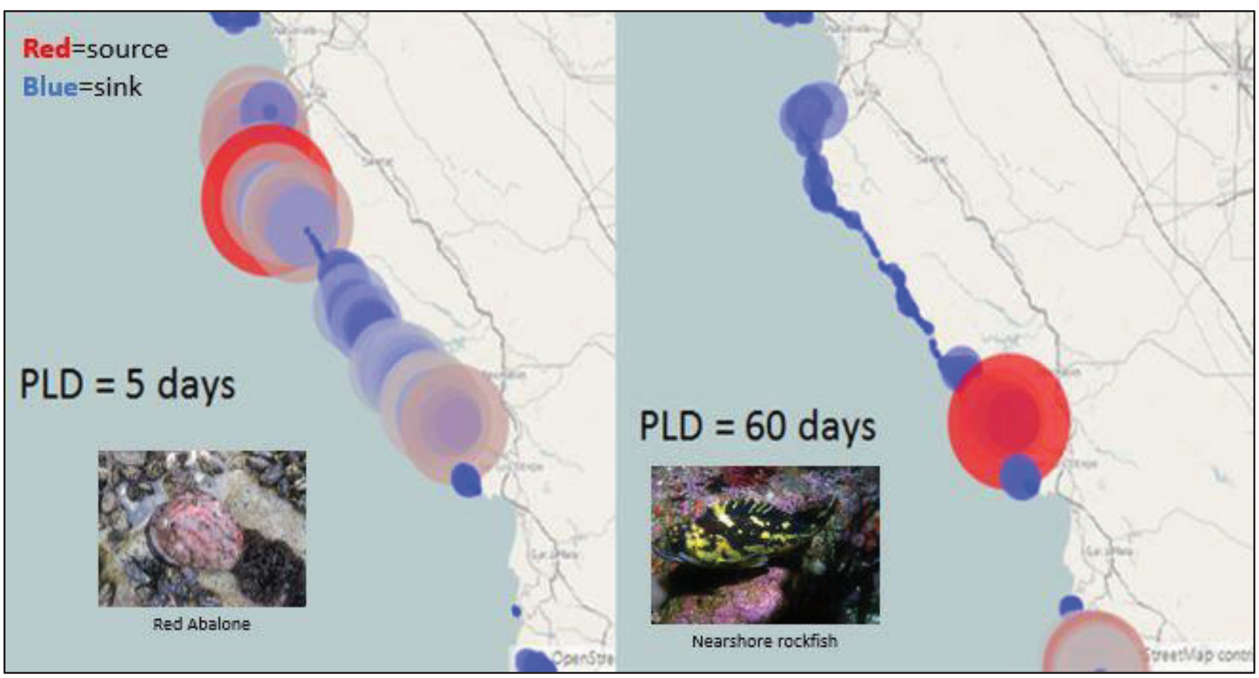


Figure 5. Preliminary results demonstrating the effect of PLD on regional connectivity in central California shallow 0-30m rocky reef/kelp forest habitat for species with a short PLD of 5 days, such as red abalone (left), and species with a longer PLD of 60 days, such as nearshore rockfishes (right). Bubble size indicates the degree of connectivity between cells (i.e., relative effect/contribution for larval production), with larger bubbles indicating areas of greater connectivity (i.e., source populations). Red bubbles represent larval sources, and blue bubbles represent larval sinks.

Several modifications and improvements were made to the ROMS since a focused ROMS workshop in August 2017.[17] First, in collaboration with CDFW, the mapping and habitat data used in the ROMS has been improved by filling in the shallow, nearshore 0-15m depth seafloor ("white zone") along the entire California coast with interpolated data (encompasses a 50-500m wide band of previously unmapped seafloor). Other small or missing areas of unmapped seafloor are now complete. In addition, the topology of ROMS cell relative to MPA boundaries was edited allowing better analysis of MPA vs. non-MPA sites. Continued development of the ROMS includes evaluating the current sensitivity of the model (i.e., determine what counts as a connected link), incorporating various levels of protection and geomorphological attributes, and expanding habitat inputs (particularly from Oregon and Mexico).

Key Outcomes & Next Steps

The key outcome is that the January 12, 2018 workshop, convened by CDFW and OPC, provided an important venue to discuss, inform, and facilitate a variety of long-term monitoring approaches and analyses underway. Using these approaches and analyses, the Action Plan will have prioritized long-term monitoring metrics and sites, and guide resource allocation for Phase 2. Workshop participants also determined a tiered approach for determining indicator species, first based on a classification scheme using three groupings: *Group 1* includes fished species exhibiting SSIPM high predictability and high response, *Group 2* includes fished species exhibiting SSIPM high and medium predictability, high response, and/or a commercially and recreationally important species, and *Group 3* includes ecologically important species.[18] Identifying these groups helped inform a tiered species prioritization method developed following the workshop. Identifying select indicators species will be based on the following three tiers:

- **Tier 1**: Species that experience some level of take, may be good MPA indicators due to certain life history traits, and play a role in ecosystem function.
- **Tier 2**: Species that experience some level of take and may be good MPA indicators.
- **Tier 3**: Species that experience no level of take, but play a role in ecosystem function.

Next steps include vetting species lists through a peer review process, and incorporating expert input. Additionally, UCD/CDFW post-doctoral researchers are tasked with generating estimates of local F for 19 species to see how well they perform by February – early March 2018. Workshop participants will continue to discuss and resolve the tiered approach for determining indicator species, such as fleshing out the vulnerability aspect of *Group 3*. Finally, CDFW was tasked with providing insights for current questions regarding the ROMS model, including:

- Is bioregional representation necessary?
    - CDFW response: Yes. It is important to have good coverage of priority MPAs for long-term monitoring in each bioregion.
- Should regional representation be proportional or not?

[17] CDFW. (2017). *Proceedings of the Regional Ocean Model System Overview Workshop*. University of California, Santa Cruz, August 10-11, 2017. 17 pages.
[18] Identifying *Group 3* species should primarily focus on whether they are functionally important (e.g., high interaction strength, habitat forming, have direct effects on community structure), but also on whether they are vulnerable (e.g., susceptible to climate change, environmental, and fishing impacts).

  - CDFW response: Our current approach is to pick a representational set of MPAs in each bioregion so that tier 1 MPAs are distributed relatively evenly across the entire network.
- Should a particular metric be developed to gauge the relative importance of individual locations to supplying propagules to MPAs, to SMRs, or to cells in general?
  - CDFW response: To start, we would like to see the supply to cells in general. Once we have the results we can target specific locations inside and outside MPAs.
- Should there be a mix of index sites that include places that are characterized as sources, as sinks, and/or a combination of both sources and sinks?
  - CDFW response: Ideally, we will prioritize a mix of both sources and sinks in any given region.

Appendix A: Workshop Agenda

Marine Protected Areas Site Selection Workshop

January 12, 2018; 8 AM to 4 PM

Long Marine Lab, UC Santa Cruz
Classroom 118, Center for Ocean Health
115 McAllister Way, Santa Cruz CA 95060

Workshop Purpose/Objectives:

- Inform the development of MPA site selection for Statewide Monitoring Action Plan. To this effect:
    - Receive updates on analytical approaches to spatial sampling design
    - Discuss and identify the best approaches for detecting MPA effects and predict effectiveness through monitoring
    - Develop recommendations for integrating discussed approaches to inform the Statewide MPA Monitoring Action Plan

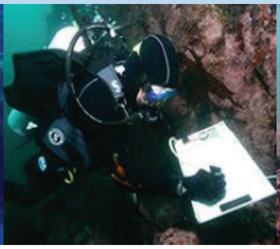
Time	ITEM	PRESENTER
8:00 AM	Introductions and Workshop Purpose	Becky Ota Cyndi Dawson
8:15	Presentation and Discussion: update on MLPA Initiative planning and habitat matrix and interactive map	Amanda Van Diggelen
8:45	Presentation and Discussion: update on Regional Oceanographic Modeling System	Peter Raimondi
9:05	Presentation and Discussion: update on spatial point process model for benthic visual survey and sampling design	Nick Perkins
9:25	Presentation and Discussion: update on state space integration projection model	Lauren Yamane
9:45	Presentation Discussion: approaches for monitoring species responses to MPAs and community level metrics	Katie Kaplan
10:05	BREAK	
10:20	Group Discussion and Brainstorm: integration of information	All (plenary)
12:00 PM	LUNCH (lunch will be brought in; bring $10 cash for food)	
12:30	Continued Group Discussion and Brainstorm	All (plenary)
2:15	BREAK	
2:30	Continued Group Discussion and Brainstorm	All (plenary)
3:30	Overview, reflections, and next steps	Becky Ota
4:00	Adjourn	

(Appendix B)
CDFW's MPA Features and Monitoring Matrices

CALIFORNIA MARINE PROTECTED AREAS

Amanda Van Diggelen, Environmental Scientist
MPA Site Selection Workshop, Santa Cruz, CA
January 12, 2018






Matrices

1) Key Marine Protected Areas (MPA) Design Features

- MPA size
- Habitat thresholds
- Level of protection (LOP)
- Areas of Special Biological Significance (ASBS)
- Historical MPAs

MPA Name	MPA Size	MPA Size points	Rocky Shores-0.60 Linear Miles	Level of Protection	LoP Multiplier	ASBS % of MPA	ASBS points	Historic v. current size	Historic MPA LoP	TOTAL POINTS
Sea Lion Cove SMCA	0.2	0	1	mod low	0.2	0%	0.0	0.00	0	1.2
Saunders Reef SMCA	9.4	1	1	mod low	0.2	12%	0.1	0.00	0	2.3
Del Mar Landing SMR	0.2	0	1	very high	1	38%	0.4	0.41	0	2.8
Stewarts Point SMCA	1.2	0	1	low	0	0%	0.0	0.00	0	1.0
Stewarts Point SMR	24.1	2	1	very high	1	0%	0.0	0.00	0	4.0
Salt Point SMCA	1.8	0	1	mod low	0.2	0%	0.0	0.68	0	1.9
Gerstle Cove SMR	0.0	0	0	very high	1	84%	0.8	0.87	0	1.7
Russian River SMRMA	0.4	0	0	very high	1	0%	0.0	0.00	0	0.0
Russian River SMCA	0.8	0	0	mod	0.4	0%	0.0	0.00	0	0.0
Bodega Head SMR	9.3	1	1	very high	1	3%	0.0	0.05	1	4.1
Cluster - Bodega Head SMCA / Bodega Head SMR	21.7	2	1	mod high	0.6	1%	0.0	0.02	0.5	4.1
Bodega Head SMCA	12.3	1	0	mod high	0.6	0%	0.0	0.00	0	1.0
Estero Americano SMRMA	0.1	0	0	very high	1	0%	0.0	0.00	0	0.0

Matrices

2) MPA Monitoring

- Rocky Intertidal (RIM)
  - Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO)
- Kelp Forest (0-30m; KFM)
  - Reef Check California (RCCA)
  - PISCO
- Mid-depth rock (30-100m; ROV)
  - Department of Fish and Wildlife
  - Marine Applied Research and Monitoring

MPA Name	RIM: PISCO Diversity	RIM: PISCO Fixed	KFM: RCCA	KFM: PISCO	ROV	Monitoring History Points	Monitoring Multiplier	TOTAL POINTS
Sea Lion Cove SMCA	3	12	3	2	0	20	2	40
Saunders Reef SMCA	2	2	0	3	1	8	3	24
Del Mar Landing SMR	2	3	0	2	0	7	2	14
Stewarts Point SMCA	0	0	0	2	0	2	1	2
Stewarts Point SMR	1	0	0	2	1	4	3	12
Salt Point SMCA	1	2	1	2	0	6	2	12
Gerstle Cove SMR	2	3	12	0	0	17	2	34
Russian River SMRMA	0	0	0	0	0	0	0	0
Russian River SMCA	1	1	0	0	0	2	1	2
Bodega Head SMR	7	17	0	0	4	28	2	56
Cluster - Bodega Head SMCA / Bodega Head SMR	3.5	8.5	0	0	4	16	2	32
Bodega Head SMCA	0	0	0	0	4	4	1	4
Estero Americano SMRMA	0	0	0	0	0	0	0	0

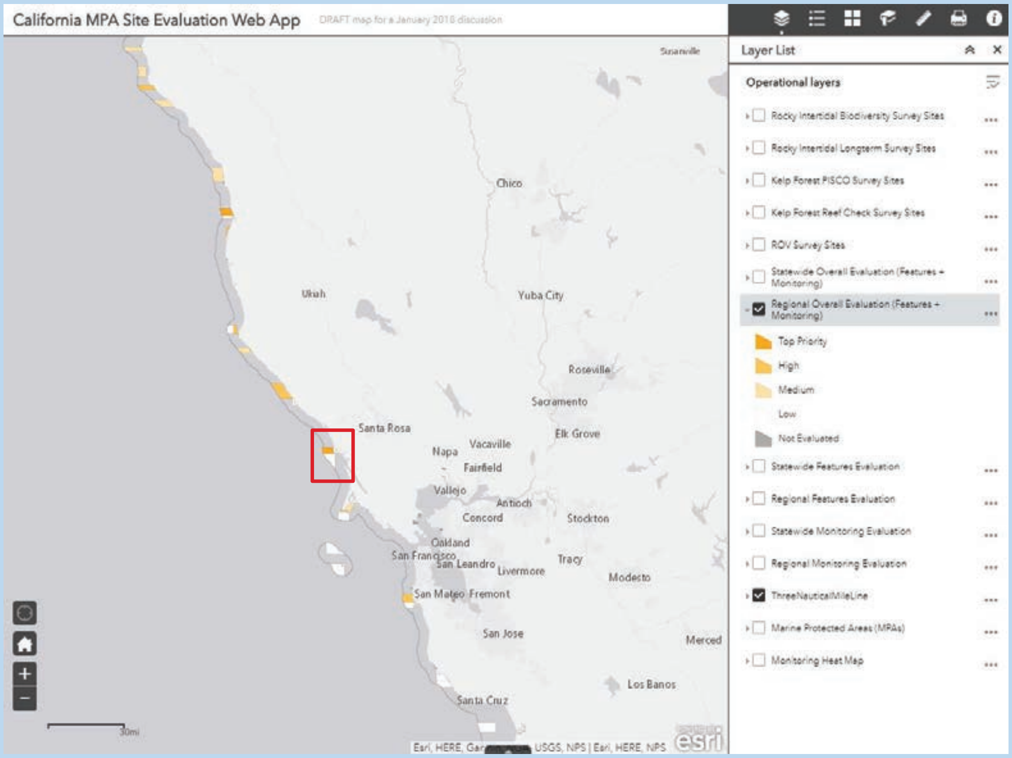
Matrices

1) MPA Features + 2) MPA Monitoring = 3) All Rankings

- Final MPA siting priorities

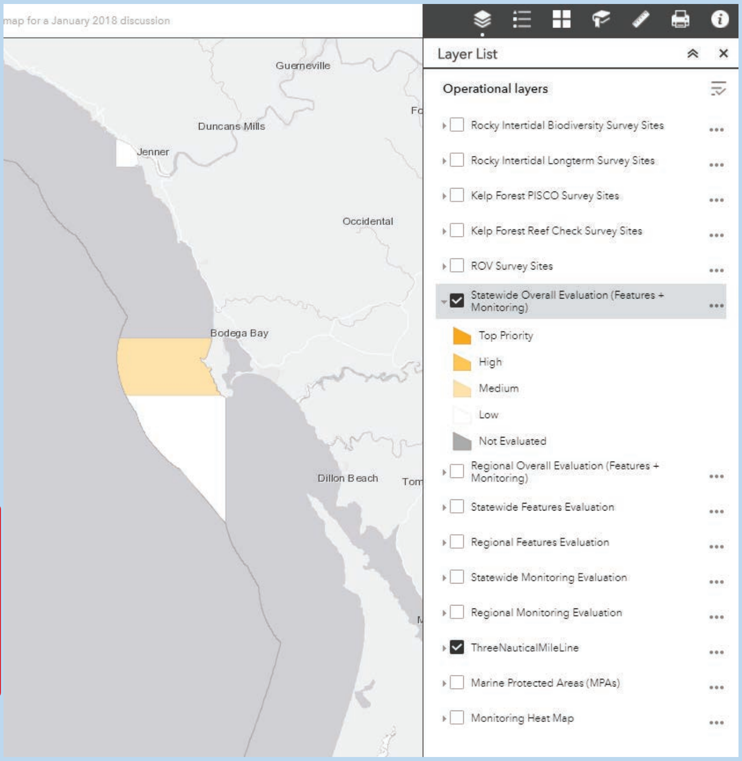
MPA Name	Statewide MPA Features	Statewide MPA Monitoring	Statewide Combo	Regional MPA Features	Regional MPA Monitoring	Regional Combo
Sea Lion Cove SMCA	4 Low	4 Low	4 Low	4 Low	2 High	3 Medium
Saunders Reef SMCA	4 Low	4 Low	4 Low	3 Medium	3 Medium	3 Medium
Del Mar Landing SMR	4 Low	4 Low	4 Low	4 Low	3 Medium	4 Low
Stewarts Point SMCA	4 Low	4 Low	4 Low	4 Low	4 Low	4 Low
Stewarts Point SMR	2 High	4 Low	3 Medium	1 Priority	3 Medium	2 High
Salt Point SMCA	4 Low	4 Low	4 Low	4 Low	3 Medium	4 Low
Gerstle Cove SMR	4 Low	4 Low	4 Low	4 Low	2 High	3 Medium
Russian River SMRMA	4 Low	4 Low	4 Low	4 Low	4 Low	4 Low
Russian River SMCA	4 Low	4 Low	4 Low	4 Low	4 Low	4 Low
Bodega Head SMR	2 High	3 Medium	3 Medium	1 Priority	1 Priority	1 Priority
Cluster - Bodega Head SMCA / Bodega Head SMR	3 Medium	4 Low	4 Low	3 Medium	2 High	3 Medium
Bodega Head SMCA	4 Low	4 Low	4 Low	3 Medium	4 Low	4 Low
Estero Americano SMRMA	4 Low	4 Low	4 Low	4 Low	4 Low	4 Low

Interactive Mapping Tool



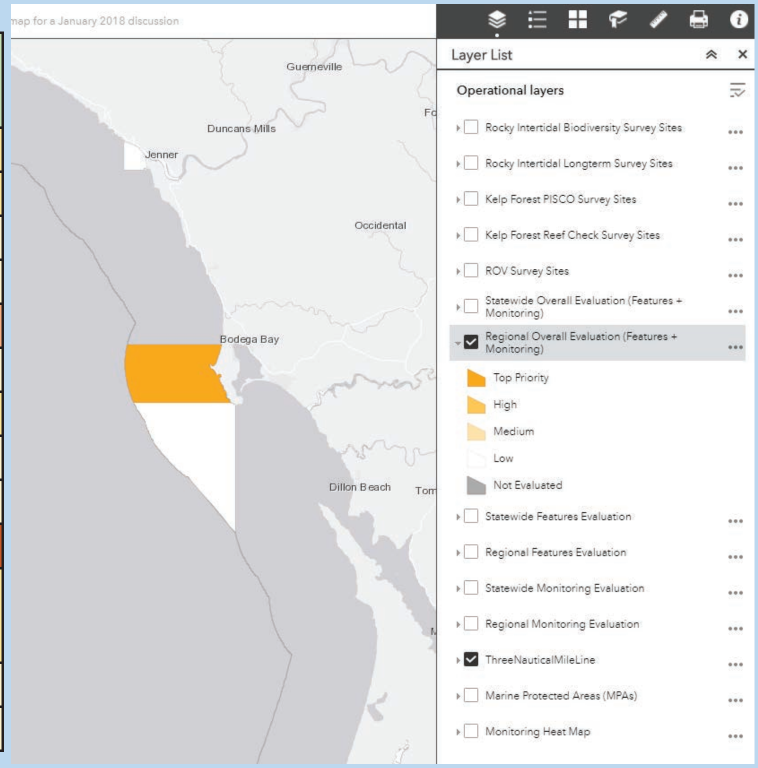
Mapping Tool and Matrix

MPA Name	Statewide Features	Statewide Monitoring	Statewide Combo
Sea Lion Cove SMCA	4 Low	4 Low	4 Low
Saunders Reef SMCA	4 Low	4 Low	4 Low
Del Mar Landing SMR	4 Low	4 Low	4 Low
Stewarts Point SMCA	4 Low	4 Low	4 Low
Stewarts Point SMR	2 High	4 Low	3 Med
Salt Point SMCA	4 Low	4 Low	4 Low
Gerstle Cove SMR	4 Low	4 Low	4 Low
Russian River SMRMA	4 Low	4 Low	4 Low
Russian River SMCA	4 Low	4 Low	4 Low
Bodega Head SMR	2 High	3 Med	3 Med
Cluster - Bodega Head SMCA / Bodega Head SMR	3 Med	4 Low	4 Low
Bodega Head SMCA	4 Low	4 Low	4 Low
Estero Americano SMRMA	4 Low	4 Low	4 Low



Mapping Tool and Matrix

MPA Name	Regional Features	Regional Monitoring	Regional Combo
Sea Lion Cove SMCA	4 Low	2 High	3 Med
Saunders Reef SMCA	3 Med	3 Med	3 Med
Del Mar Landing SMR	4 Low	3 Med	4 Low
Stewarts Point SMCA	4 Low	4 Low	4 Low
Stewarts Point SMR	1 Priority	3 Med	2 High
Salt Point SMCA	4 Low	3 Med	4 Low
Gerstle Cove SMR	4 Low	2 High	3 Med
Russian River SMRMA	4 Low	4 Low	4 Low
Russian River SMCA	4 Low	4 Low	4 Low
Bodega Head SMR	1 Priority	1 Priority	1 Priority
Cluster - Bodega Head SMCA / Bodega Head SMR	3 Med	2 High	3 Med
Bodega Head SMCA	3 Med	4 Low	4 Low
Estero Americano SMRMA	4 Low	4 Low	4 Low



Potential Sites Example

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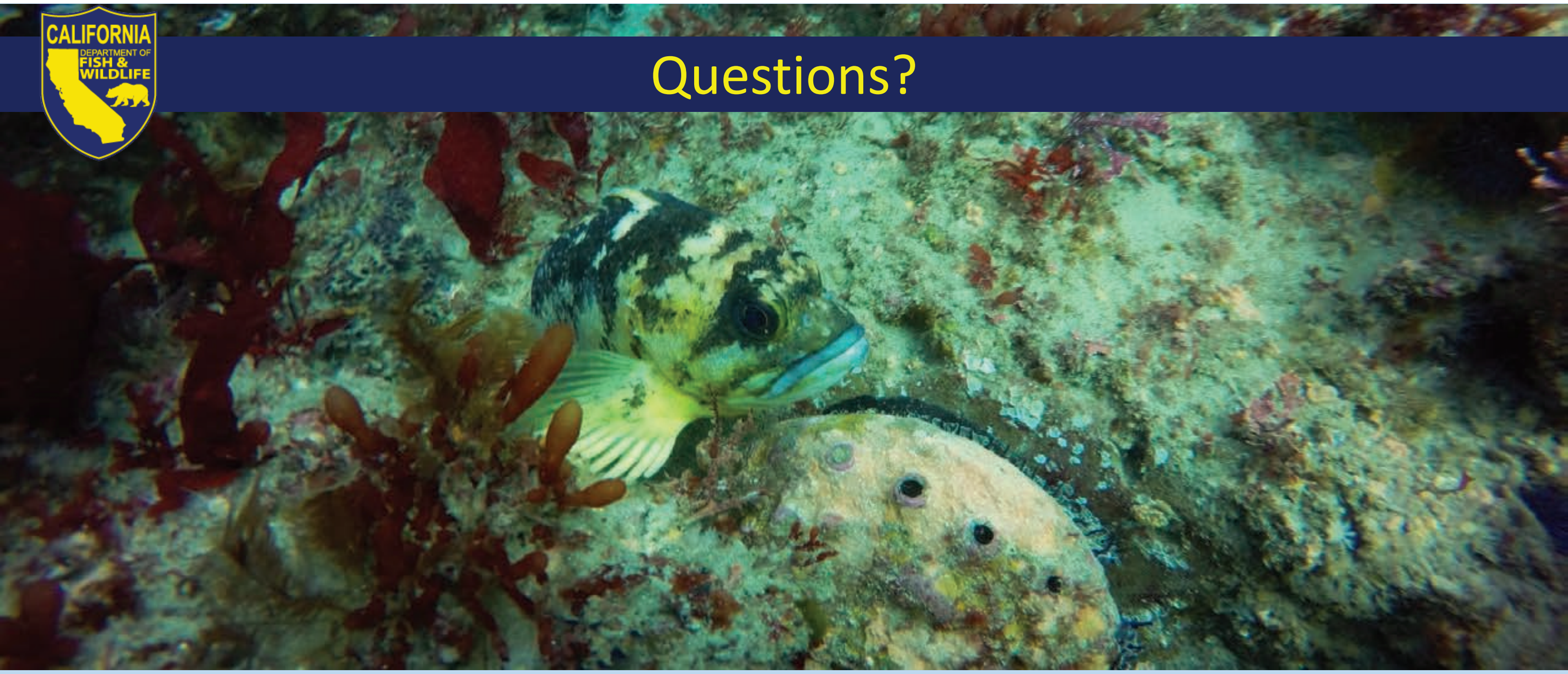
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	MPA Name	IMPORTANT: ALWAYS SORT THIS A TO Z AFTER OTHER FILTERS ARE USED IN ORDER TO LOOK AT PRIORITIES BY REGION Region	MPA Groupin	MPA Survey Group	MPA type	Final_Monitoring Priority STATEWIDE (Priority=top 10; high=top 20, medium=top 40; low=remaining)	Final_MPA Features Priority STATEWIDE (Priority=top 10; high=top 20, medium=top 40; low=remaining)	Final_Combo Priority STATEWIDE (Priority=Priority & Priority; High= Priority & High or High & High; Medium= High & Med or Med & Med; Low= Med & Low or Low & Low)		Final_Monitoring Priority REGIONAL (Priority=top 2; high=top 5, medium=top 15; low=remaining)	Final_MPA Features Priority REGIONAL (Priority=top 2; high=top 5, medium=top 15; low=remaining)	Final_Combo Priority REGIONAL (Priority=Priority & Priority; High= Priority & High or High & High; Medium= High & Med or Med & Med; Low= Med & Low or Low & Low)		ROV Monitoring	KF Monitoring	RI Monitorin		Site Selection Justification
8	Cluster - Point Arena SMCA / Point Arena SMR	2 North Central	Cluster	NCC1	Coastal	4 Low	3 Medium	4 Low		3 Medium	3 Medium	3 Medium		Yes	Yes	Yes		This cluster is limited for SMR vs SMC
9	Point Arena SMCA	2 North Central	Single	NCC1	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	No		This SMCA will only support ROV rese location and monitor only the SMR si
10	Sea Lion Cove SMCA	2 North Central	Single	NCC1	Coastal	4 Low	4 Low	4 Low		2 High	4 Low	3 Medium		No	Yes	Yes		Small MPA adjacent to an SMR that p based kelp forest and rocky intertidal
11	Salt Point SMCA	2 North Central	Single	NCC2	Coastal	4 Low	4 Low	4 Low		3 Medium	4 Low	4 Low		No	Yes	Yes		Chose this site since it closes the gap this is a potential site that can be swit
12	Gerstle Cove SMR	2 North Central	Single	NCC2	Coastal	4 Low	4 Low	4 Low		3 Medium	4 Low	4 Low		No	Yes	Yes		Same as row 11 information
13	Bodega Head SMR	2 North Central	Single	NCC3	Coastal	3 Medium	2 High	3 Medium		1 Priority	1 Priority	1 Priority		Yes	No	Yes		This is the highest ranking MPA in the region, but doesnot have any KFM d
14	Cluster - Bodega Head SMCA / Bodega Head SMR	2 North Central	Cluster	NCC3	Coastal	4 Low	3 Medium	4 Low		2 High	3 Medium	3 Medium		Yes	No	Yes		The Bodega cluster will be useful for comparison
15	Bodega Head SMCA	2 North Central	Single	NCC3	Coastal	4 Low	4 Low	4 Low		4 Low	3 Medium	4 Low		Yes	No	No		The SMCA is primarily offshore and d ROV
16	Montara SMR	2 North Central	Single	NCC4	Coastal	4 Low	3 Medium	4 Low		2 High	2 High	2 High		Yes	Yes	Yes		This MPA has had previous monitorin closes the spacing difference betwe
17	Cluster - Pillar Point SMCA / Montara SMR	2 North Central	Cluster	NCC4	Coastal	4 Low	3 Medium	4 Low		3 Medium	2 High	3 Medium		Yes	Yes	No		May consider droppping the cluster a as a medium priority in the region
18	Pillar Point SMCA	2 North Central	Single	NCC4	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	No		Same as row 17 information
19	Natural Bridges SMR	3 Central	Single	CC1	Coastal	2 High	4 Low	3 Medium		3 Medium	4 Low	4 Low		No	Yes	Yes		This site will help close the spacing g has KRM data available as well; this s
20	Carmel Bay SMCA	3 Central	Single	CC2	Coastal	1 Priority	4 Low	3 Medium		1 Priority	3 Medium	2 High		Yes	Yes	Yes		Adjacent to an SMR that prohibits tal forest and rocky intertidal monitoring;
21	Point Lobos SMR	3 Central	Single	CC2	Coastal	1 Priority	2 High	2 High		1 Priority	3 Medium	2 High		Yes	Yes	Yes		This is a highest state priority site; the allow for SMR vs SMCA ROV compar
22	Cluster - Point Lobos SMCA / Point Lobos SMR	3 Central	Cluster	CC2	Coastal	2 High	2 High	2 High		3 Medium	3 Medium	3 Medium		Yes	Yes	Yes		The Pt Lobos cluster will be useful fo KFMcomparison
23	Point Lobos SMCA	3 Central	Single	CC2	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	No		The SMCA is offshore and doesn't h
24	Point Sur SMR	3 Central	Single	CC3	Coastal	1 Priority	2 High	2 High		2 High	3 Medium	3 Medium		Yes	Yes	Yes		This is a highest state priority site; ha
25	Cluster - Point Sur SMCA / Point Sur SMR	3 Central	Cluster	CC3	Coastal	3 Medium	2 High	3 Medium		3 Medium	2 High	3 Medium		Yes	Yes	Yes		The Pt Sur cluster will be useful for a comparison
26	Point Sur SMCA	3 Central	Single	CC3	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	No		The SMCA is offshore and doesn't h recommend using this cluster and jus
27	Piedras Blancas SMR	3 Central	Single	CC4	Coastal	2 High	1 Priority	2 High		2 High	2 High	2 High		Yes	Yes	Yes		This SMR has all three types of monit oceanogrpahic linkages between Po
28	Cluster - Piedras Blancas SMCA / Piedras Blancas SMR	3 Central	Cluster	CC4	Coastal	4 Low	1 Priority	3 Medium		4 Low	1 Priority	3 Medium		Yes	Yes	Yes		This cluster is limited for SMR vs SMC
29	Piedras Blancas SMCA	3 Central	Single	CC4	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	No		The SMCA is offshore and doesn't h
30	Point Buchon SMR	3 Central	Single	CC5	Coastal	3 Medium	3 Medium	3 Medium		3 Medium	3 Medium	3 Medium		Yes	Yes	Yes		This SMR has all three types of monit
31	Cluster - Point Buchon SMCA / Point Buchon SMR	3 Central	Cluster	CC5	Coastal	4 Low	2 High	3 Medium		4 Low	2 High	3 Medium		Yes	Yes	Yes		Recommend keeping this cluster to s
32	Point Buchon SMCA	3 Central	Single	CC5	Coastal	4 Low	4 Low	4 Low		4 Low	4 Low	4 Low		Yes	No	Yes		Flagging for Sara: this is an offshore
33	Campus Point SMCA	4 South	Single	SC1	Coastal	1 Priority	1 Priority	1 Priority		2 High	3 Medium	3 Medium		Yes	Yes	Yes	3	Monitoring data for all three survey m
34	Harris Point SMR	4 South	Single	SC2	Coastal	1 Priority	1 Priority	1 Priority		1 Priority	1 Priority	1 Priority		Yes	Yes	Yes	3	Monitoring data for all three survey m justify site selection
35	Anacapa Island SMCA	4 South	Single	SC3	Coastal	3 Medium	4 Low	4 Low		3 Medium	4 Low	4 Low		Yes	Yes	No	2	Does not have RIM data available bu to date:



Amanda Van Diggelen
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CALIFORNIA MARINE PROTECTED AREAS

(Appendix C)

MONITORING CALIFORNIA'S MPA NETWORK BASED ON MULTIPLE OBJECTIVES FOR ADAPTIVE MANAGEMENT

JANUARY 12TH, 2018

MPA WORKSHOP

OUTLINE

- I. INTRODUCTION
- II. MLPA GOAL: FISHERIES SUSTAINABILITY
  - RESPONSE OF AN OPEN POPULATION
  - RESPONSE OF A CLOSED POPULATION
- III. MLPA GOAL: ECOSYSTEM STRUCTURE, FUNCTION INTEGRITY
  - DIRECT EFFECTS: TARGETED SPECIES THAT ALSO PLAY A STRONG ROLE IN ECOSYSTEM STRUCTURE/FUNCTION
  - INDIRECT EFFECTS: SPECIES IMPACTED BY FISHED SPECIES (I.E. FOOD WEB DYNAMICS)
  - INDICATORS OF COMMUNITY STRUCTURE THAT ARE NOT AFFECTED BY FISHED SPECIES (I.E. HABITAT FORMING SPECIES)
  - BROAD-SCALE METRICS FROM THE LITERATURE (BIODIVERSITY INDICATORS)
- IV. PUTTING IT ALL TOGETHER INTO ONE APPROACH

DESIGNING AND IMPLEMENTING A MONITORING PLAN FOR ADAPTIVE MANAGEMENT

- FIRST STEP IS TO DETERMINE EXPECTATIONS OF SPECIES RESPONSES TO MPAS
- THEN LONG-TERM MONITORING EVALUATES IF EXPECTATIONS WERE MET

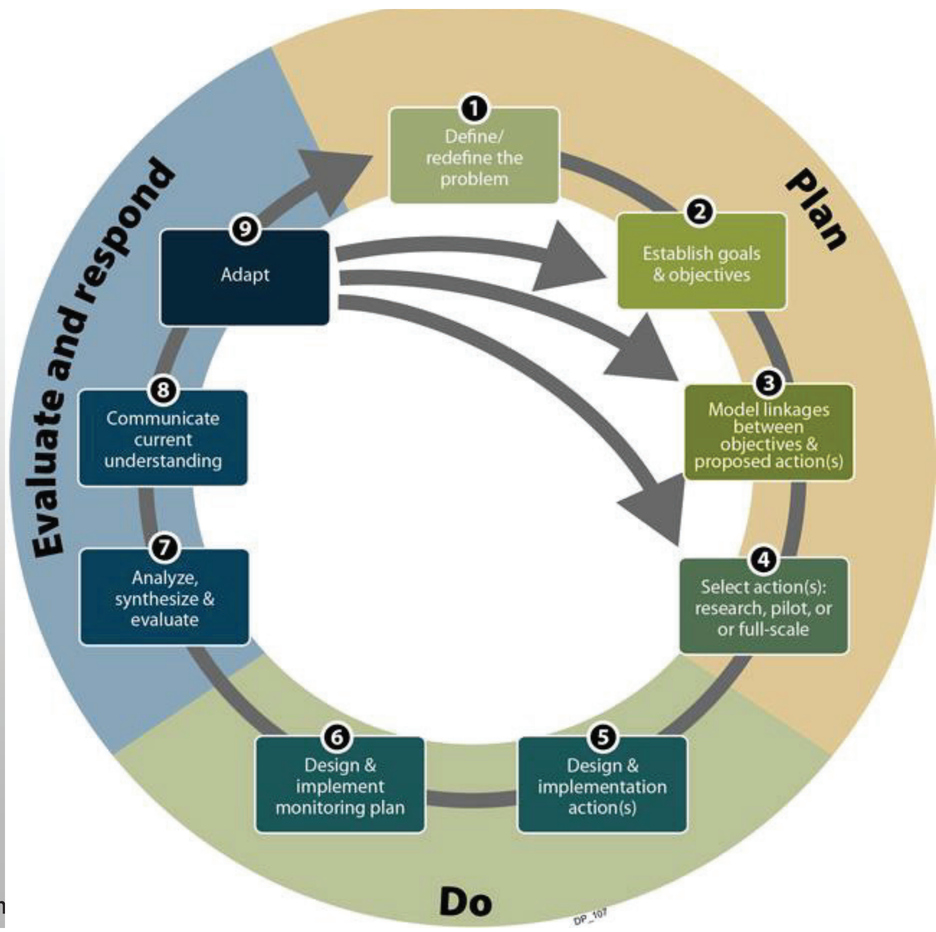


Figure credit: http://www.dfg.ca.gov/erp/adaptive_m

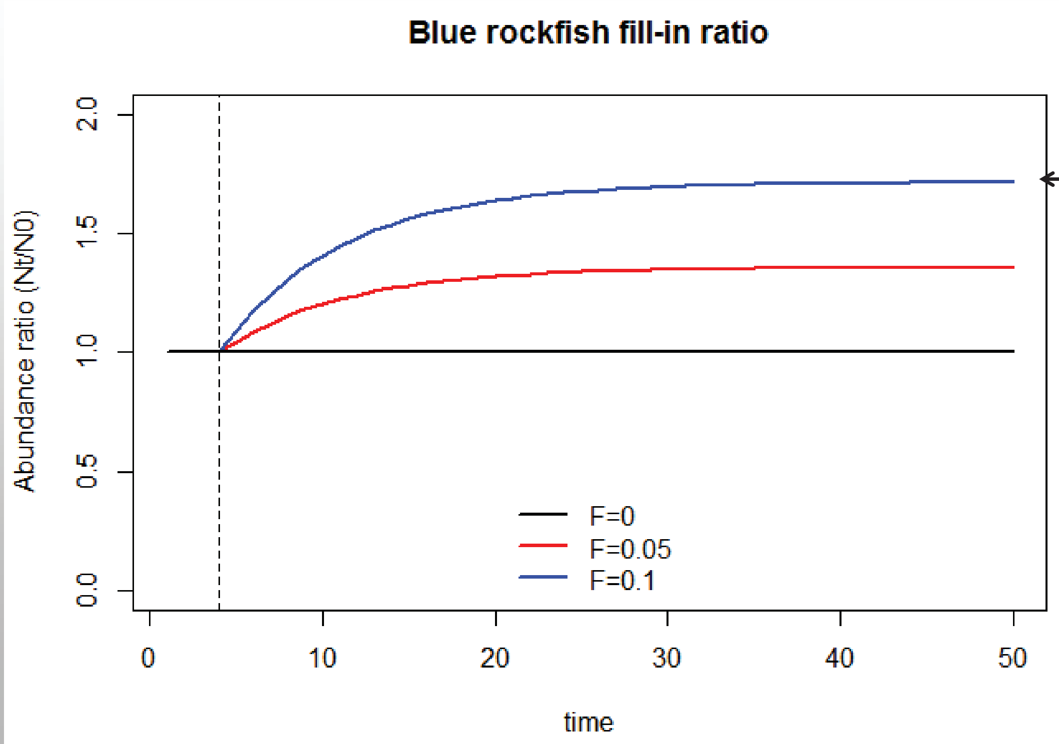
OBJECTIVES

- PROBLEM: EXISTING WORK ON MONITORING SELECTED TOO MANY SPECIES AND INDICATORS TO MONITOR WITHOUT A CLEAR DIRECTION FOR PRIORITIZATION GIVEN A LIMITED BUDGET
- SOLUTION: PROVIDE A METHOD FOR PRIORITIZING INDICATORS BASED ON OVERLAPPING OBJECTIVES OF THE MLPA

RESPONSES OF FISHED POPULATIONS TO THE IMPLEMENTATION OF THE MLPA

- APPROACH: PROJECT TIMELINE OF FISHED SPECIES RESPONSES TO MPAS
- RESPONSES DEPEND ON LEVEL OF FISHING MORTALITY BEFORE MPA IMPLEMENTATION
  - LAUREN IS USING SSIPM MODEL TO GET SPATIALLY EXPLICIT FISHING MORTALITY RATES
- CURRENTLY ASSESSING TIMELINE OF FISHED POPULATION RESPONSES BASED ON FISHING MORTALITY RATES USED IN STOCK ASSESSMENTS FOR THE 90S AND 2000S

Final responses depend of prior fishing



Natural mortality rate

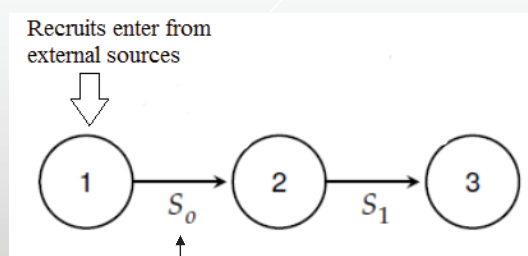
$$\left\{ \frac{M + F}{M} \right.$$

Fishing mortality rate

MODELING AN OPEN POPULATION

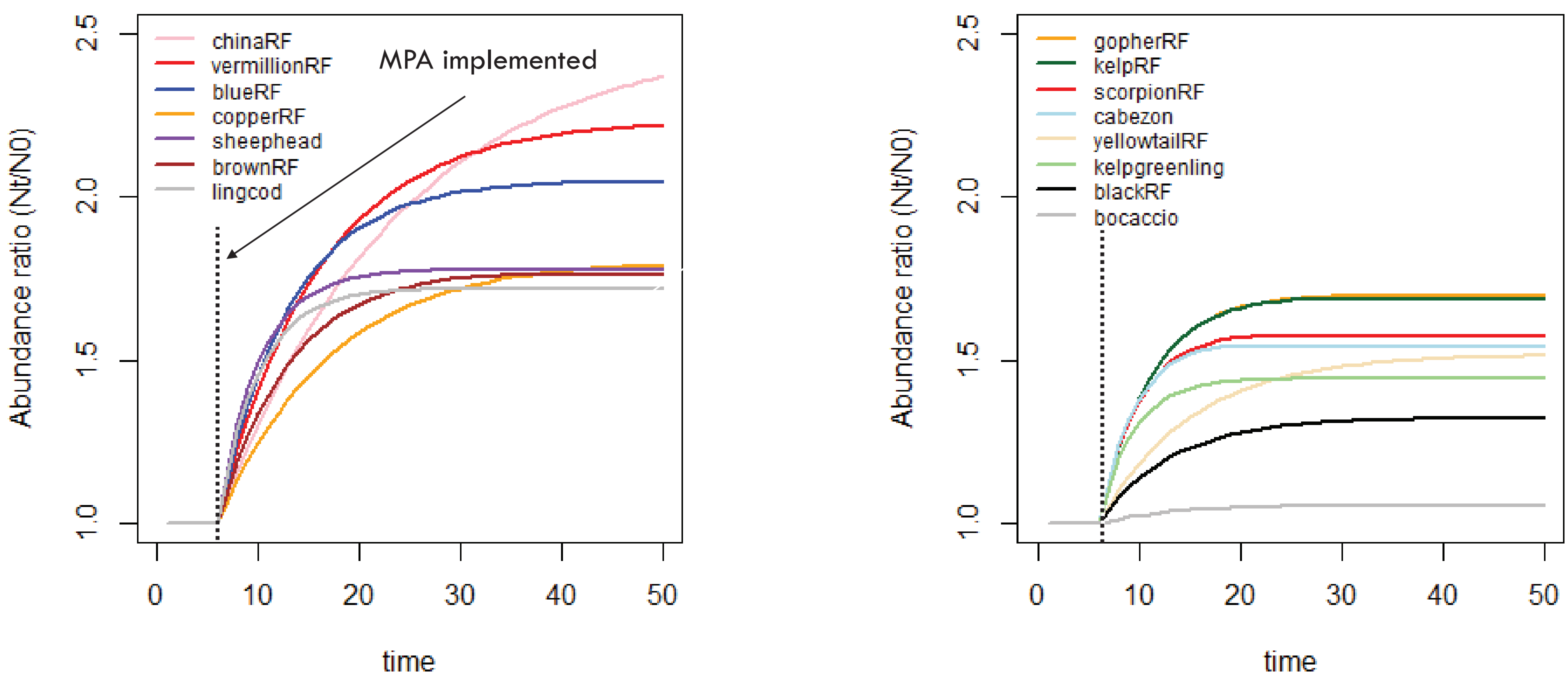
- CONSTRUCT LESLIE MATRIX
- CONSTANT RECRUITMENT ADDED TO THE POPULATION
  - CAN ADD VARIABILITY TO RECRUITMENT
- TO DETERMINE THE POPULATION RESPONSE WE REMOVE F (FISHING MORTALITY) AND SEE HOW THE ABUNDANCE CHANGES OVER TIME

$$\mathbf{N}_{t+1} = \mathbf{A}\mathbf{N}_t + \mathbf{R},$$

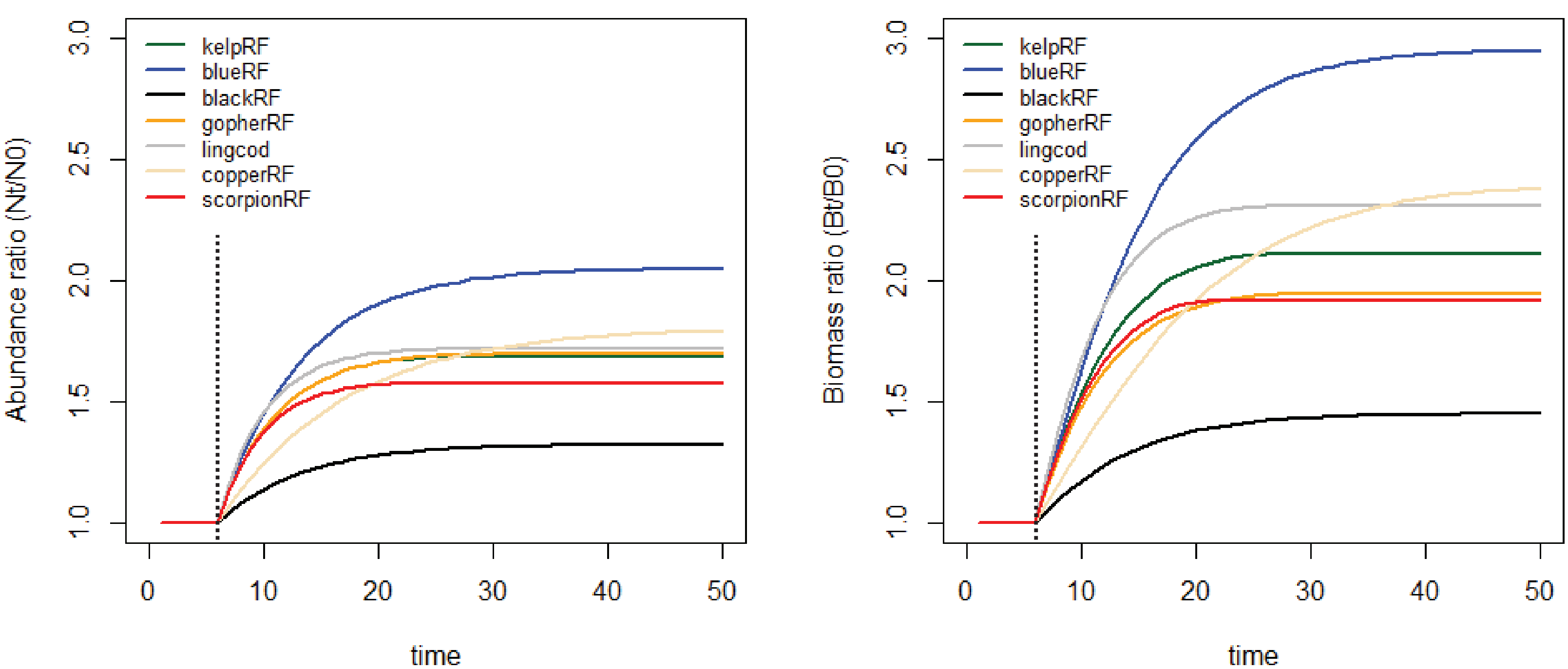


Survivorship to the next age class is based on the fishing mortality (F) and natural mortality rate (M)

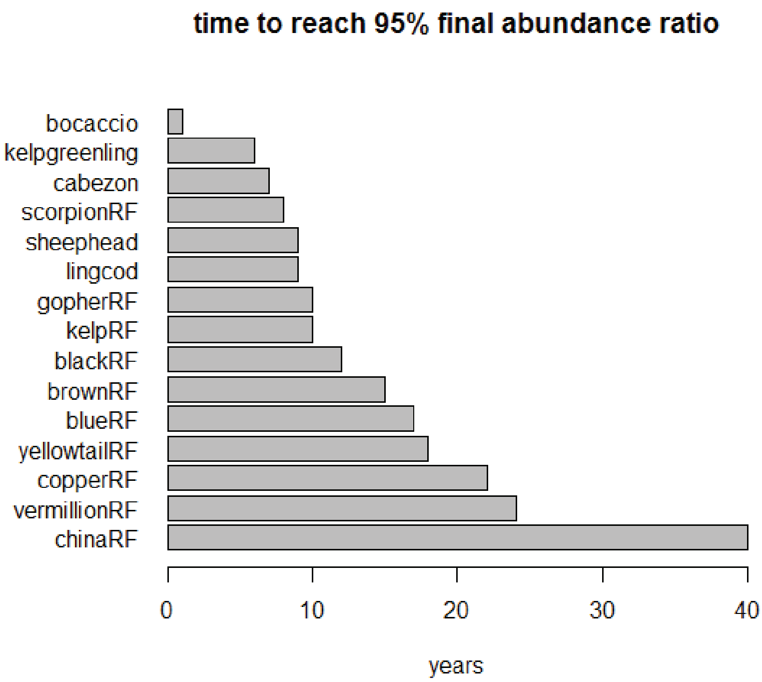
MODELING MPA RESPONSES: ABUNDANCE CHANGES OVER TIME FOR AN OPEN POPULATION

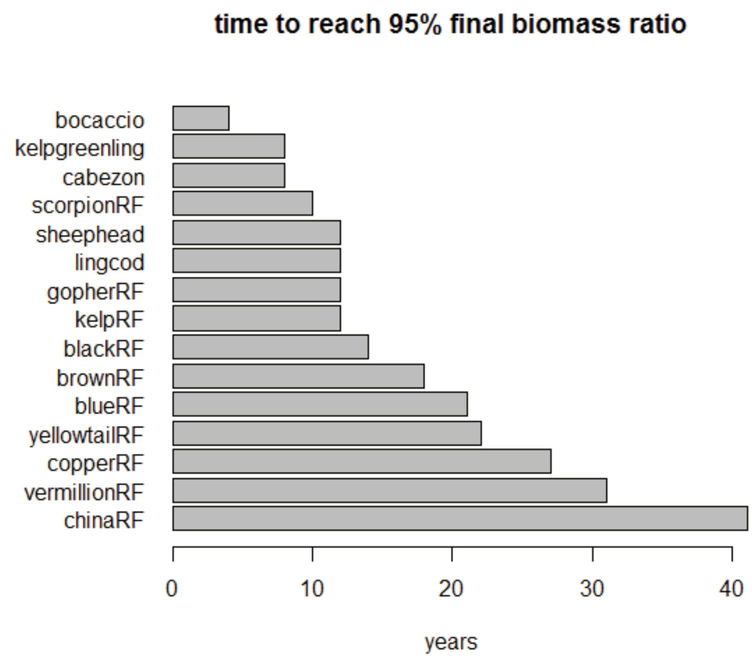


BIOMASS RATIO INCREASE IS GREATER THAN ABUNDANCE

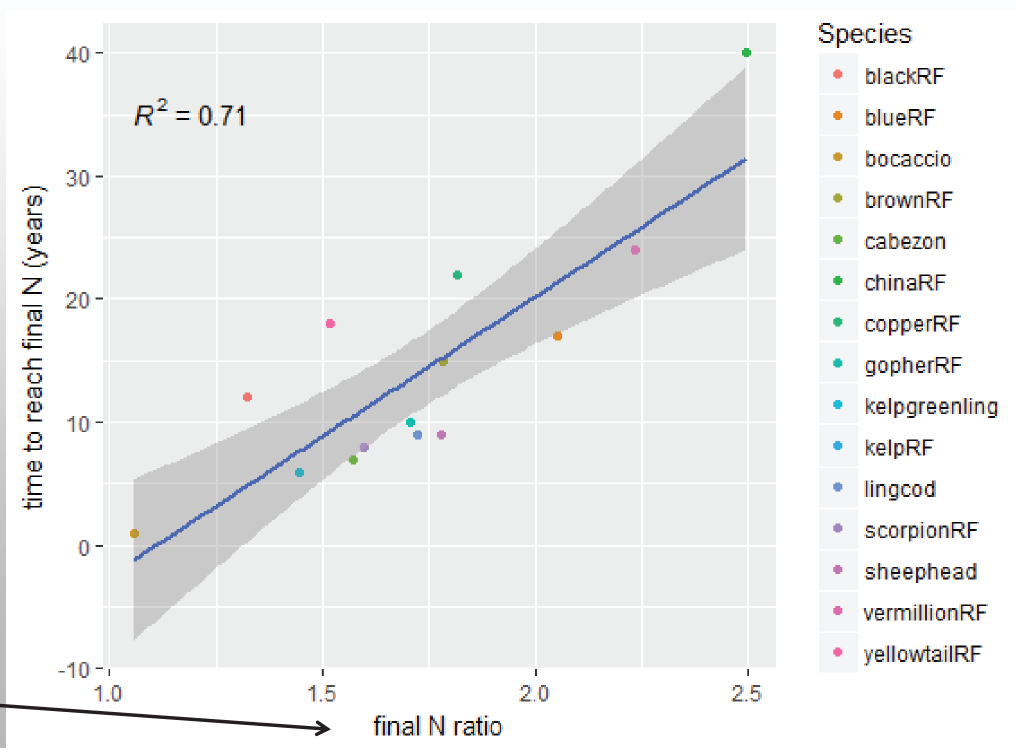


TIMELINES FOR ABUNDANCE AND BIOMASS USING OPEN POPULATION DETERMINISTIC MODEL



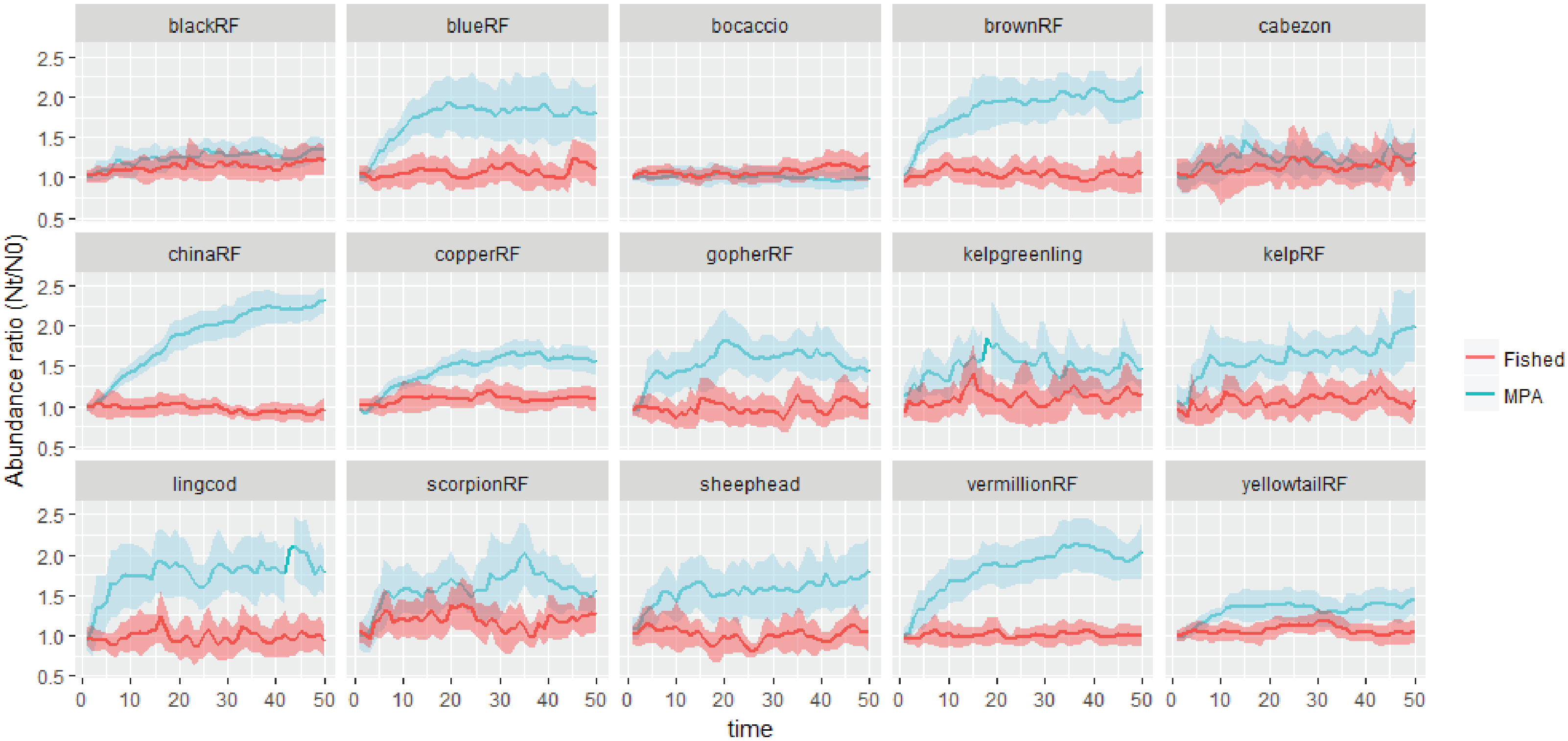


TIME TO REACH FINAL ABUNDANCE IS CORRELATED TO THE FINAL ABUNDANCE RATIO

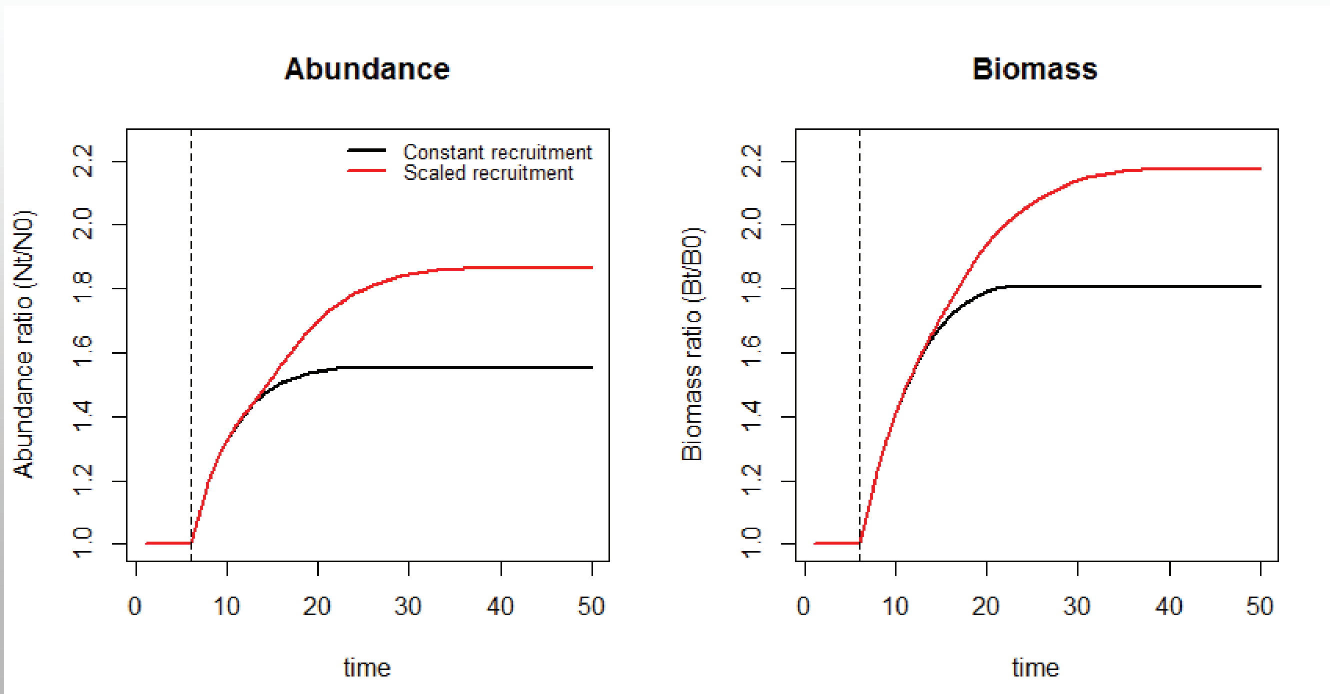


$$\frac{M+F}{M}$$

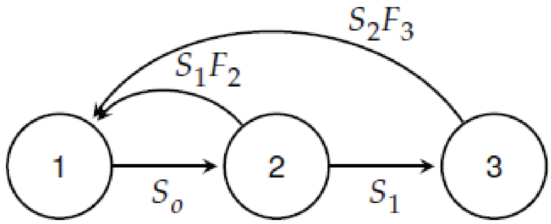
MODELING STOCHASTICITY IN RECRUITMENT (preliminary result)



MODELING RESPONSE RATIOS WITH CHANGES IN RECRUITMENT DUE TO MPA IMPLEMENTATION

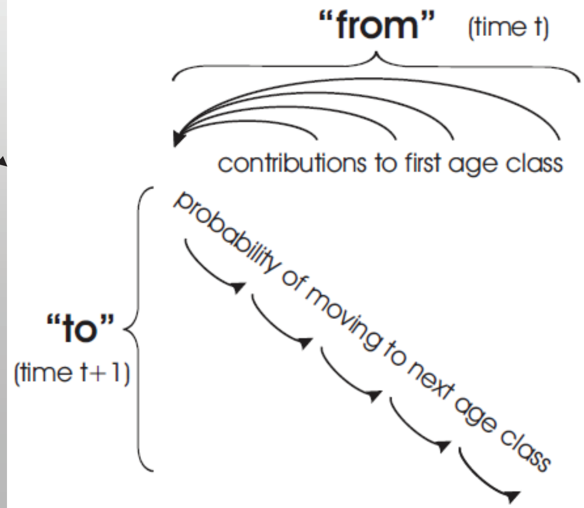


MODELING A CLOSED POPULATION



- CAN DETERMINE TIME SCALE OF TRANSIENT RESPONSE
- STEP1: DETERMINE STABLE AGE DISTRIBUTION FOR FISHED POPULATION
- STEP 2: DETERMINE RATIOS OF INCREASE ONCE FISHING MORTALITY IS REMOVED

$$\mathbf{N}_{t+1} = \mathbf{A}\mathbf{N}_t,$$

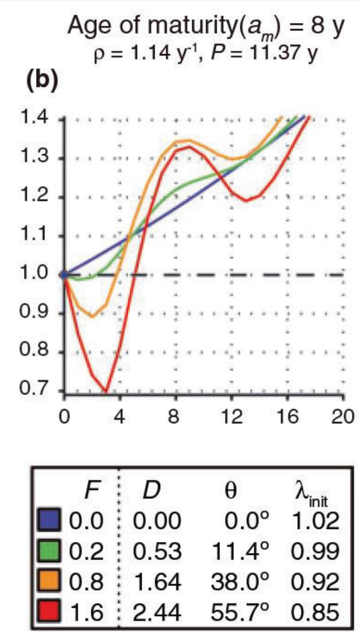


DETERMINING TRANSIENT RESPONSES FOR A CLOSED POPULATION

- THE TRANSIENT RESPONSE OF THE CLOSED POPULATION IS A SINE WAVE OF THE PERIOD (P), THAT DIES OUT AS DAMPING RATIO (RHO)

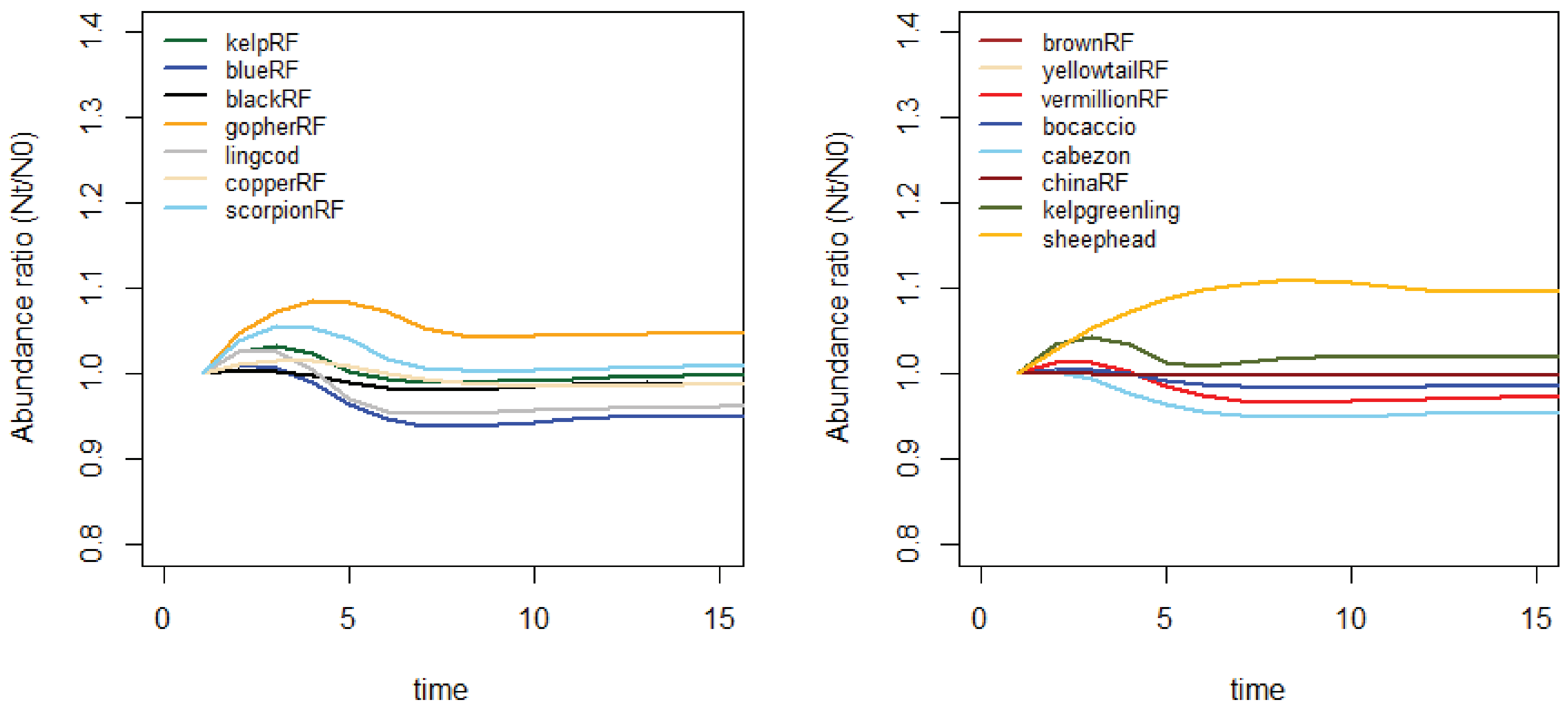
$$\rho \approx \lambda_1 / |\lambda_2|$$

$$P = 2\pi / \arctan\left(\frac{\mathrm{Im}(\lambda_2)}{\mathrm{Re}(\lambda_2)}\right)$$

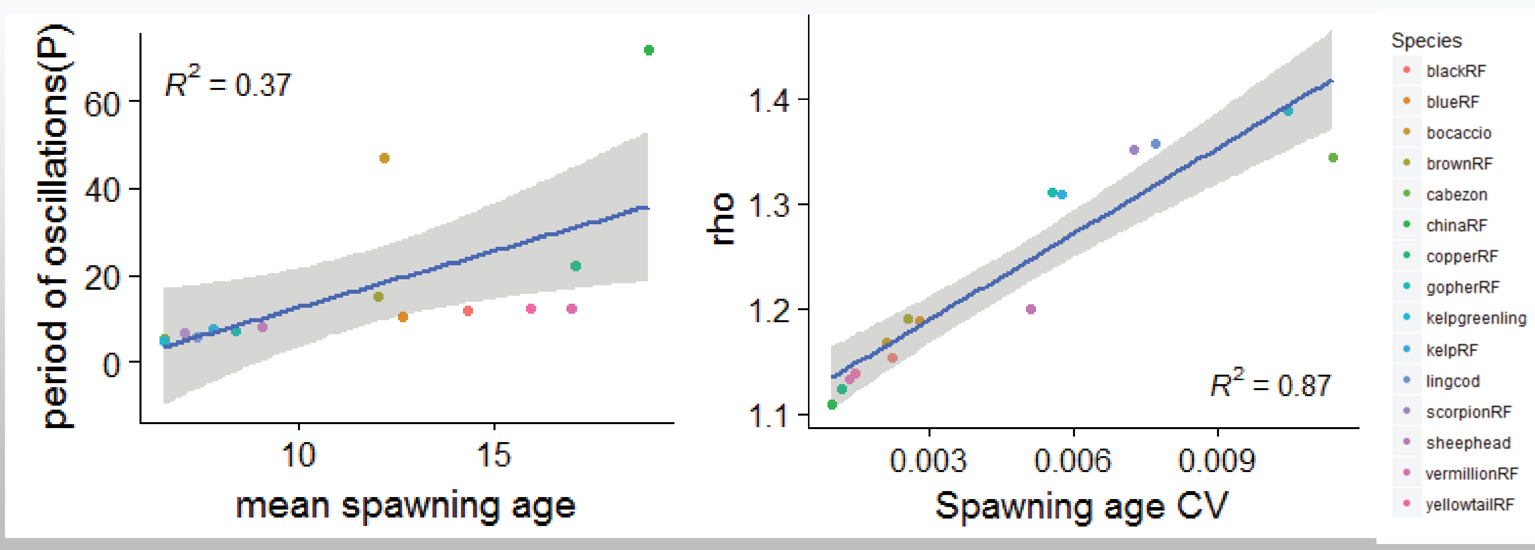


White et al. 2013

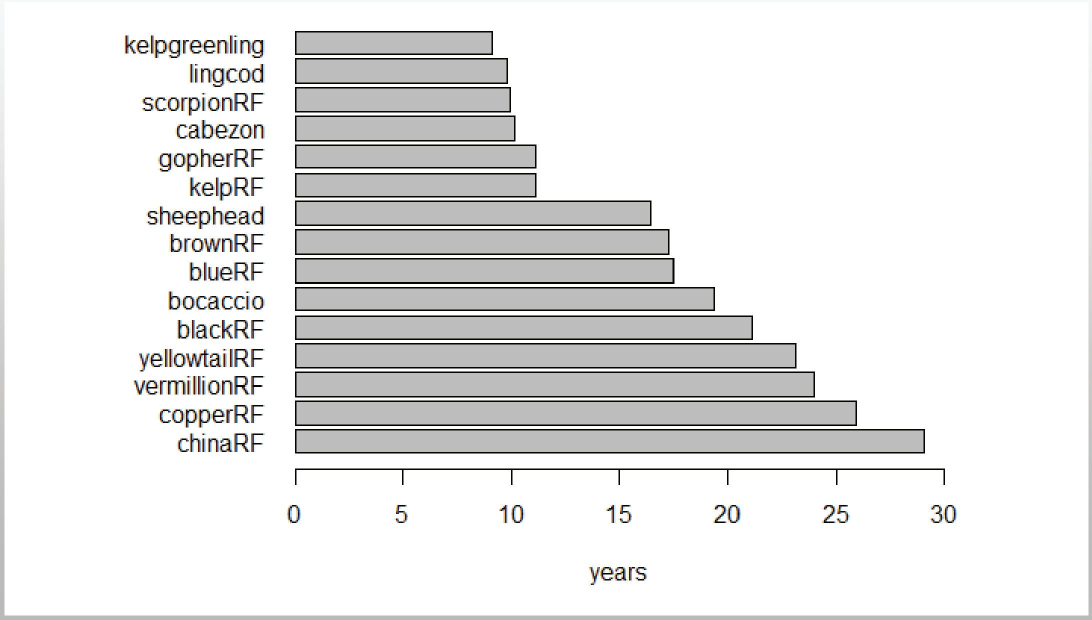
CLOSED POPULATIONS HAVE OSCILLATORY TRANSIENT DYNAMICS



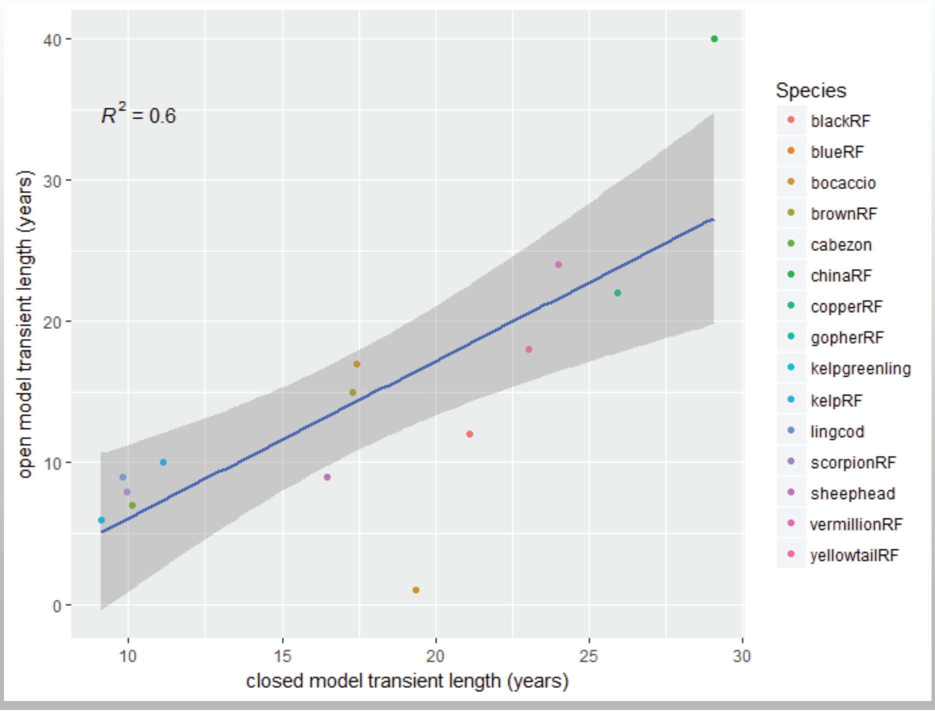
GENERAL TRENDS OF TRANSIENT RESPONSE METRICS BASED ON LIFE HISTORIES



LENGTH OF TRANSIENCE IN CLOSED POPULATION CASE



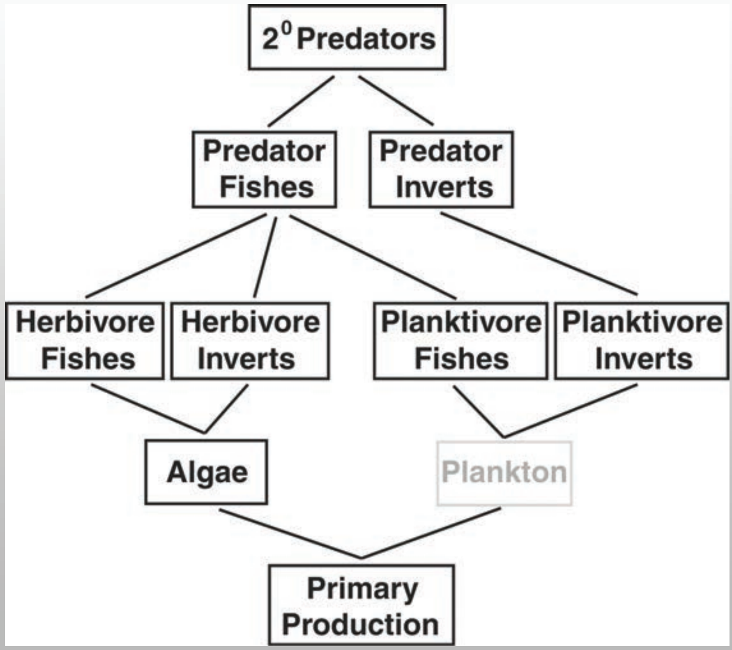
OPEN POPULATION V. CLOSED POPULATION LENGTH OF TRANSIENT PERIODS



PART II: ECOSYSTEM STRUCTURE, FUNCTION AND INTEGRITY GOAL

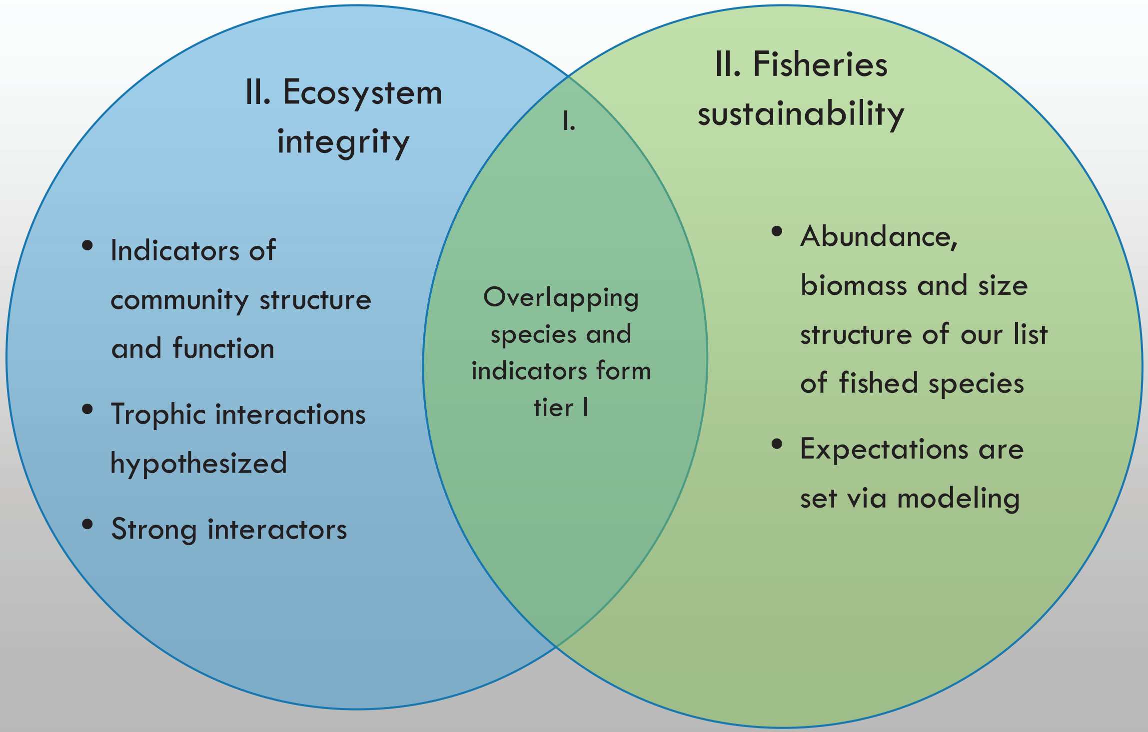
INDICATORS BASED ON:

- I. DIRECT EFFECTS: TARGETED SPECIES THAT ALSO PLAY A STRONG ROLE IN ECOSYSTEM STRUCTURE/FUNCTION
- II. INDIRECT EFFECTS: SPECIES IMPACTED BY FISHED SPECIES (I.E. FOOD WEB DYNAMICS)
- III. INDICATORS OF COMMUNITY STRUCTURE THAT ARE NOT AFFECTED BY FISHED SPECIES (I.E. HABITAT FORMING SPECIES)
- IV. BROAD-SCALE METRICS FROM THE LITERATURE (BIODIVERSITY INDICATORS)



Halpern et al. 2006

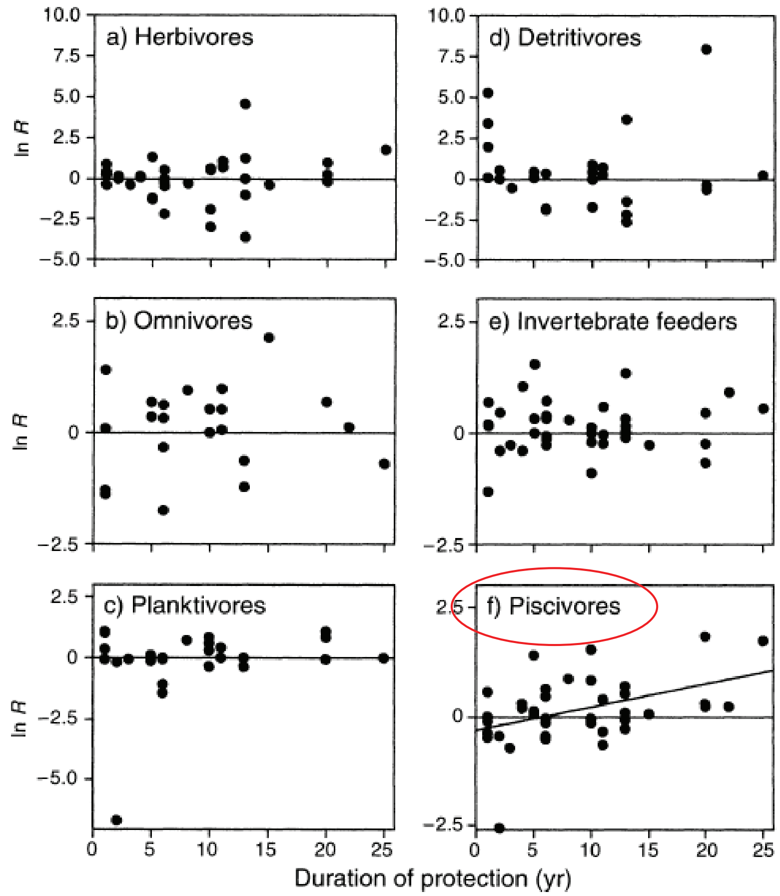
CREATING A TIERED APPROACH



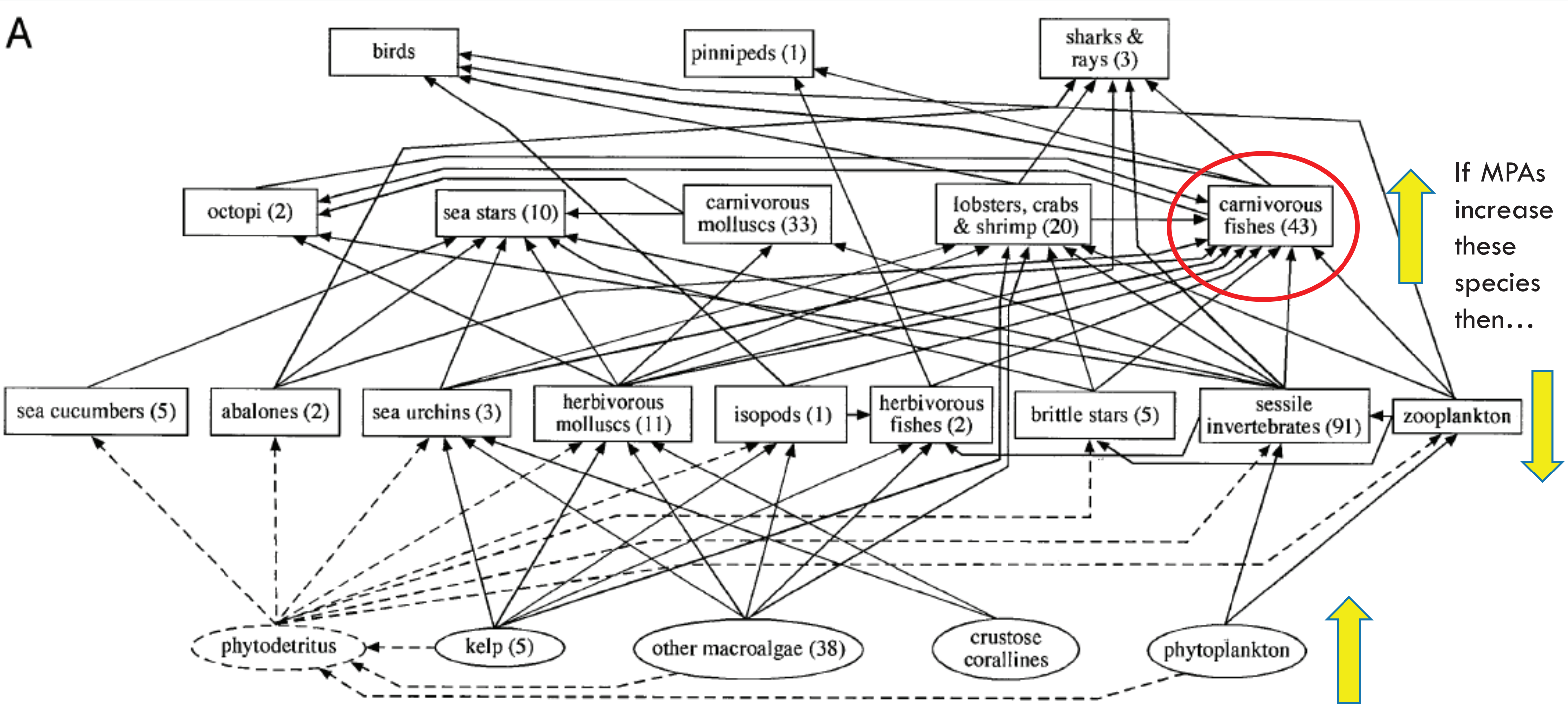
II. INDIRECT EFFECTS: TROPHIC LEVELS SHOW DIFFERENT RESPONSES TO MARINE RESERVES

- INCREASING POSITIVE EFFECTS FOR HIGHER TROPHIC LEVELS
- MARINE RESERVES EFFECTIVE IN INCREASING **ABUNDANCES** OF EXPLOITED SPECIES AND RESTORING COMMUNITY STRUCTURE, THOUGH CHANGES OCCUR THROUGH A SERIES OF TRANSIENT STATES OVER LONG TIME FRAMES

Micheli, F; Halpern, BS; Botsford, LW; and Warner, RR. 2004



II. INDIRECT EFFECTS: DYNAMICS OF A KELP FOREST ECOSYSTEM



Babcock et al. 2010:
Average indirect effect is 13 years or longer

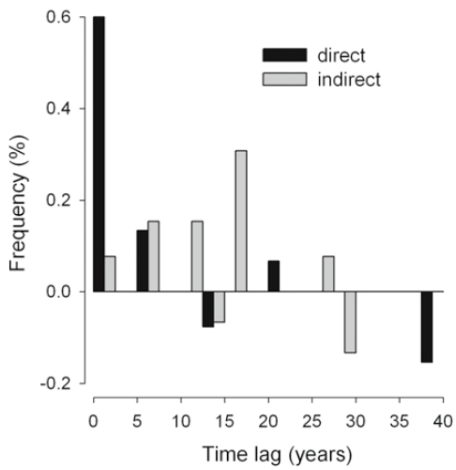
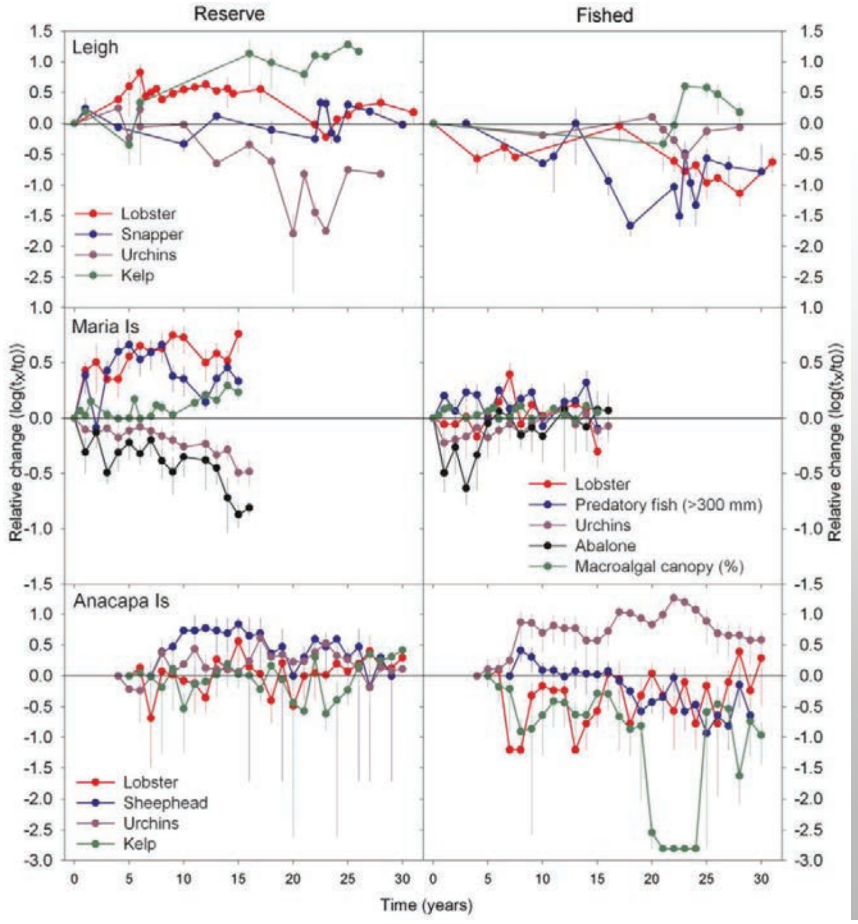


Fig. 3. Time to first detection of direct and indirect responses to marine reserve protection. Positive data indicate the proportion of observed species displaying direct and indirect effects, negative values indicate taxa for which no effect was observed. *n* = 28.



III. INDICATORS OF COMMUNITY STRUCTURE

- APPROACHES
  - DETERMINE SUBSET OF COMMUNITY INDICATORS THAT CORRELATE TO FULL COMMUNITY
  - COMPARE TO REGIONAL MONITORING PLANS INDICATOR/FOCAL SPECIES LIST

APPROACH

Raw data - >300 species

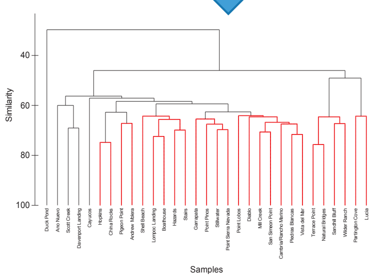
	anthopleura s	bossiella spp	chthamalus s	c
Pigeon Point	4.4151E-2	6.7442E-2	0.12998	
Ano Nuevo	0.10622	3.7556E-2	9.1993E-2	
Scott Creek	8.0553E-2	0.12305	0.13154	
Davenport Landing	0.10003	8.1677E-2	8.9473E-2	
Sandhill Bluff	7.5512E-2	2.6698E-2	0.17302	
Wilder Ranch	2.8296E-2	6.3271E-2	0.12005	
Terrace Point	3.8028E-2	2.689E-2	0.27024	

Start with all species

Similarity matrix

	Pigeon Point	Ano Nuevo	Scott Creek	Davenport L
Pigeon Point				
Ano Nuevo	58.102			
Scott Creek	55.827	57.16		
Davenport Landing	53.051	62.838	69.044	
Sandhill Bluff	35.721	42.813	50.279	53.62

Calculate similarity/dissimilarity for all pairs of sites



Link sites to assess relationships in space or time

APPROACH

Raw data - >300 species

	anthopleura s	bossiella spp	chthamalus s	c
Pigeon Point	4.4151E-2	6.7442E-2	0.12998	
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Similarity matrix

	Pigeon Point	Ano Nuevo	Scott Creek	Davenport L
Pigeon Point				
Ano Nuevo	58.102			
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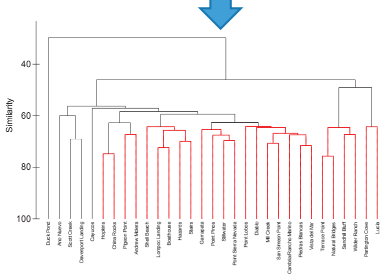
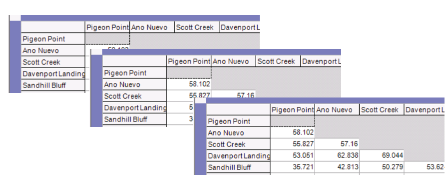


Create random subsets of species
(e.g. sets of 100, 99, 98, ….3, 2, 1species)

Similarity matrices (millions of combinations)

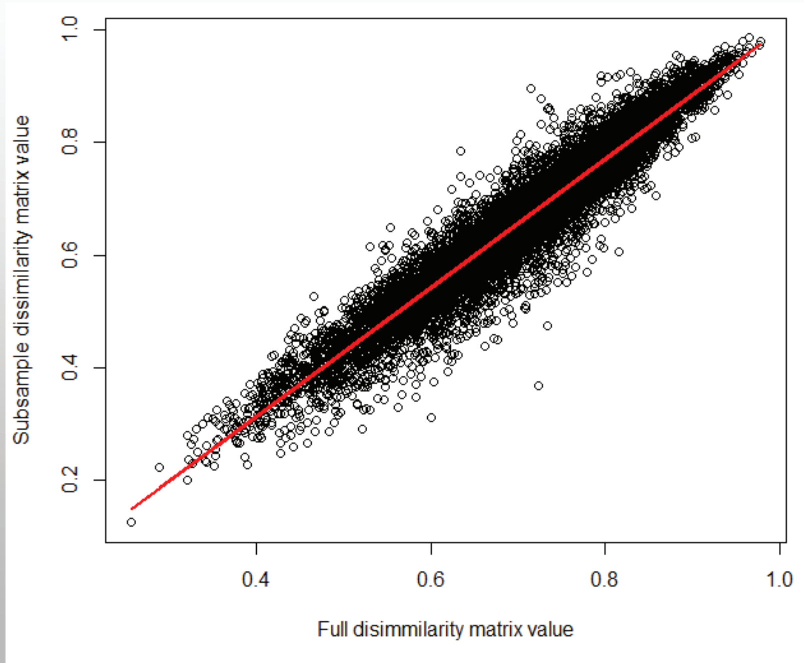


Compare fit of original matrix (all species) to new (reduced # species) matrices

	Pigeon Point	Ano Nuevo	Scott Creek	Davenport L
Pigeon Point				
Ano Nuevo	58.102			
Scott Creek	55.827	57.16		
Davenport Landing	53.051	62.838	69.044	
Sandhill Bluff	35.721	42.813	50.279	53.62

VS

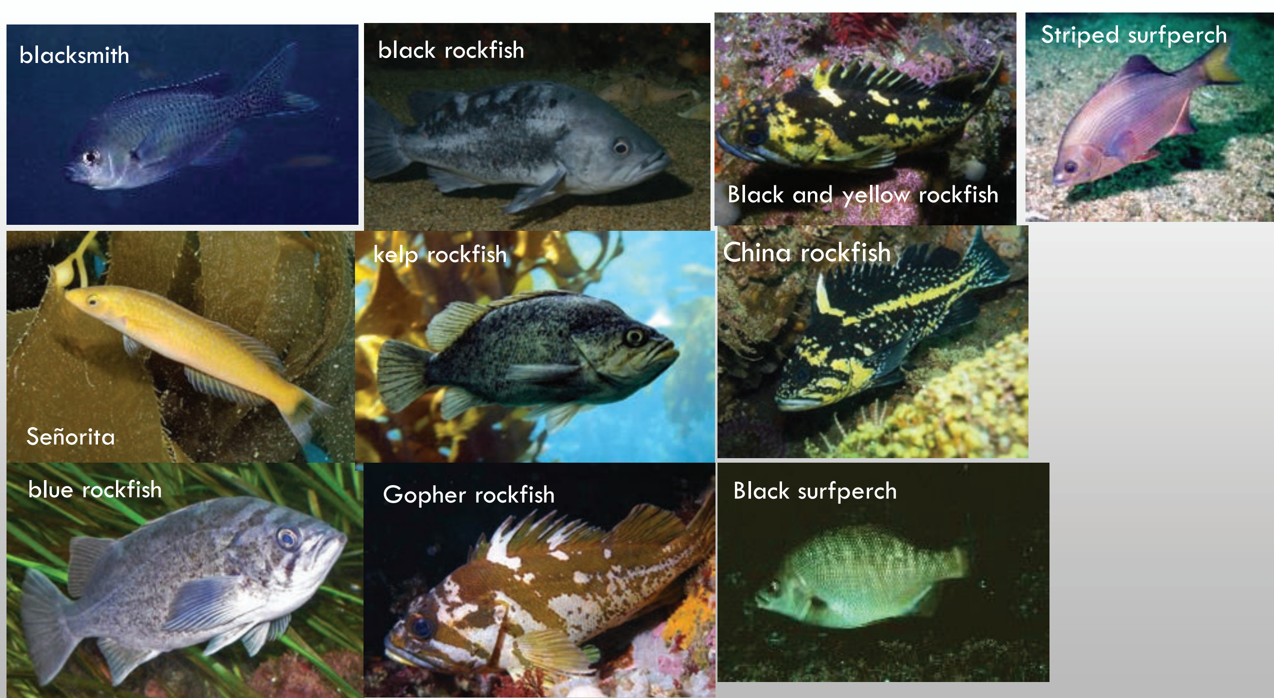
COMPARE REDUCED MODEL TO FULL MODEL



Bray-Curtis dissimilarity matrix for all site pairs

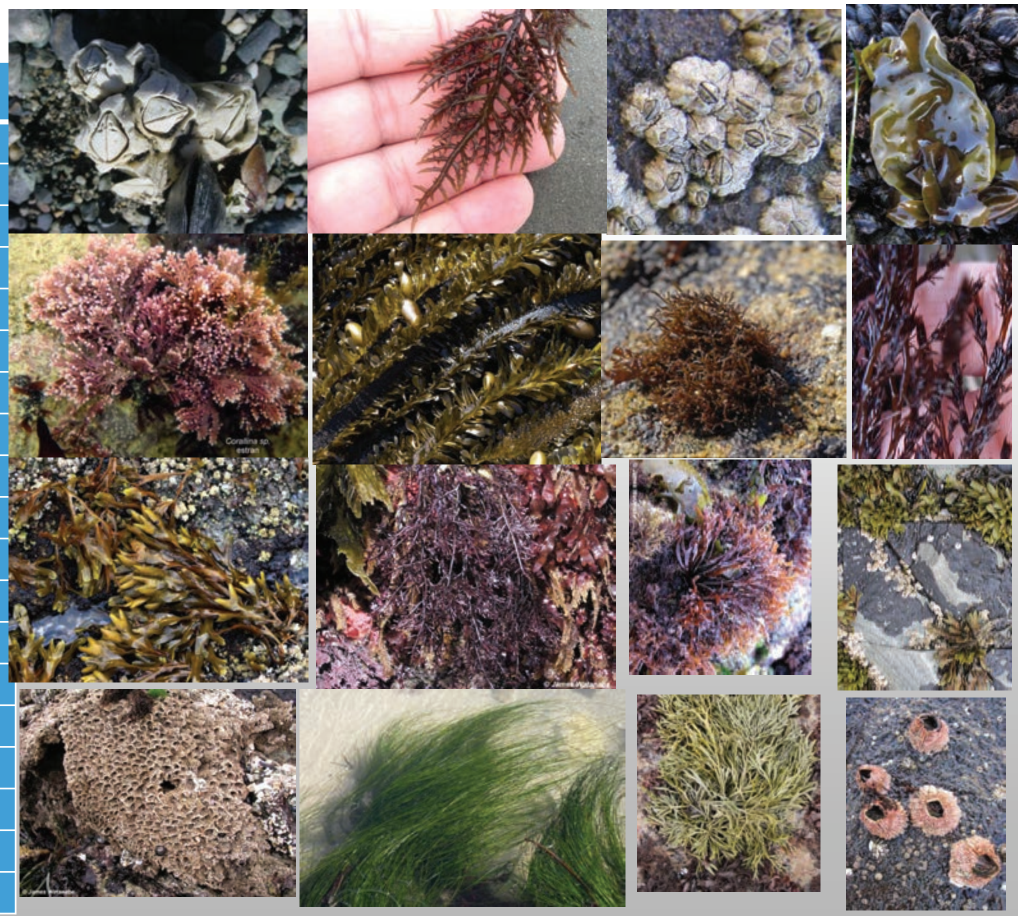
III. KELP FOREST COMMUNITY INDICATORS

Species with 95% correlation to full list
Chromis punctipinnis
Oxyjulis californica
Sebastes mystinus
Sebastes melanops
Sebastes atrovirens
Sebastes carnatus
Sebastes chrysomelas
Sebastes nebulosus
Sebastes serranoides
Embiotoca jacksoni
Embiotoca lateralis



III. Rocky intertidal sedentary species

Species with 95% correlation to full list
Balanus glandula
Blue green algae callothrix
Chondracanthus canaliculatus
Chthamalus dalli/fissus
Corallina spp
Egregia menziesii
Endocladia muricata
Fucus spp
Gelidium coulteri
Mastocarpus spp
Mazzaella cordata /Mazzaella splendens
Odonthalia floccosa
Petrocelis
Phragmatopoma sabellaria spp
Phyllospadix scouleri
Phyllospadix torreyi
Silvetia compressa
Tetraclita rubescens
Ulva.spp/Enteromorpha.spp/Monostroma.spp



III. MOBILE INTERTIDAL SPECIES

Species with 95% correlation to full list
Periwinkle (*Littorina keenae*)
Checkered periwinkle (*Littorina plena scutulata*)
Littorina spp
Lottia austrodigitalis digitalis
Small limpet
Pisaster ochraceus

II. COMPARISON: KELP FOREST INDICATORS SELECTED IN REGIONAL MONITORING PLANS

Central coast example

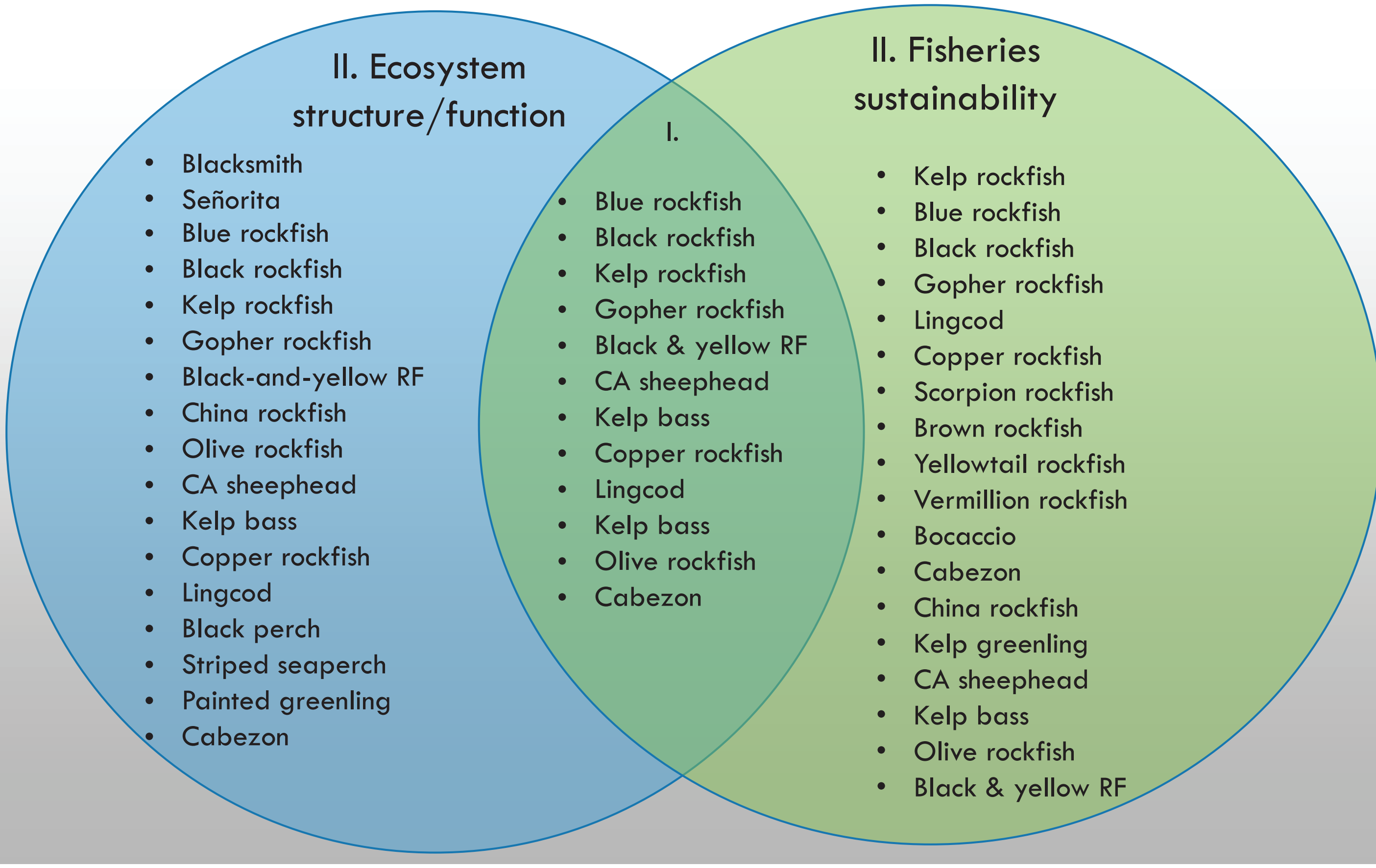
ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	**Indicator/Focal Species**
Biogenic Habitat: Macroalgal assemblage	Areal extent of surface kelp canopy (e.g., *Macrocystis pyrifera, Nereocystis luetkeana*)
	Number of kelp stipes: ➤ Bull kelp (*Nereocystis luetkeana*) ➤ Giant kelp (*Macrocystis pyrifera*), stipes per plant
Trophic Structure: Omnivorous Invertebrates	Density & size structure of focal species: ➤ Black abalone (*Haliotis cracherodii*) ➤ Purple sea urchin (*Strongylocentrotus purpuratus*) ➤ Red abalone (*Haliotis rufescens*) ➤ Red sea urchin (*Strongylocentrotus franciscanus*)
Trophic Structure: Detritivorous Invertebrates	Density & size structure of sea stars (e.g., *Patiria miniata*)
Trophic Structure: Predatory Invertebrates	Density & size structure of sea stars (e.g., *Pisaster* spp., *Pycnopodia helianthoides*)
Trophic Structure: Planktivorous fishes	Density & size structure[1] of blue rockfish (*Sebastes mystinus*)
Trophic Structure: Omnivorous fishes	Density & size structure[1] of focal species: ➤ Black & yellow rockfish (*Sebastes chrysomelas*) ➤ Cabezon (*Scorpaenichthys marmoratus*) ➤ Gopher rockfish (*Sebastes carnatus*) ➤ Kelp rockfish (*Sebastes atrovirens*) ➤ Painted greenling (*Oxylebius pictus*) ➤ Striped seaperch (e.g., *Embiotica lateralis*) ➤ Black perch (e.g., *Embiotica jacksoni*)
Trophic Structure: Piscivorous fishes	Density & size structure[1] of focal species: ➤ Black rockfish (*Sebastes melanops*)

FINAL KELP AND SHALLOW ROCK INDICATORS FOR COMMUNITY STRUCTURE SELECTED FROM COMBINATION OF METHODS

Indicators from subsample matrices	South coast regional list	Central coast regional list	North coast regional list
blacksmith (*Chromis punctipinnis*)	Giant kelp (*Macrocystis pyrifera*)	Bull kelp (*Nereocystis luetkeana*)	Stalked kelp (*Pterygophora californica*)
Señorita (*Oxyjulis californica*)	Red sea urchin (*Strongylocentrotus franciscanus*)	Sea stars (*Patiria miniata*)	California sea cucumber (*Parastichopus californicus*)
Blue rockfish (*Sebastes mystinus*)	Purple sea urchin (*Strongylocentrotus purpuratus*)	Painted greenling (*Oxylebius pictus*)	
Black rockfish (*Sebastes melanops*)	Spiny lobster (*Panulirus interruptus*)	Striped seaperch (*Embiotica lateralis*)	
Kelp rockfish (*Sebastes atrovirens*)	California sheephead (*Semicossyphus pulcher*)	Black perch (*Embiotica jacksoni*)	
Gopher rockfish (*Sebastes carnatus*)	Kelp bass (*Paralabrax clathratus*)	Copper rockfish (*Sebastes caurinus*)	
Black-and-yellow rockfish (*Sebastes chrysomelas*)	Cabezon (*Scorpaenichthys marmoratus*)	Lingcod (*Ophiodon elongatus*)	
China rockfish (*Sebastes nebulosus*)	Kellet's whelk (*Kelletia kelletii*)	Sea otters (*Enhydra lutris*)	
Olive rockfish (*Sebastes serranoides*)	Sea stars (*Pisaster spp., Pycnopodia helianthoides*)		
Black surfperch (*Embiotoca jacksoni*	Abalone (*Haliotis spp.*)		
Striped surfperch (*Embiotoca lateralis*)	Giant keyhole limpet (*Megathura crenulata*)		
	Wavy turban snail (*Megastraea undosa*)		

TIERED APPROACH: KELP AND SHALLOW ROCK HABITAT FISH SPECIES



IV. BROAD-SCALE COMMUNITY LEVEL METRICS AND BIODIVERSITY INDICATORS

Table 2. Indicators of community-level response to marine protected area establishment recommended for use by managers.

Category	*metric (s)*
Biomass	total biomass
Abundance	total abundance & log normal μ
Dominance	McNaughton & relative dominance
Evenness	eCDF slope
Rarity	log skew
Richness	log series α
Diversity	Shannon & Simpson diversity

Soykan et al. 2015

HOW TO FOCUS ASSESSMENT OF ECOSYSTEM CONDITION?

- HIRE FIELD STAFF THAT ARE EXPERTS IN SPECIES IDENTIFICATION WHO CAN MONITOR EVERYTHING AT KEY SITES?
  - METRICS FOR EVENNESS, RICHNESS, RARITY ETC. WILL REQUIRE INTENSIVE MONITORING EFFORT
- FOCAL SPECIES LISTS CAN BE USED TO GUIDE CITIZEN SCIENCE PROGRAMS AND/OR ANALYSIS OF KEY SPECIES OF INTEREST?
  - FULL LIST OR SUBSET OF INDICATOR SPECIES?

DISCUSSION QUESTIONS

- SHOULD WE MONITOR COMMUNITY INDICATORS SUCH AS HABITAT-FORMING SPECIES THAT ARE NOT DIRECTLY IMPACTED BY MPAS?
  - IS IT AN OBJECTIVE OF THE MPA MONITORING PROGRAM TO EVALUATE BROADER ECOLOGICAL PATTERNS AND CHANGE INDEPENDENT OF MPA EFFECTS?

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(Appendix D)

Estimating Local Values of F: Needed for both Fisheries (MLMA) and MPAs (MLPA)

Lauren Yamane

Local fishing mortality provides a way to integrate MLMA and MLPA for adaptive management

Fishing mortality (F) = instantaneous rate of mortality due to fishing

- Has a direct effect on population dynamics! Which means you can set expectations of population response

MLMA : Stock assessments often include only broad, regional estimates of fishing mortality (F)

- Spatial heterogeneity in F can influence yield (Ralston and O'Farrell 2008)
- Lobster FMP identifies F as an EFI of the highest priority:

*"**F directly links to the MLMA objectives** (Table 5-1), to **reference points** determined or used by the FMP models, and to **any control rule** described by the FMP."*

MLPA : Expect greater biomass increases for MPAs/species with high historical F

Tiered methods to determine fishing pressure

Data-rich: Estimating pre-MPA local F with SSIPM

- Fit PISCO/Reef Check size data to model
- First step: When does the model produce reliable estimates of F?
- Estimated local F's (Central Coast; future focus: South Coast)

Data-moderate: Estimate fine-scale historical fishing effort with fisheries-dependent data

- Use spatially-explicit CRFS data (2006-present) to visualize fishing effort across state
- Private/rental boats (future focus: party boats)

Data-poor: Use regional proxies for historical fishing

Use data-rich to inform data-poor?

Management decisions informed by fishing pressure analyses

Data-rich: Estimating local F with SSIPM

- Biological characteristics = *Who* to monitor? Done — **Indicator species**
- Sample size = *How many* to monitor? In progress
- Time series length = *How much* and *where* to monitor? In progress — **Site selection**

Data-moderate: Estimate fine-scale historical fishing effort — **Site selection** Olivia Rhoades

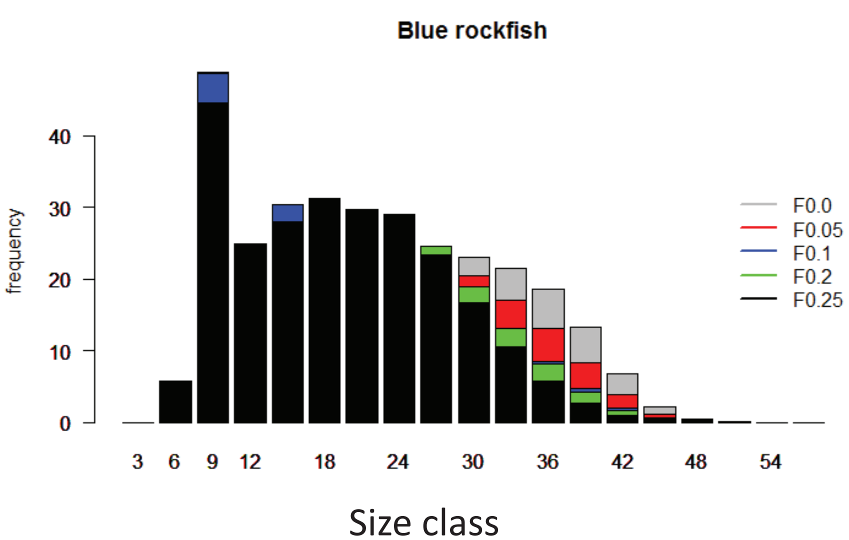
- Can't plug these in to Katie's estimates of fill-in rates
- *Who* and *where* to monitor

Data-poor: Regional proxies of historical fishing effort

- Best guess on *where* to monitor (North Coast) Still needed — **Site selection**

Blue rf

Reminder: higher Fs mean greater truncation of size structure and greater ability to detect fill-in response

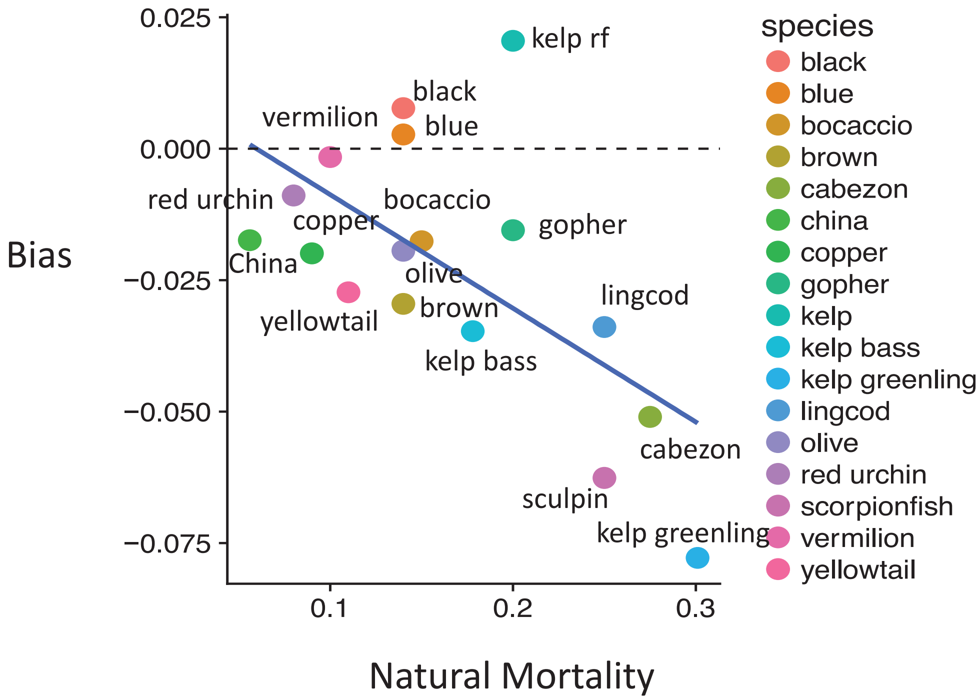


Linf	38.15
K	0.172
t0	-1.145
M	0.14
Lmat	27.086
Lfish	21.02
Recruit size	4
YOY	<10

Every species has different biological characteristics

As natural mortality increases model underestimates F

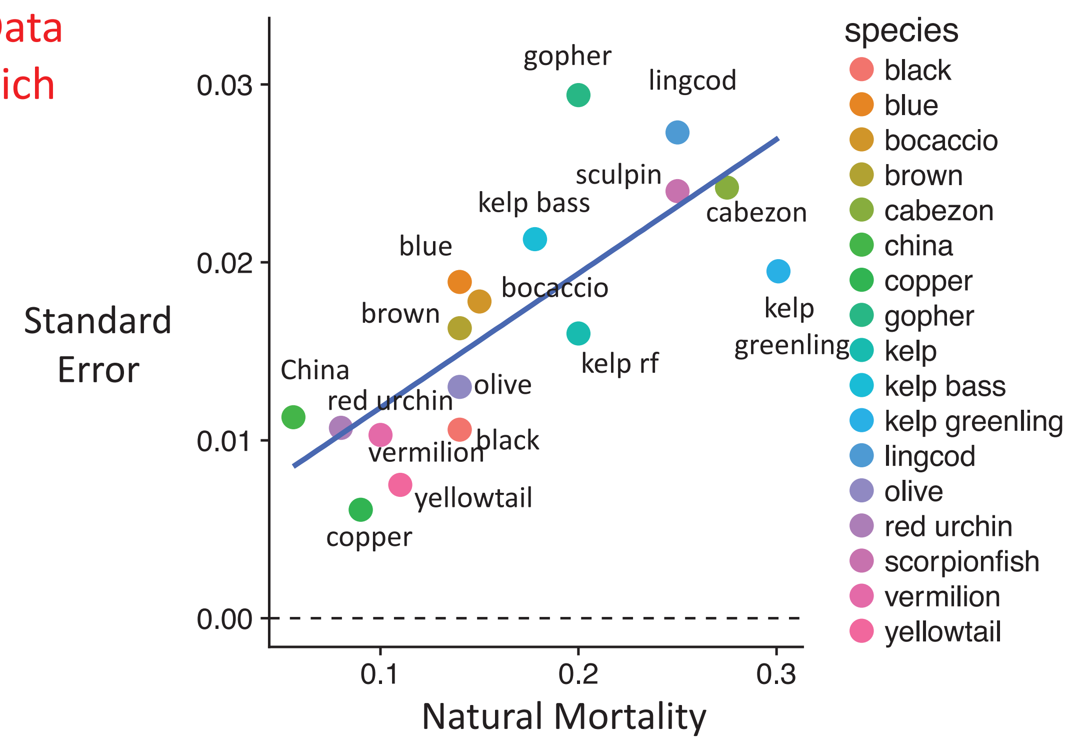
Data Rich



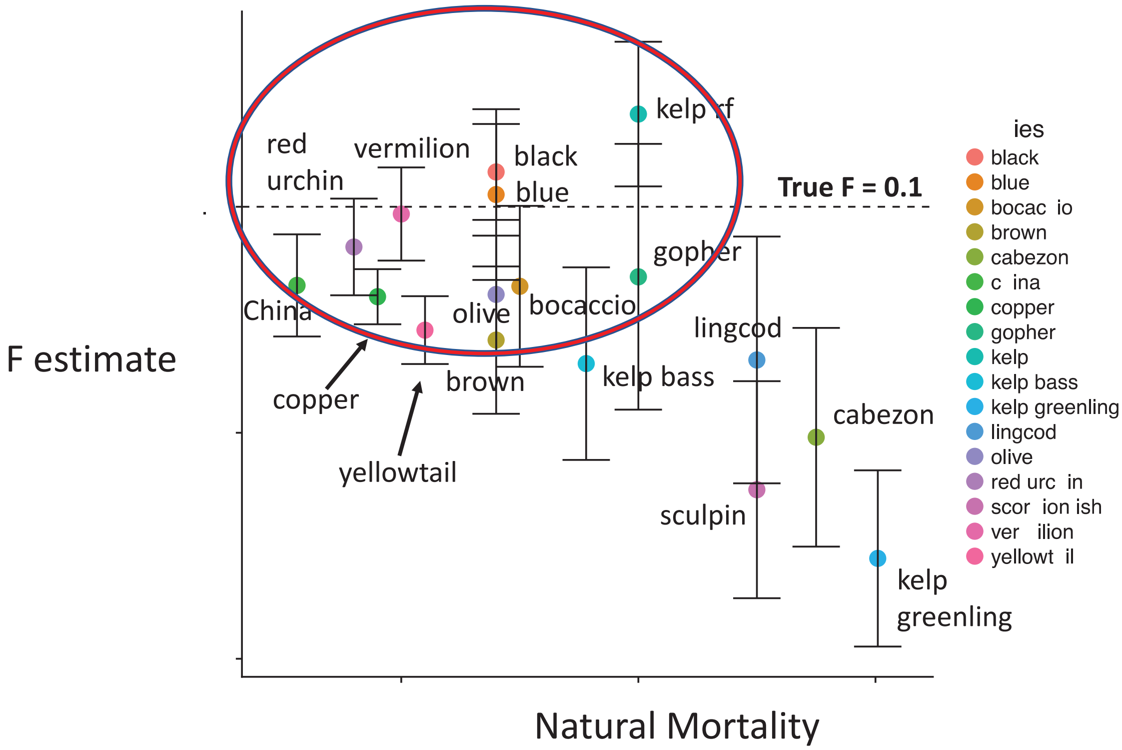
F=0.1

… and error increases

Data Rich

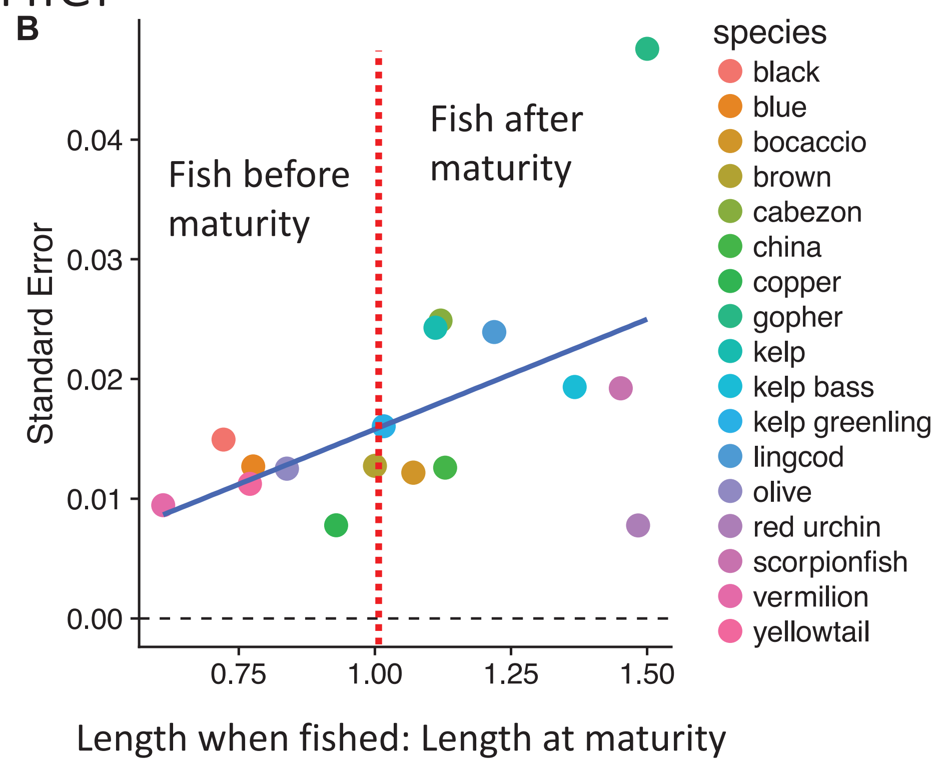


F=0.1



Precision of F estimate increases if species is fished earlier

Data Rich



Overall: what species characteristics enhance estimate of the local fishing mortality?

Species with:

- Lower natural mortality (M) rates
- A growth rate exceeding the natural mortality rate (e.g., k>M)
- Fished early in life history

Which species would enable more reliable local F estimates based on biological characteristics?

Data Rich

Worse choices

- CA Scorpionfish
- Lingcod
- Cabezon
- Kelp greenling

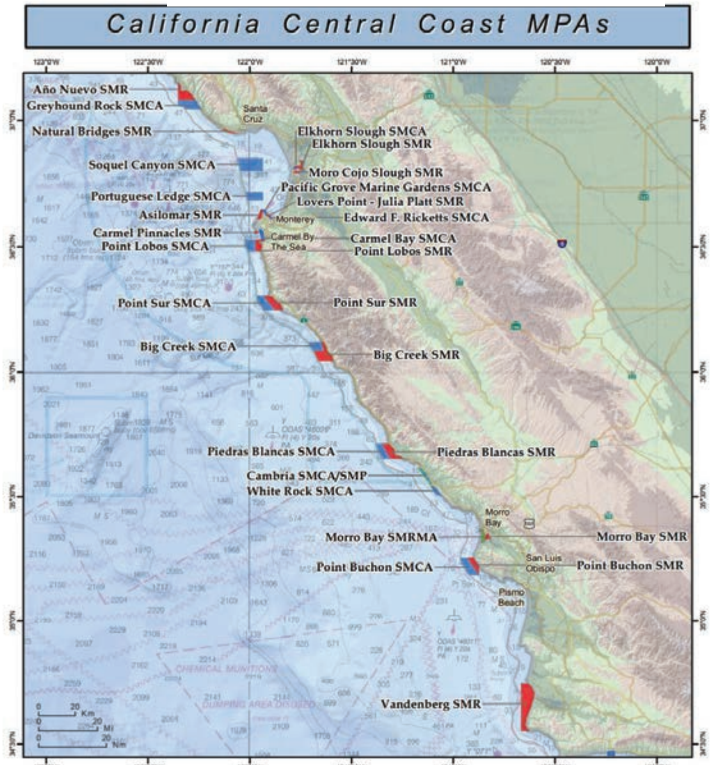
Better choices

- Blue rockfish
- Vermilion rockfish
- Copper rockfish
- Yellowtail rockfish
- Kelp rockfish
- China rockfish
- Red urchin

Where model has been applied to data to estimate local F so far

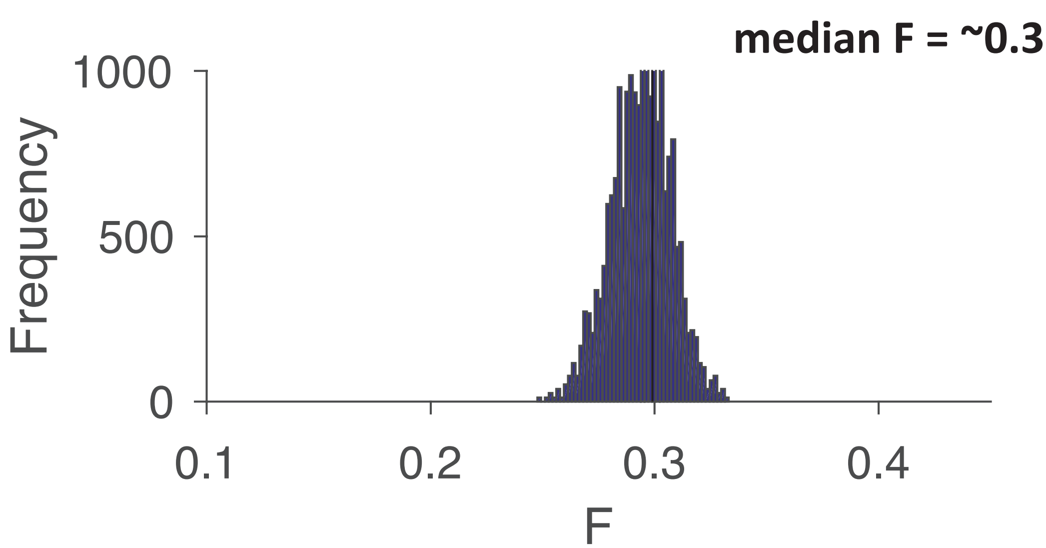
Central Coast:

- Copper, Black-and-Yellow, Blue, Olive/Yellowtail complex at 4 different MPAs (appeared most abundant of the "better choices")
- Blue most reliable F estimates
- Olive/Yellowtail complex may be too complicated given different movement patterns of two species



Blue Rockfish at Vandenberg SMR : F estimate

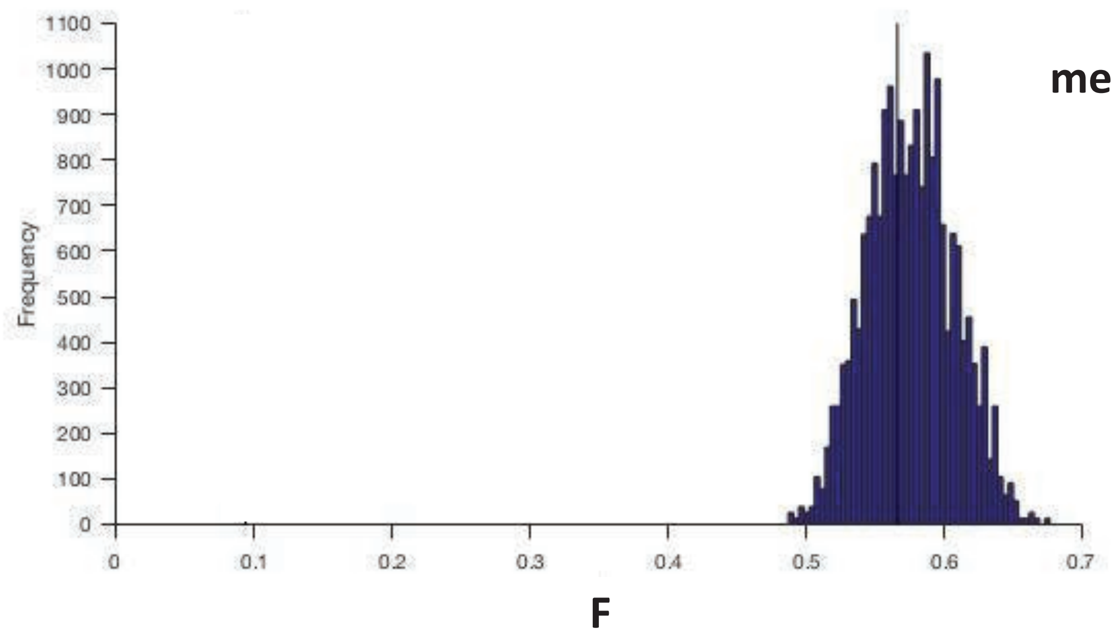
Data Rich



Blue rockfish seems to be a model indicator species for understanding MPA responses
(other projections of responses for blue rockfish at other Central Coast MPAs by Nickols et al., in prep)

Blue Rockfish at Natural Bridges SMR (Santa Cruz) : F estimate

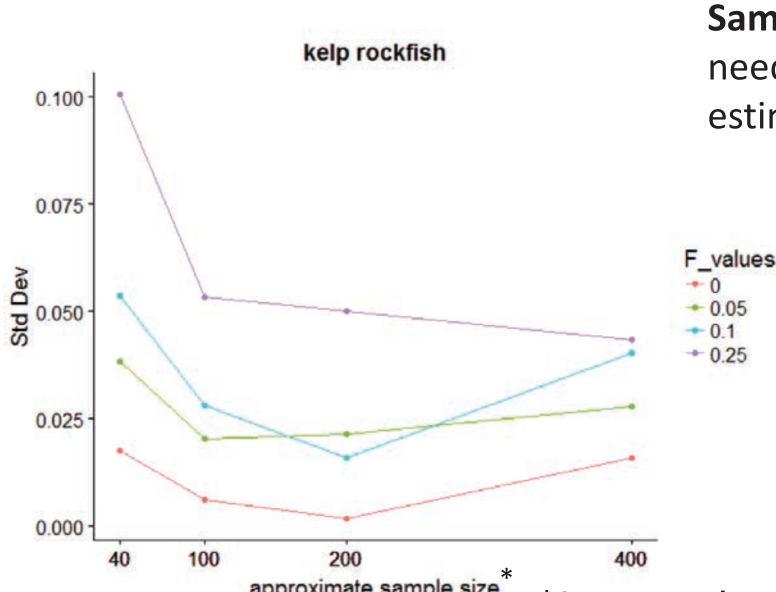
Data Rich



median F = ~0.58

Higher sample sizes lead to greater precision of F estimate

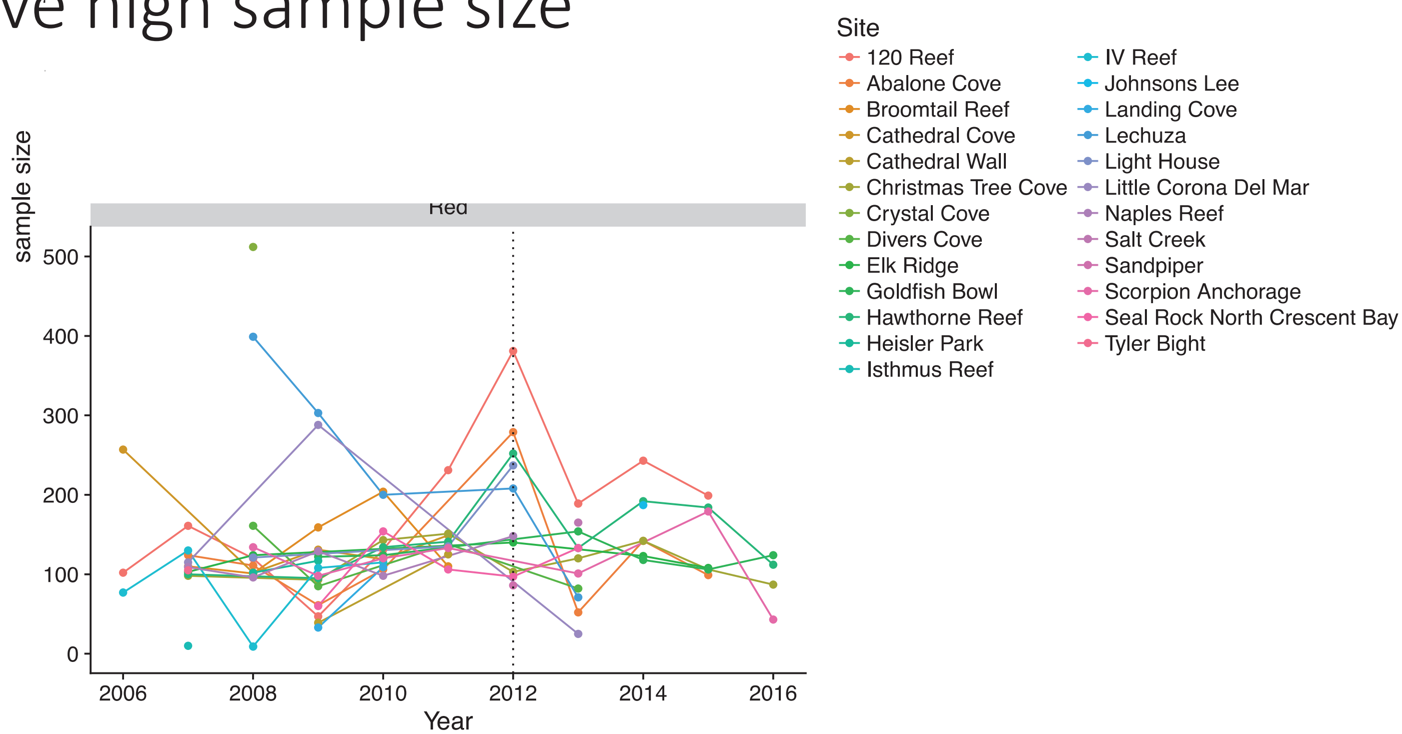
Sample size*: May need 100's to estimate F



***Caveat : need to transform this to be sample size**

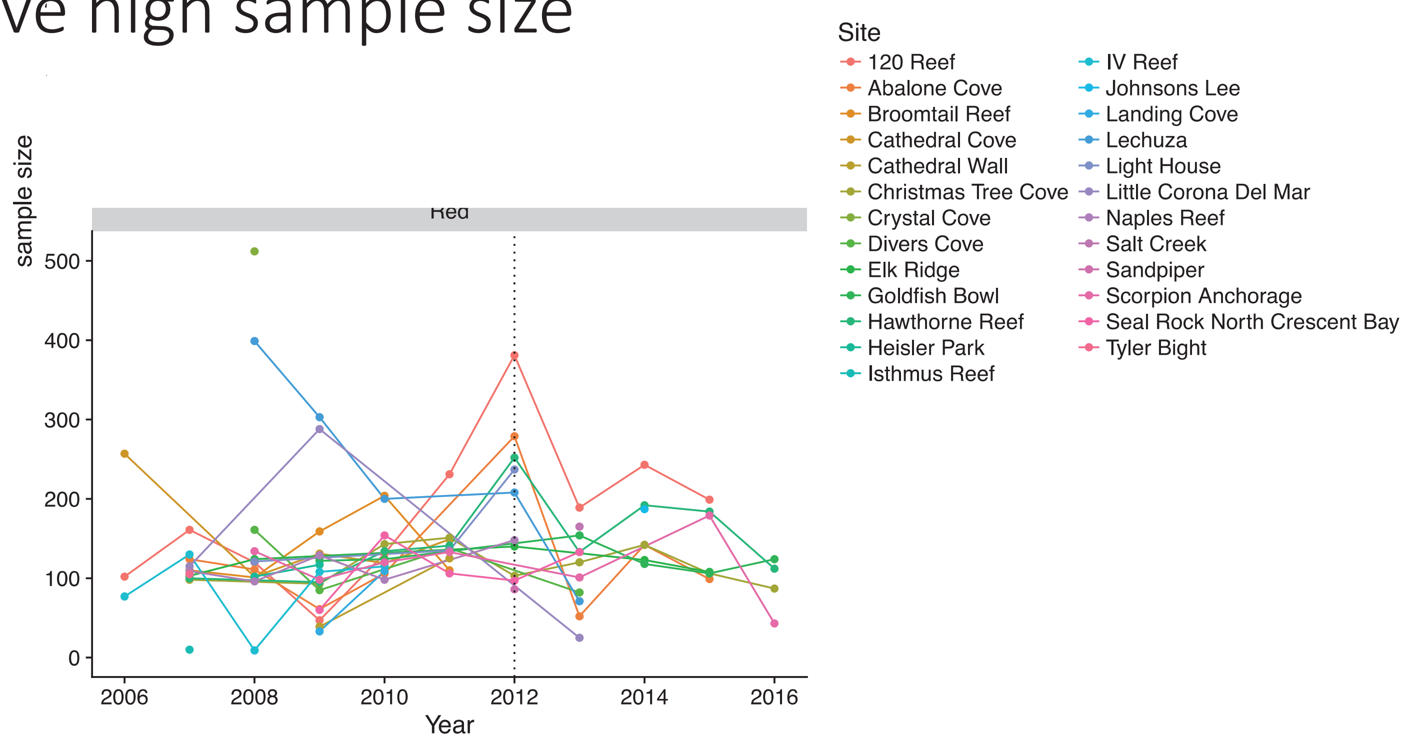
Reef Check data: South Coast red urchins have high sample size

Data Rich

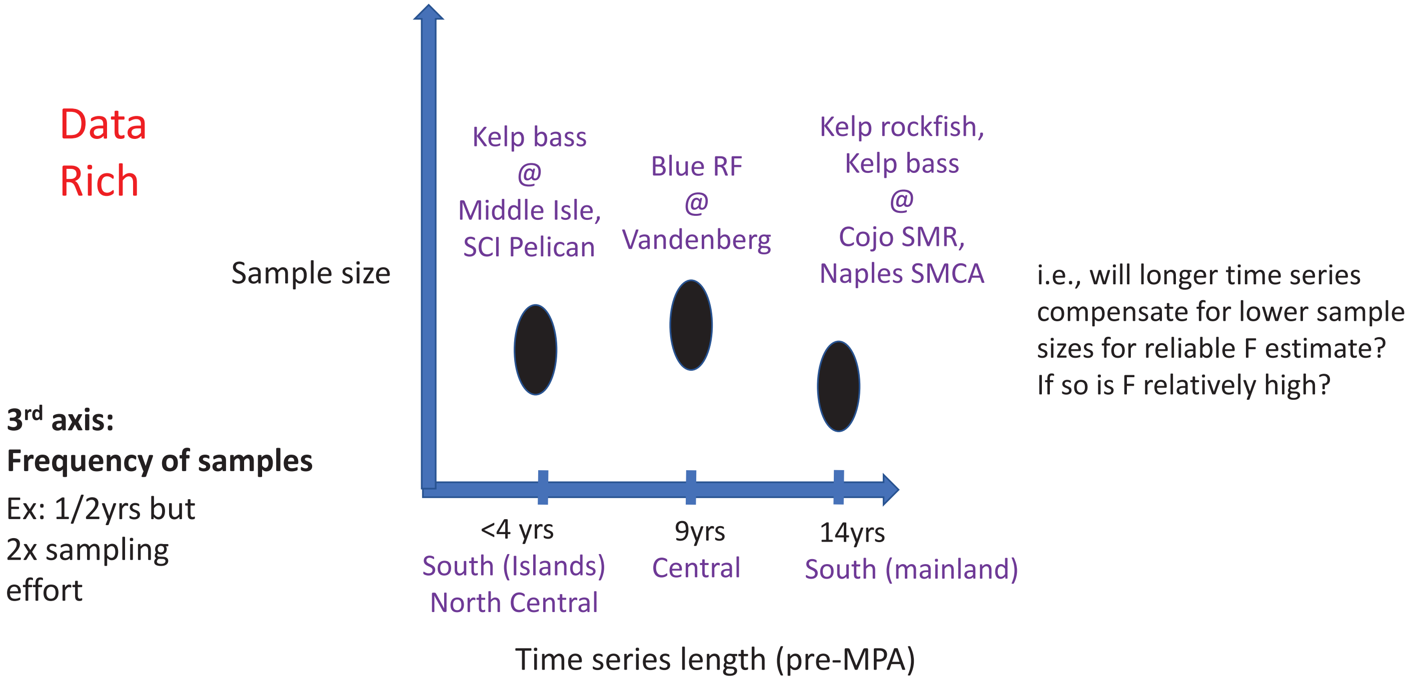


Reef Check data: South Coast red urchins have high sample size

Data Rich



Exploring sample size, time series length, and sampling frequency can inform Action Plan



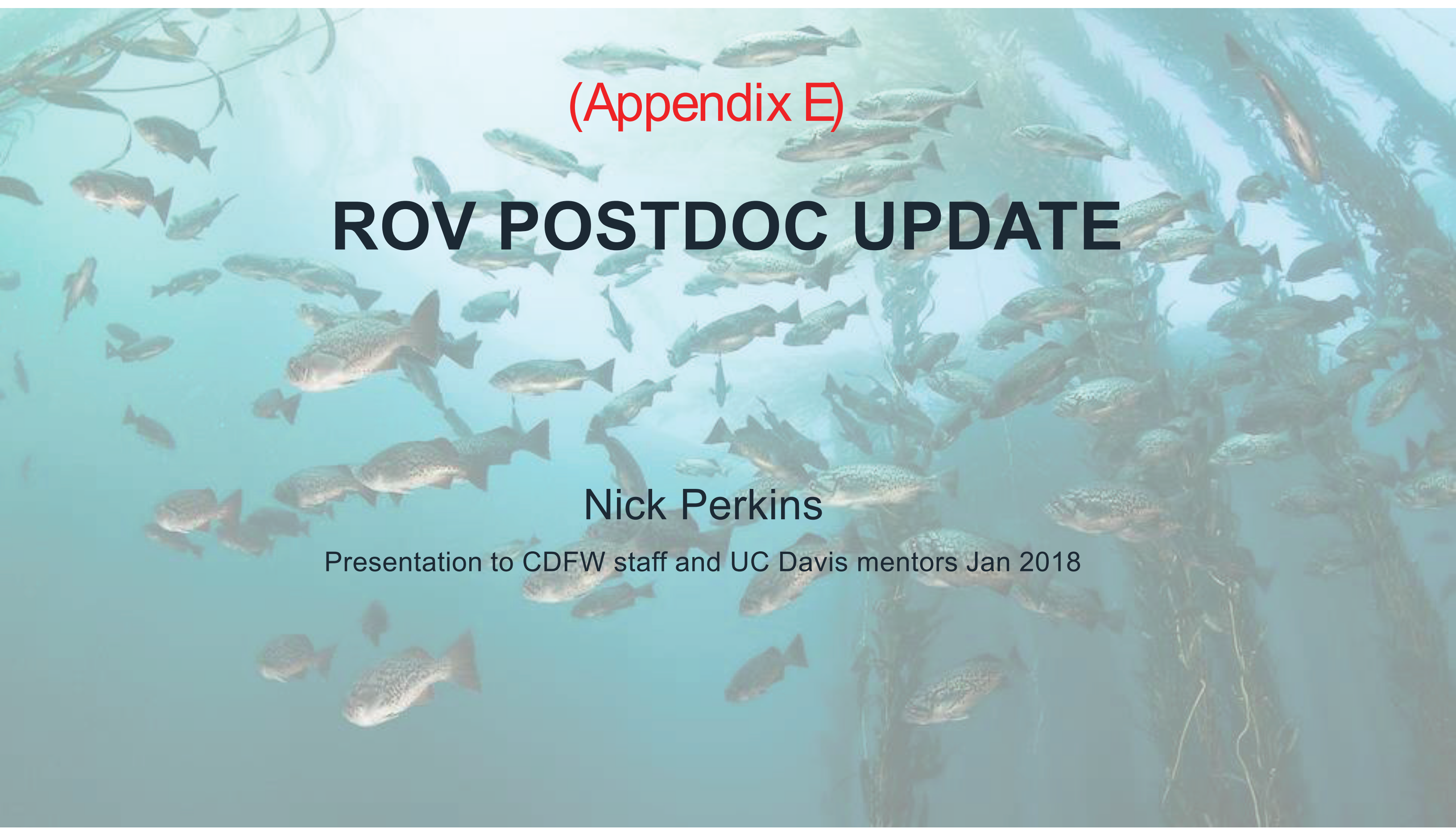
Data moderate: Estimate fine-scale historical fishing effort

- Fishing effort may be proportional to Fishing mortality
- Focus on important recreational species not ideal for SSIPM, e.g.:
  - Lingcod
  - Cabezon
  - CA Scorpionfish
  - Kelp bass

  (Lingcod, Cabezon, CA Scorpionfish, Kelp bass: Particularly important in the Southern region)
- Determine historical fishing effort within MPAs
  - Olivia Rhoades (OST/SCCWRP) has mapped relative fishing effort, following Paulo Serpa's approach
- Can compare relative effort among ports within region for private/rental and party boat modes
  - Standardize by the number of samples (interviews)
  - This can help us select monitoring sites with high historical fishing for each region

Thanks for listening!

Questions or Suggestions??



(Appendix E)

ROV POSTDOC UPDATE

Nick Perkins

Presentation to CDFW staff and UC Davis mentors Jan 2018

COMPONENTS OF PROJECT

1. Methods for analyzing ROV transect data
    - Model based approaches
    - Spatial point process models

2. Survey and sampling design with a ROV

3. Eco-regionalization using ROV and SCUBA data

1. METHODS FOR ANALYZING ROV TRANSECT DATA

- Model-based approaches:
    - Able to incorporate habitat and bathymetry covariates
    - Improved estimates across areas

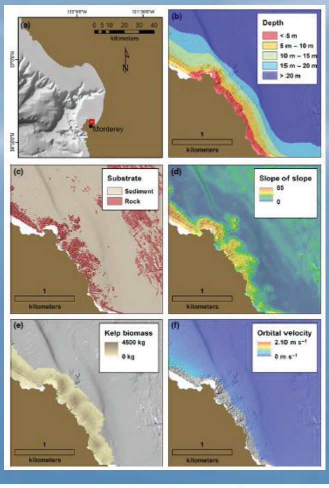


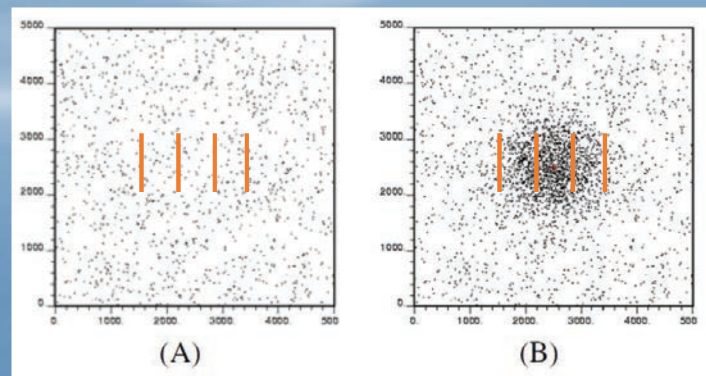
Table 3 Comparison of species abundance estimates generated by three methods for extrapolating species density within the Point Sur MPA: uniform extrapolation treating all rocks as equal, non-spatial habitat-based extrapolation and the abundances predicted from the spatially explicit species distribution models

Species	Common name	Uniform extrapolated abundance	Geomorphic-based extrapolated abundance	SDM-based extrapolated abundance
Embiotoca jacksoni	Black Perch	9149	2897	4890
Embiotoca lateralis	Striped Perch	59,065	23,014	22,655
Sebastes serranoides	Olive Rockfish	157,071	46,466	19,895
Sebastes atrovirens	Kelp Rockfish	38,133	13,313	9198
Sebastes carnatus	Gopher Rockfish	69,650	19,072	14,621
Sebastes chrysomelas	Black & Yellow Rockfish	20,977	11,315	10,817
Sebastes melanops	Black Rockfish	161,165	12,844	8666

Figure and table from Young and Carr (2015)

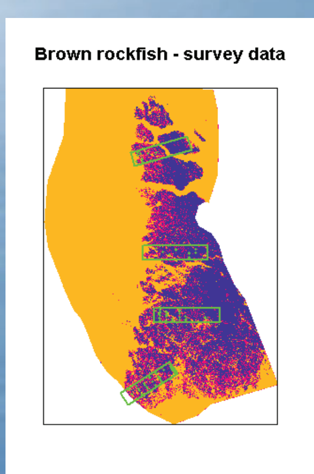
SPATIAL AUTOCORRELATION

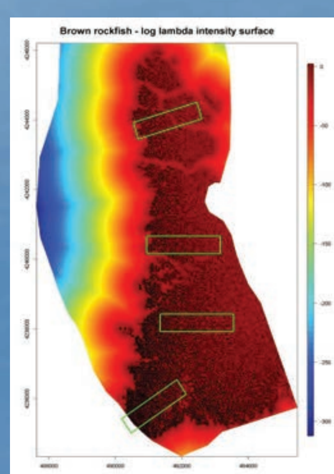
- Model parameter estimates assume that samples are independent
- Often acknowledged, but rarely explored
- Not taking into account spatial autocorrelation leads to biased results e.g. parameter estimates ~25% different (Dormann et al. 2007)
    - ➡ Biased estimates of abundance

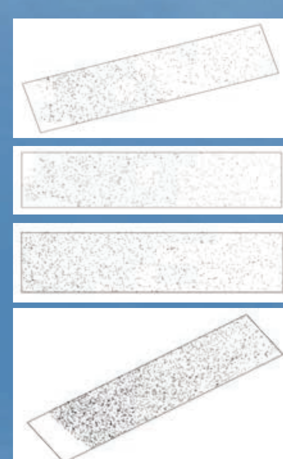


SPATIAL POINT PROCESS MODELS

- Spatial model where occurrence of individuals (e.g. fish) are modeled as points across a landscape, taking into account the spatial structuring
- Models the intensity (i.e. the number) of fish expected to occur in an area given the weighting of all other covariates
- Allows prediction of the total number of fish (i.e. abundance) across an area and where they are likely to occur

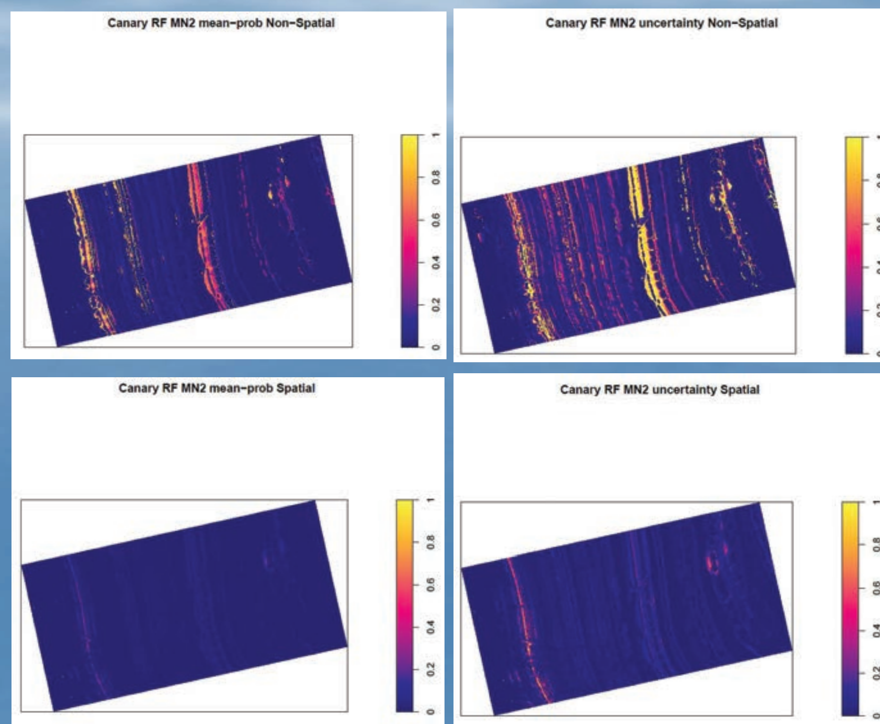






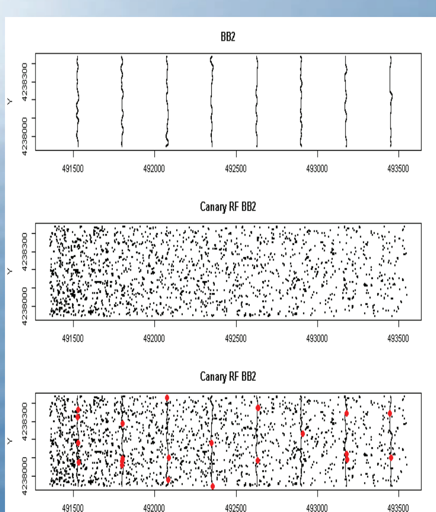
MODELING APPROACH

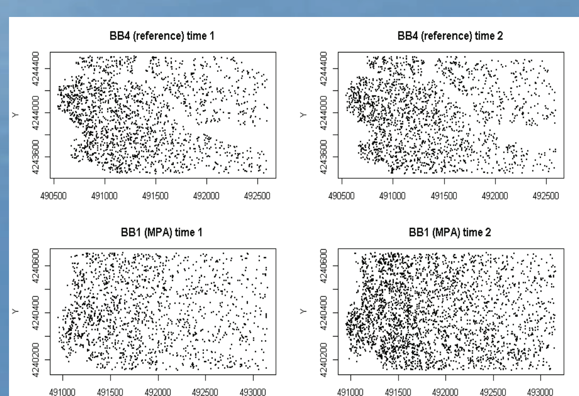
- Exploration of important bathymetry derived covariates using multiple sites within a region:
  - Depth
  - Habitat and distance to hard substrate
  - Bathymetric Profile Index (BPI) – different scales
  - VRM and other measures of rugosity
  - Slope and curvature
  - Aspect
- Modeling of spatial effects at the individual site level
- Comparison of non-spatial and spatial models

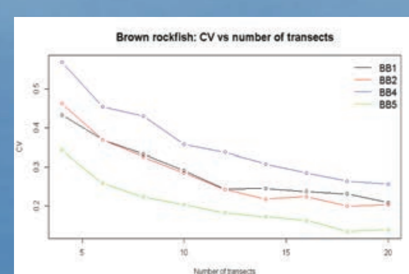


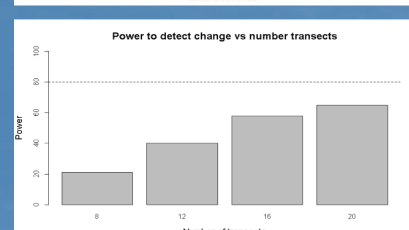
2. SURVEY AND SAMPLING DESIGN WITH A ROV

- Building on the previous work, using model parameter estimates, we can simulate fish distributions across sites/regions
- Test different designs and sampling effort
- Simulate changing abundance and/or size distributions



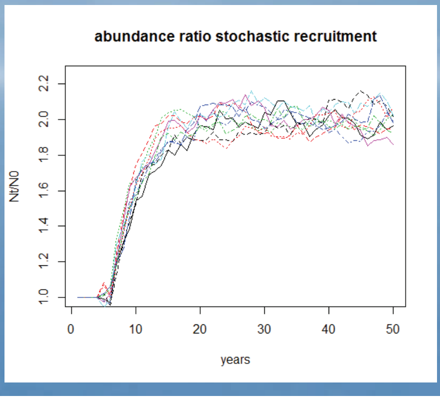


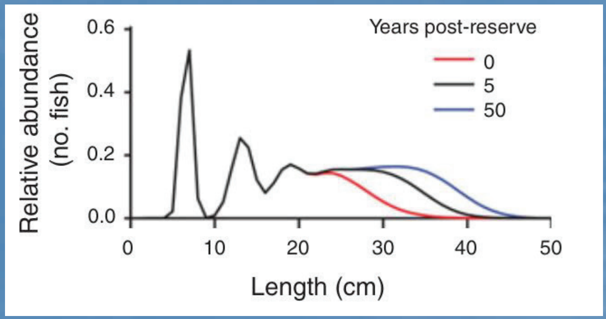




SIMULATION: TIME-SERIES AND POWER TO DETECT CHANGE

- Based on work by the other postdocs we can simulate a time-series of data of expected recovery inside a MPA – abundance and size structure
- Test power to detect change
- Need to decide on:
  - Species to model
  - Sites
  - Designs

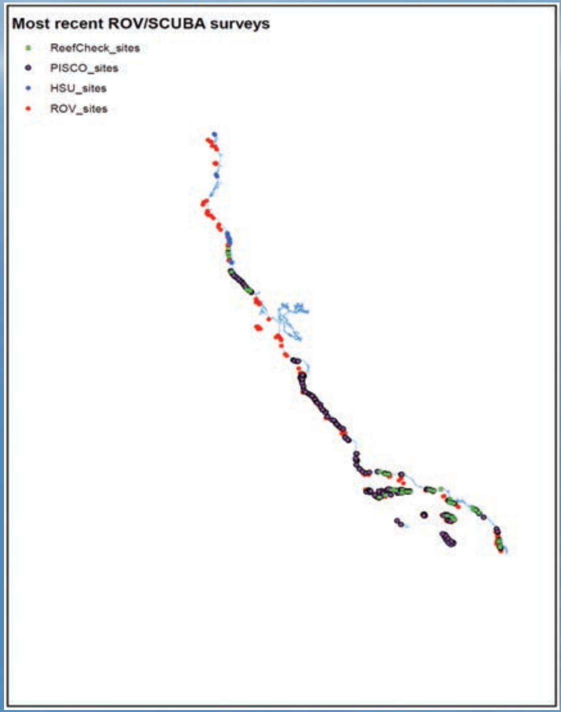




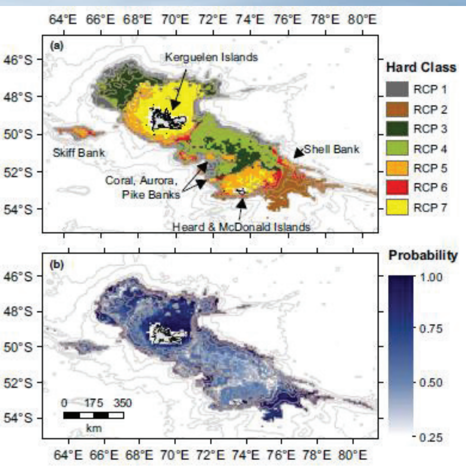
Figures taken from presentations by Katie Kaplan and Will White

3. ECO-REGIONALIZATION OF SUBTIDAL COMMUNITIES

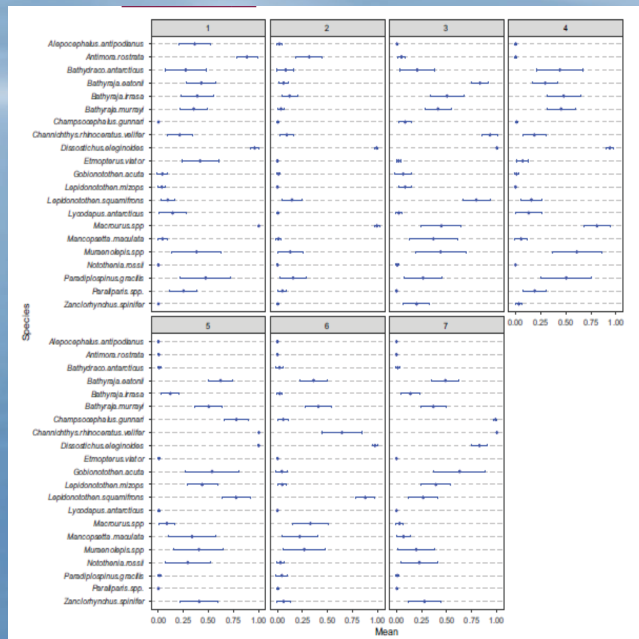
- Combine:
  - ROV and SCUBA data sets
  - Oceanographic variables: SST and indices, fronts, Chl a, SSH
  - Habitat – 1 km cells
- “Regions of Common Profile” (RCP) model:
  - Allows sampling effects to be incorporated
  - Data driven map of eco-regions across the state
  - Places MPA and reference sites in broader context
  - May aid in site selection: representative sites and/or replication within eco-regions



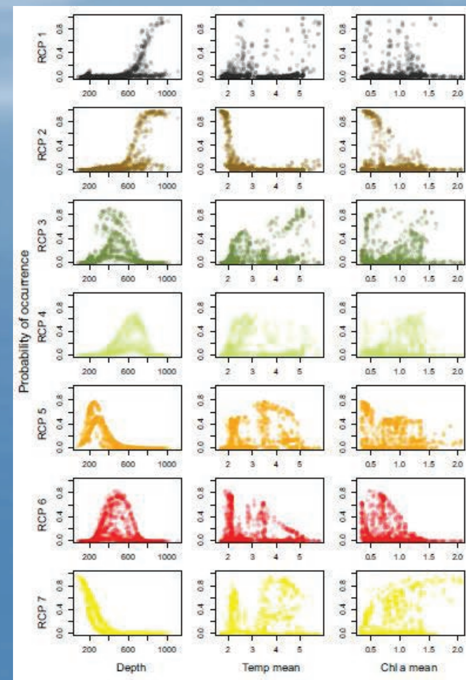
RCP MODEL: EXAMPLE OUTPUT



Mapped groupings and uncertainties



Species contributions to groups



Environmental drivers for groups

Figures taken from Hill et al. (2017)

ECO-REGIONS AND MONITORING

- We may expect regions with similar assemblages and environmental conditions to have similar responses
- Models that take eco-regions into account have been shown to have higher power to detect MPA effects
- Potential to link community changes over time to changing environmental/oceanographic conditions

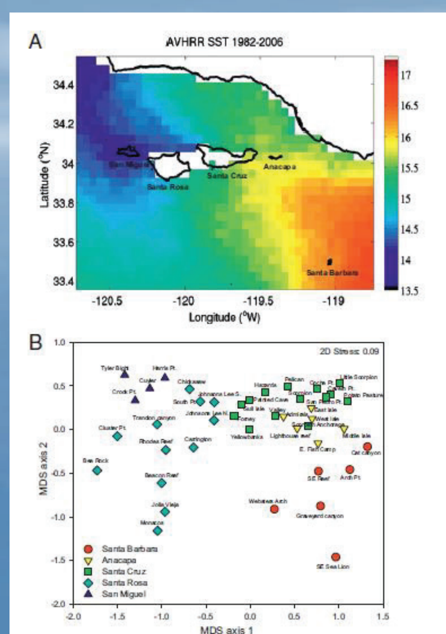


Fig. 2. (*A*) Map of the Channel Islands showing long-term (1982–2006) average SST recorded by Advanced Very High Resolution Radiometer satellite. The sharp gradient in SST between the western and eastern islands is apparent. (*B*) Nonmetric MDS analysis depicting similarities in fish community structure among survey sites. Most sites group at the island scale, suggesting similarities among fish communities at this scale. MDS axis 1 is positively correlated with average SST at each site ($r = 0.88$; $P < 0.0001$).

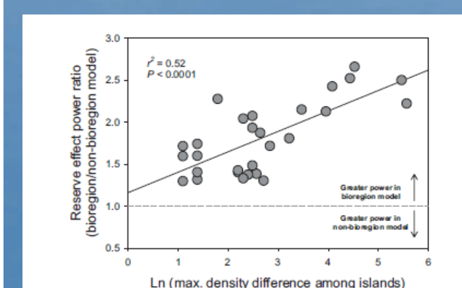


Fig. 3. Relationship between the reserve effect power ratio (power in bioregion model/power in nonbioregion model) and the maximum difference in a species' density across the Channel Islands (values from Table S3). In all cases, the power to detect reserve effects is improved by controlling for biogeography (i.e., all points occur above the dashed line, indicating improved power in the bioregion model). Statistical power increases most for species that exhibit strong biogeographic differences in abundance.

Figures taken from Hamilton et al. (2010)

ECO-REGIONS AND SITE SELECTION

- Understanding broad distributional patterns and their drivers can aid in:
  - Choosing sites so that there is replication within regions (may not always be feasible given budget and logistical constraints)
  - Making sure that regions that have distinct species assemblages are included in long-term monitoring plans (MLPA obligations)
  - Ensuring that reference sites are truly comparable in terms of communities and environmental drivers that are likely to influence them over time
  - Linking to connectivity matrices: do eco-regions regions = regions with ROMs connectivity?

Appendix H:

PROCEEDINGS OF THE REGIONAL OCEAN MODELING SYSTEM OVERVIEW WORKSHOP

Proceedings of the Regional Ocean Model System Overview Workshop

August 10-11, 2017
Long Marine Lab, UC Santa Cruz

Hosted by California Department of Fish and Wildlife Marine Region

Table of Contents

Workshop Participants

University of California, Santa Cruz (UCSC)

Mark Carr and Pete Raimondi

California Department of Fish and Wildlife (Department)

Becky Ota, Steve Wertz, Adam Frimodig, Sara Worden, Paulo Serpa, Amanda Van Diggelen, Mike Prall, and Leandra Lopez

University of California, Davis/Department Post Docs

Lauren Yamane, Nick Perkins, and Katie Kaplan

Acknowledgements

We extend a special thank you to UCSC, Long Marine Lab for allowing us to use their facility to host the workshop. We also thank Department staff Leandra Lopez for recording detailed notes of the discussions at the workshop.

Executive Summary

Pursuant to the Marine Life Protection Act (MLPA),[1] significant steps were taken to ensure California's marine protected areas (MPAs) were designed as an ecologically connected network. The California Department of Fish and Wildlife (Department) is developing priorities for designing a Statewide MPA Monitoring Program in coordination with the Ocean Protection Council and Ocean Science Trust. A Statewide MPA Monitoring Action Plan (Action Plan) will synthesize quantitative and expert informed approaches to long-term monitoring, and identify a priority list of indicators and sites for long-term monitoring to evaluate the performance of the network at meeting the goals of the MLPA.

The Department convened a workshop titled "Regional Ocean Modeling for Site Selection" in Santa Cruz, California, on August 10-11, 2017. The purpose of this two-day workshop was to facilitate the Regional Ocean Modeling System (ROMS) effort in progress by Dr. Pete Raimondi and Dr. Mark Carr of UC Santa Cruz, and develop a shared understanding for how the Department may utilize their ROMS connectivity modeling results to inform long-term MPA monitoring site selection.

On the first day of the workshop, discussions among the participants centered around 1) understanding how the ROMS model works; 2) reviewing the model results for a subset of priority habitats and indicator species; and 3) discussing the model accuracy and the process for fine-tuning the model to include specific physical and biological parameters. On the second day, UC Davis/Department post-doctoral researchers shared their progress on 1) analyzing and integrating extensive remotely operated vehicle (ROV) data, along with other visual data, to gain insights on MPA performance; and 2) developing effective methods to integrate MPAs with fisheries management. The focus of this proceedings document is to highlight key outcomes and next steps facilitated primarily during the first day of the workshop.

The workshop participants identified core priorities for moving forward on the ROMS connectivity model and eventual long-term monitoring site selection criteria. Next steps include:
1) Focusing on modeling planktonic larval duration (PLD) for species that are data-rich and recognized as species likely to benefit from MPAs, focusing on PLDs between 30-60 days
2) Fine-tuning the model by integrating specific physical and biological parameters
3) Modeling network connectivity both between and within rocky reef habitat types
4) Integrating the ROMS modeling results with the state-space integral projection models

[1] FGC §2850-2863.

Overview

California has adopted a two-phase approach to MPA monitoring to track the ecological and socioeconomic conditions in and around the network of MPAs, including Phase 1 regional baseline monitoring, and Phase 2 statewide long-term monitoring. A key priority for the Department for Phase 2 is to develop practical, cost-efficient standardized metrics that can be gathered consistently over time. Gathering consistent ecological and socioeconomic information over sufficient time and geographic scales is necessary to evaluate MPA network performance, inform adaptive management decisions, and ensure that the statewide network of MPAs is meeting the goals of the MLPA.

One component of long-term monitoring design is MPA and reference site selection. Establishing long-term data collection efforts at a select set of sites to better track MPA network performance over time will help inform adaptive management in a manner that is scientifically rigorous, cost-effective, and consistent with MLPA goals.[2] By leveraging existing partnerships and capacity of academic partners, this project will lower costs and ensure a scientifically robust product that meets or exceeds the scientific standards established by the state in order to effectively evaluate the performance of the MPA network.

Dr. Raimondi and Dr. Carr (PIs) of University of California, Santa Cruz (UCSC) have been tasked with developing long-term monitoring site recommendations inside and outside MPAs statewide to most efficiently support MPA network evaluation. These recommendations include:

1. Minimum number of sites that will support an assessment of condition and trends to evaluate the progress of the statewide network at meeting MLPA goals within the ten year management review time frame;
2. Siting recommendations that will support a more robust assessment of condition and trends to evaluate the progress of the statewide network at meeting MLPA goals within the same time frame;
3. Siting recommendations that will support a comprehensive assessment of condition, trends to evaluate the progress of the statewide network at meeting MLPA goals, and explicitly links to other state priorities.

The PIs have opted to use the Regional Ocean Modeling System (ROMS) as one tool to evaluate connectivity of California's rocky intertidal habitats, shallow rocky-reef/kelp forest habitats (0-30m), and deep rock habitats (30-100 m) as driven by oceanographic currents. The proceedings from this workshop are summarized below.

[2] FGC §2853(c)(3)

Day 1: Developing an Understanding for MPA Site Selection Criteria

1. ROMS based connectivity matrix overview: Network analytical approach to spatial sampling design

The ROMS framework is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications. The PIs are using the ROMS model to evaluate connectivity of rocky intertidal habitats, shallow rocky-reef/kelp forest habitats (0-30m), and deep rock (30-100 m) habitats driven by oceanographic conditions. In simplest terms, the ROMS model allows users to make the basic assumption that larvae particles are moved around by oceanographic currents, and then track where those larvae particles are moving over a set period of time.

Detailed ROMS model approach:

1. The eastern Pacific coast is divided into eight regions ranging from Canada south to Mexico.
    a. Each region is divided into a number of 5km cells along its coast. There are 557 cells in total. (Figure 1)
    b. Mexico and Canada are included in the model because particles are subject to ocean currents and are not constrained to state/country borders.
2. The ROMS model simulates the release and movement of planktonic larvae from each cell under different temporal scenarios with respect to dispersal times (planktonic larval durations [PLD]) and oceanographic conditions.
    a. Particles can move in any direction (3-Dimensional movement)
    b. Oceanographic conditions are average annual conditions over 15-years (1999-2013)
        i. Current time period to model oceanographic conditions avoids major El Niño events, but these can be added to the model, or run separately, to simulate planktonic movement during anomalous years
    c. Over the 15 year period approximately 88000 larvae particles were released from each cell, within each bioregion
        i. Settlement of larvae depends on the PLD; PLD's can last from 5, 10, 15, 20, 30, 45, 60, 90, 120, 150, or 180 days
            1. ROMS model can used to model PLD for indicator species to track possible movement into and out of MPAs (Table 1)
        ii. Larvae particles either settle (larvae end up in an appropriate habitat) or die
3. The ROMS model currently assumes that habitat is proportional to amount of larvae production for species from that habitat (e.g. more kelp forest = more production of blue rockfish larvae)
    a. Estimates could (and should) be improved in the future through incorporation of:
        i. Site specific geomorphological, and physical attributes such as geology, rugosity, relief, sand scour, wave climate
        ii. MPA effect–over time protection should lead to increased propagule production for certain species

2. What is an appropriate geographic scale for network connectivity evaluation?

Three primary considerations and needed to determine an appropriate geographic scale for long-term site selection 1) oceanographic drivers (biogeographic scale), 2) the demographic life history traits of nearshore species, and 3) overlay of logistical constraints (access to sites, white sharks, etc.) While the current ROMS model has eight regions, the model shows large regional differences. Participants thought it best to discuss the current boundaries and adjust them based on our current understanding of biogeographic regions.

At or near the time of MPA implementation, baseline monitoring data was collected in each of four coastal regions: the north coast (OR-CA border to Alder Creek, 2013-2016), north central coast (Alder Creek to Pigeon Point, 2010-2012), central coast (Pigeon Point to Point Conception, 2007-2011), and south coast (Point Conception to the US-MEX border, 2011-2013). However, these divisions were selected during the MPA planning period in order to divide the California coast into reasonable geographies from a planning logistics viewpoint, not a biogeographical one. In order to better define bioregions informed by clusters of similar biota, workshop participants selected new bioregions for consideration in connectivity modeling. These new regions are the north coast (OR-CA border to Cape Mendocino), north-central coast (Cape Mendocino to San Francisco Bay), south-central coast (San Francisco Bay to Point Conception), and south coast (Point Conception to the US-MEX border.)

3. How will long-term monitoring sites be selected?

With long-term monitoring regions established, the PIs will use the ROMS model to determine how cells connect to all other cells using source-sink dynamics. A source cell is considered a cell where larval particle distribution has a higher rate of connectivity with all other cells, essentially larvae distributed from this cell disperse and settle to a disproportionate number of other cells (Figure 2). A sink cell exhibits the reverse trend, where larval particle distribution is low, but larval particle settlement from other cells is high. To determine if the network displays true connectivity, a mixture of both source and sink locations is recommended for site selection.

The PIs will use the ROMS model to determine which cells are contributing significantly as source locations both within their respective region as well as statewide. This includes running the ROMS model for PLDs, which primarily fall within the 30-60 day larval duration period; how larvae connect within the same habitats (i.e. cell connectivity from one rocky intertidal habitat to another rocky intertidal habitat); as well as between habitats (i.e. cell connectivity from rocky intertidal habitat to shallow rocky-reef habitat.)

MPAs and reference sites that have the following criteria are likely to be good indicators of MPA network connectivity and should be considered for long-term monitoring sites:

- High degree of connectivity with other cells prioritizing statewide connectivity over regional connectivity
    - Source locations will be prioritized for cells south of Cape Mendocino, as these are the locations that will be connecting the network through propagule distribution

  - Sink locations will be prioritized north of Cape Mendocino, any source cells north of Cape Mendocino will be contributing more to Oregon and Washington waters and are outside the evaluation of California's MPA network connectivity
- Multiple habitats represented within their boundaries
  - MPAs with multiple habitat types allow for cross collaboration on monitoring projects, and can help determine how marine ecosystems and species move across different depths and habitat types
- Historic monitoring data are available
  - MPAs and reference sites with historic data available will allow for data sets to be expanded temporally increasing the available information to help determine network performance for meeting the goals of the MLPA
- Sites are accessible for long-term monitoring (i.e. the site safe to monitor)
  - If other criteria are met, but researchers cannot physically get to the location there will be little utility in selecting that MPA or reference site as a long-term monitoring location

Figure 1. Eight regions assigned for the ROMS MPA network connectivity model

Table 1. Planktonic larval duration (PLD) of potential indicator species for network evaluation

PLD	Potential Indicator Species
10 DAYS	Red and black abalone
20 DAYS	Barnacles
30 DAYS	California mussel, basses
45 DAYS	California sheephead
60 DAYS	Nearshore rockfish, red and purple sea urhcins
90 DAYS	Yellowtail rockfish, rock crab, lingcod
120 DAYS	Blue rockfish

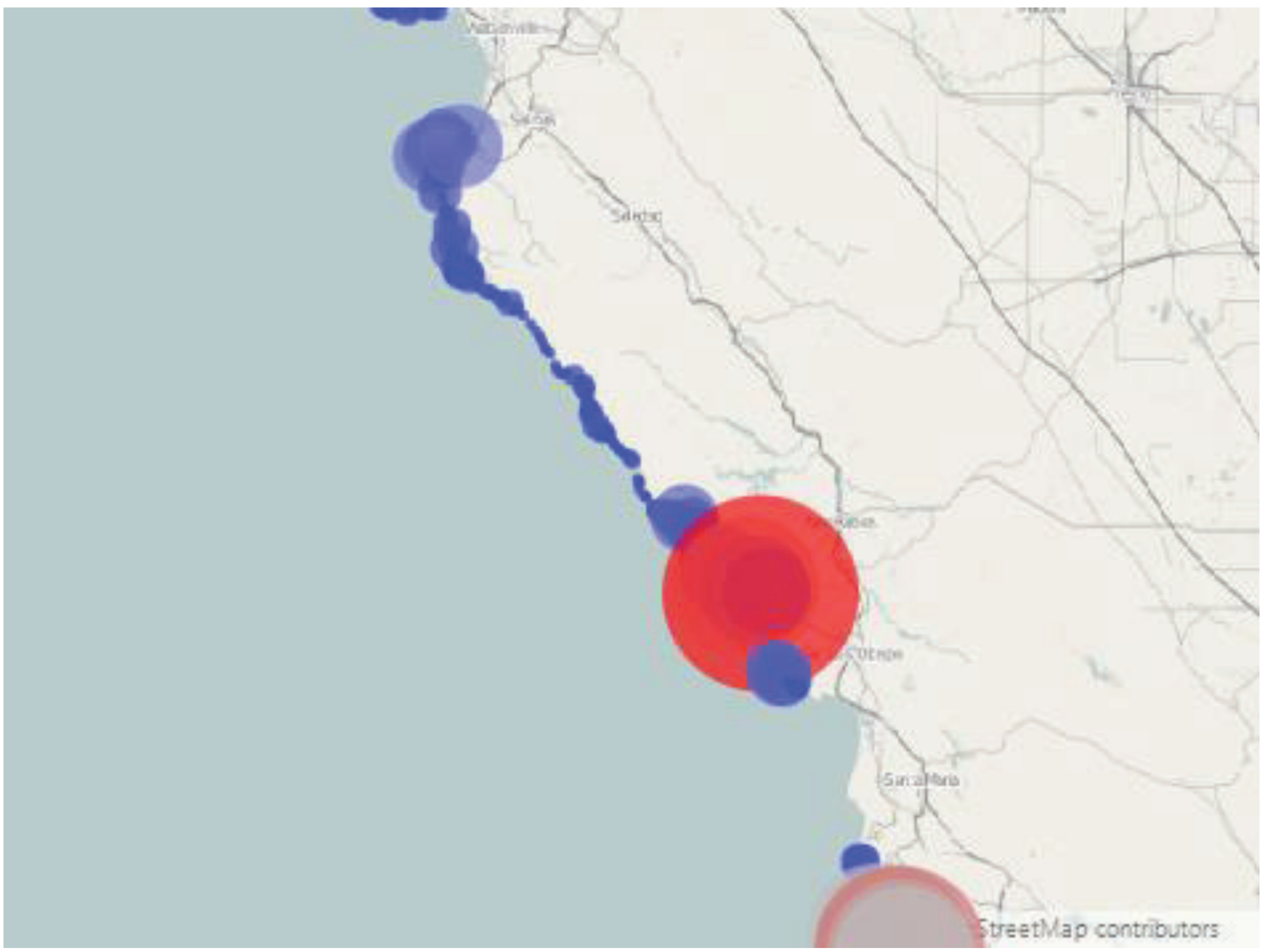


Figure 2. Effect of planktonic larval duration (PLD) on network connectivity; shallow rocky-reef habitat with a PLD of 60 days. Bubble size indicates the degree of connectivity with other cells, with larger bubbles indicating areas of greater connectivity (source populations).

Day 2: Integration Projects Update

MPA managers and partners are interested in learning from regional baseline monitoring efforts, and seeking resolution from a statewide network perspective, to discuss the best approach for arriving at a select set of MPAs throughout the network. Three, one-year contracts for post-doctoral fellows with a background in MPA data synthesis and integration began in early 2017, to aid in statewide, long-term monitoring planning. The three projects focus on:

1. Analyzing and integrating extensive remotely operated vehicle (ROV) data to gain insights on MPA performance;
2. Develop effective methods to integrate MPAs with fisheries management; and
3. Helping to develop the Action Plan to inform long-term statewide MPA monitoring.

Two of the three post-doctoral fellows were able to attend the workshop and provide an update on their progress to help inform the evaluation of the MPA network at meeting the goals of the MLPA.

1. Deep-water habitat surveys with ROVs: Spatial point process models for benthic visual survey and sampling design

This project focuses on the analysis and integration of an extensive ROV data set collected by CDFW and Marine Applied Research and Exploration to gain insights on MPA performance to date and inform the creation of the Statewide MPA Monitoring Action Plan.

ROV data needed to be conditioned for ongoing development of spatial analyses to examine species density at hard bottom index sites inside and outside of MPAs. Now that data conditioning is complete, spatial point process models can model ROV transect data and bathymetric layers. A model simulation was presented for rockfish in the Bodega Bay area. The simulation informs understanding of ROV transect precision, number of transects needed to achieve similar results between ROVs and video landers, and number of transects necessary to achieve a statistical power that will show significant results over time. While a scarcity of data associated with some species can lead to high model uncertainty, spatial point process models may be useful as a power analysis to decide final sampling design for the deep water MPA monitoring program.

Workshop participants recommended:

- ROVs be used over video landers due to the amount of data that can be collected within the same period of time;
- The model be expanded to simulate/test other areas; and
- Incorporate information such as fishing effort to project changing abundances

2. Integrate MPAs with Fisheries Management: Assessing MPA effectiveness and integrating MLMA-MLPA

This project focuses on the development of effective methods for the integration of MPAs with fisheries management. The development of quantitative approaches to integrate the ocean health goals of the

MLPA with ecosystem-based fisheries management requirements of the Marine Life Management Act in fishery management plans is the goal.

In order to assess MPA effectiveness local fish mortality rates are being modeled. Local mortality rates can be estimated by looking at fish species size distributions over time and modeling size structure changes by taking into account both natural mortality (i.e. disease, old age, predation) and fishing mortality (removal of fish from a stock by fishing.) High fishing mortality will be apparent in areas where fewer large, old fish are present. By modeling mortality rates, pre-MPA annual recruitment rate can be estimated to help establish transient population dynamics.

Workshop participants recommended:

- Looking to regulations for particular minimum sizes of indicator species;
- Choosing species that have strong data sets, and avoid certain species with missing size distributions based on cryptic size classes
    - Red abalone, blue rockfish, and scorpionfish were identified as species with strong data sets
- Considering the need to model recruitment data

3. Develop the Action Plan to inform long-term, statewide MPA monitoring

The third project will focus on the development of the Action Plan that will inform the approach to long-term monitoring of the statewide MPA network. The creation of the Action Plan, which will identify the sites and temporal frequency of sampling and metrics, needed to evaluate network performance and inform the adaptive management of California's MPA network.

Next Steps

The immediate primary purpose of the workshop and ROMS connectivity model, along with post-doctoral contracts, is to assist the state in identifying priority monitoring parameters and sites to include in the Action Plan, which is anticipated to be released in 2018. MPAs and reference sites should also be selected to represent and span important biogeographic features along the coast. Because there are many definitions of biogeographic regions and the MLPA planning regions are not based strictly on biogeography, the group suggested that selection of MPAs to be monitored should not be constrained by the MLPA planning regions, but rather using newly drawn borders, or a statewide focus as required by the MLPA. The PIs should also work to incorporate potential MPA effects into the ROMS model (increase production in any given cell), and look both within and between the three types of habitats. At least one other workshop, if not more, will likely be needed to continue fine-tuning the model to display MPA network connectivity statewide.

Appendix A: Workshop Agenda

ROMs Model Workshop Agenda

Long Marine Lab, UC Santa Cruz
115 McAllister Way, Santa Cruz CA 95060
August 10-11, 2017

Participants

UCSC: Mark Carr and Pete Raimondi
CDFW: Becky Ota, Steve Wertz, Adam Frimodig, Sara Worden, Paulo Serpa, Amanda Van Diggelen, Mike Prall, Leandra Lopez
UCD/CDFW Post Docs: Lauren Yamane, Nick Perkins, and Katie Kaplan (she will try to join us for some of the time via phone)

Workshop Objectives

Day One:

- Gain understanding of how the ROMs model works
- Review model results for a subset of priority habitats, indicator species (PLDs), and sources/sinks for indicator species
- Discuss model accuracy and parameters, the process for fine-tuning the model to include specific physical and biological parameters, and integrating the model with other work (i.e. post-docs' projects, CDFW MPA habitat spreadsheet)
- Identify next steps for how to best use the model to inform the Statewide MPA Monitoring Action Plan

Day Two:

- Presentations by post-docs on MPA Monitoring Action Plan, MLMA, and ROV projects
- Discuss post-doc projects, alignment with state priorities, and integration with ROMs model

August 10: ROMs Model Overview and Brainstorm Session
10:00-5:00: Center for Ocean Health Library, room 201 (upstairs to the left)

10:00-10:10	Introductions and logistics for the day
10:10-11:10	Presentation: ROMs model overview and question/answer session
11:10-11:25	BREAK
11:25-12:30	Presentation: Model results for priority habitats, indicator species, sources, sinks with time for questions
12:30-1:00	LUNCH

1:00-2:45	Group Discussion and Brainstorm: Preliminary results, model accuracy, fine tuning the model, action plan integration
2:45-3:00	BREAK
3:00-4:30	Continue Group Discussion and Brainstorm
4:30-5:00	Next steps
5:00-???	Optional team activity

August 11: CDFW/UCD Post-docs Project Presentations and Discussion

8:30-11:30, Center for Ocean Health Library, room 201

8:30-8:35	Welcome
8:35-9:30	Presentation (Nick and Mike): ROV work, workshop overview and group questions
9:30-9:40	BREAK
9:40-10:30	Presentation (Lauren): MLMA/Action Plan and group questions
10:30-11:30	Group Discussion: Project alignment with state priorities and ROMs model

Appendix B: Workshop Detailed Notes

Regional Ocean Model Workshop Notes

Long Marine Lab, UC Santa Cruz

August 10-11, 2017

Participants

UCSC: Mark Carr and Pete Raimondi

CDFW: Becky Ota, Steve Wertz, Adam Frimodig, Sara Worden, Paulo Serpa, Amanda Van Diggelen, Mike Prall, and Leandra Lopez

UCD/CDFW Post Docs: Lauren Yamane, Nick Perkins, and Katie Kaplan (telephoned in)

Note Taker: Leandra Lopez

Workshop Outcomes

Day One:

1. Gained a deeper understanding of how the ROMs model works through a presentation about and live example outputs produced from the model.
2. Developed a list of key priorities for the Action Plan:
   - Identify the MPAs that are the largest sources
   - Model a range of PLDs that produce the most accurate results across the three priority habitats
   - Examine MPAs regional vs. statewide contributions
   - Model connectivity by decided upon bioregions
   - Recommend run ROMS statewide as tier 1 and regional as tier 2 to validate statewide outcomes
   - Important to fine tune model by integrating specific physical and biological parameters, and other work (i.e. post-docs' projects, CDFW MPA habitat spreadsheet)

Day Two:

1. Gained a deeper understanding of post-doc projects through presentations and discussions of preliminary simulation results.
2. Developed a list of suggested changes to strengthen the projects (see UCD/CDFW Post-Doc action items)

Action Items

UCSC:

1. Produce model outputs for tier I priorities (listed under Day 1 workshop outcomes) agreed upon by the group to present at the next modeling/siting workshop.
2. Refine/integrate south coast habitat mapping data into ROMS (requires input from #5 CDFW below)
3. Incorporate MPA effect into the model (increase production in any given cell)
4. Make reference site selections

5. Overlay criteria on CA map
    a. Determine if source/priority MPAs are distributed statewide
    b. How source/priority MPAs align with other design criteria (i.e. ASBSs)

CDFW:

1. Provide new list of practical de facto SMR specifically for the habitat UCSC is looking for
2. Request habitat mapping data from ODFW
3. Ground truth MPAs that rise to the top of the models using MPA criteria spreadsheet
    a. Determine how feasible it is to monitor multiple habitats at the MPAs identified as priority/source locations
4. Examine overlap with historical data
5. Send Post-docs nearshore finfish life history information from Greg Cailliet work (CDFW) Reanalyze habitat mapping data within ROMs cells with WZ updates and additional Point St. George. (First step requires pending updates from UCSC)

UCD/CDFW Post Docs:

ROV Project:

1. Link the temporal variance structure between the MPA and reference site transect simulation

MLMA/MLPA Integration

1. Examine and choose more appropriate fish data for minimum catch and recruitment sizes
2. Create model outputs using other data rich focal species like abalone
3. Consider modeling recruitment data

Critical Dates

Next Workshop tentatively planned for January 2018

Meeting Summary

Presentation by Pete Raimondi: *Network analytical approach to spatial sampling design*

Presentation Overview

- Walked through the Regional Ocean Modeling System (ROMS) and habitat based modeling system that will inform network-based evaluation of California's MPAs
- Provided background on the "construction" and function of the model
- Demonstrated some initial outputs from the model including levels of raw connectivity and contribution ("source") vs settlement ("sink") based connectivity (connectivity index) based on 11 planktonic larval durations (PLDs). The PLDs range from 5 to 180 days.
- Demonstrated model output for PRIORITY MPAs identified by CDFW. These demonstrations offered insight into the importance of time and spatial scales.
    - Model biases exist on the north and south borders due to a lack of data from Mexico and Oregon.
    - The northern most cells mainly contribute to Oregon but not California
    - Statewide vs Regional PLD contribution outputs for some Priority MPAs were drastic (Point Arena as an example), highlighting the significance of looking at the model on a regional scale.

- While model output will be prioritized statewide, looking at a regional perspective will ensure site selected can provide good source populations both on a small and large scale.

Q& A, Group Discussion, and Brainstorm:

Main Discussion points

1. Initially questions were asked about overall goals of the use of the ROMS model and ways to best frame the assessment of the Network

   Questions raised:

   a. Is the network performing in some way?
   b. What are some of the ways to measure network performance?
   c. Does the network contribute to areas that have been overfished?
   d. In what ways does the network contribute to the sustainability of other MPAs?
   e. How important are the overall contributions relative to the regional contributions?

   Conclusions:

   a. Focus should begin from a broad perspective in order to address management goals.
   b. The conceptual design of the CA MPA Network called MPAs to be spaced such that the species within would replenish stocks inside of MPAs thus the assessment should be based on this assumption
   c. Target and monitor MPAs that the model identifies as important sources for replenishing other MPAs because these subsequently replenish non-MPA areas.
2. Importance of sink sites and their relevance to monitoring
   a. Sinks represent an important aspect of the resiliency of the network. Large sinks may offer protection to certain populations, promoting their persistence in times where source populations decline
   b. Monitoring sinks is going to depend on the stage for which monitoring is conducted
   c. Viewing which MPAs are important sinks may be useful criteria for determining Tier II sites
3. Importance of appropriate PLD lengths for use in assessing the network
   a. Example outputs shown the value of viewing the model at different spatial scales and PLD lengths and lead the group to discuss what spatial scales
   b. The group discussed the merits of different PLD lengths, noting that shorter PLD lengths, especially as short as 10 days don't have much of a network affect but do allow for self-recruitment
   c. Longer PLDs, especially as long as 120 day lengths highlight the network effect but dont capture
   d. Model outputs using PLDs from 30 to 60 days would offer insight appropriate to the needs
4. Reassigning regional biogeographic boundaries
   a. Example outputs on a regional scale used boundaries based on MLPAI distinctions and seeing the drastic differences Priority MPA sites had on a statewide vs regional scale lead the group to decide that regional boundaries should be reassigned based on stronger biogeographic qualities
   b. ***New*** Biogeographic regions

   i. Oregon border to Cape Mendocino
   ii. Cape Mendocino to SF
   iii. SF to Point Conception
   iv. Point Conception to Mexico

5. Direction of monitoring efforts if ROMS analyses shows particular sites to be of higher importance
   a. It was discussed that ROMs results alone would not drive a drastic change in current monitoring project site selection until a strategy was fully incorporated in the Action Plan.
6. Best ways to compare MPAs and how to choose reference sites
7. Habitat specifics and attributes
   a. Discussed the relevance of multi-beam data for 30 to 100m rock habitat

Example Outputs that we examined

1. Contribution (y-axis) vs SMR (x-axis)
2. Contribution (y-axis) vs No-Take SMCA (x-axis)
3. Mean Contribution (x-axis) vs All MPAs (x-axis) on the central coast
4. Mean contribution of ALL MPAs Statewide & regional contribution across the PLD range
5. Mean regional contribution & mean contribution vs protection

Possible Model Tweaks:

1. Site specific geomorphological attributes
2. MPA effect (even site specific factors)
3. Look at sink factors over source north of Mendocino in order to help decide appropriate monitoring sites.
4. Toggle feature (?) for comparing Network with and without MPA effect
5. How to factor in MPAs whose historical area was smaller but are now larger?

Presentation by Mike Prall: *ROV work and workshop overview*

Presentation Overview:

- Using CIAP ROV data (2014-2016). Looking at biogeographic analyses
  - Looking at 6 fish sp. (gopher, brown, canary, lingcod, quillback, yelloweye) latitudinal breaks
- 2nd Deep Water Monitoring Workshop – June 2017
  - Provided the state with tool & MPA recommendations for long-term monitoring of deep-water habitats
  - Discuss various tool and analytical technique combinations for conducting deep-water MPA monitoring
    - ROV, manned sub, video lander, video sled
  - Articulated the tradeoffs between different approaches
  - Made recommendations for site selection

Q& A, Group Discussion, and Brainstorm:

Main Discussion points

1. ROV Methodologies and ROV video review

2. How much do we need to sample?
    a. Statistical power – effect size –
3. How do we calculate a mean density for a given site or MPA?
4. How do we model spatially specific data to reduce underlying variability?
    a. ROV in situ data
    b. Bathy survey data

Presentation by Nick Perkins: *Spatial point process models for benthic visual survey and sampling design*

Presentation Overview

- Nick provides overview of spatial point process models and their relevance to long term MPA monitoring, sampling design, and tool comparison
- Model uses ROV transect data and bathymetric layers
- Demonstrates model simulation using brown rockfish. The simulation informs understanding of ROV transect precision, number of transects needed to achieve similar results between ROVs and video landers, and number of transects necessary to achieve a statistical power that will show significant results over time

Q& A, Group Discussion, and Brainstorm:

Main Discussion Points

1. Comparing Lander drops to ROVs including number of transects,
2. Difficulty of realizing a network effect
    a. Thinking of more maybe you have a specific bioregion
    b. **Decades to detect statistical power from sampling**
    c. Issues with comparing sites. Spatial vs treatment level
3. Rugosity and relief and its effect on sampling efforts
4. Effect of ROMS model on spatial point process model – possibly providing more predictable trends

Model Tweaks

1. link the temporal variance structure between the MPA and reference site transect simulation

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Presentation by Lauren Yamane: *Assessing MPA effectiveness and integrating MLMA-MLPA*

Presentation Overview

- Provided an overview of their project's work to assess MPA effectiveness while also addressing goals of the MLMA; to shape upcoming MPA monitoring in a manner that ensures the collection of relevant fisheries management information
- Gave an overview of the rationale behind their approach which focuses on finding local fishing mortality rates
    - Can look at size distributions over time and estimate fish mortality rate (size structure changes)

  - Stock Assessments traditionally have fishing mortality rates for much larger areas
  - It can help determine the rate at which the population is expected to replenish itself
  - This model can help estimate the pre-MPA recruitment annual rate – necessary for establishing the transient population dynamics
- Gave an overview of the State Space Integral Projection Model (SSIPM) and its two main components- the Process model (IPM) and the observation model and the work of Kerry Nichols that describes the expected timelines for populations to "fill in"
- Katie conveys the impacts of her work on measuring sample size and the effect on the model's performance- for some species the model fits very well, others not so well
  - Maybe there are a handful of "indicator" species that could act as good indicators of local mortality
- Examining simulations from different species (blues, blacks, yellow)
  - For F=0.05 its never a very good fit (likely variability in recruitment is swamping out recruitment in the size structure)
  - Need to figure out why certain simulations aren't fitting very well
  - Why is it fitting better at higher f?

Q& A, Group Discussion, and Brainstorm:

Main Discussion Points

1. Minimum catch size for fish, what data to reference, and the many considerations that may have to be taken into account when choosing a size
   a. Data and things to consider included CRFS, landing data, stock assessments, fishing style changes, release mortality, high grading, live fish fishery and gear types,
   b. Recommended to look to regulations for particular minimum sizes
   c. Does the model need a hard number for this parameter or could a Bayesian input be considered?
2. More on accuracy of given parameters and choosing species that have strong data sets. Missing size distributions based on cryptic size classes for certain species
   a. Greg Caillet has a worksheet about species life histories
   b. Red abalone recommended as focal species
   c. How much info is needed to know about YOYs?
   d. Scorpion fish recruitment data is available to a very fine scale (to the cm)
3. Recruitment data, what data to reference, what other parameters should be considered when choosing recruitment size
   a. Certain species recruitment is episodic leading to gaps and absence of fill-in rates
   b. Careful of recruit sizes because it is dependent on time of year.
4. Modeling recruitment: Is there a feedback based upon the other MPAs that are in the vicinity? Is it all driven by death or input? Are there two ends to the MPA effect or is it all driven by recruitment?

Model Tweaks

1. Consider limitations of fish data for minimum catch size, recruitment size
2. Consider using data rich focal species like abalone
3. Consider modeling recruitment data
4. Determine why certain simulations aren't fitting well