California Marine Protected Area Monitoring
History and Current Status White Paper
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1 Brief History of Baseline and Long-term Monitoring

1.1 Pre-Marine Life Protection Act

Prior to the Marine Life Protection Act[1] and the Marine Areas Improvement Act[2] the state of California had 18 types or marine protected area (MPAs) designations and an array of 90 differently sized MPAs with unclear objectives and no regular monitoring. Preceding the formal implementation of the MLPA covering 2004 – 2012; there was an MPA designation process in the Northern Channel Islands completed in 2003 and expanded into federal waters in 2007. The length of time an MPA is protected is known to greatly affect how well it is performing in meeting its ecological goals. The timing and phasing of MPA implementation across California is foundational to understanding and interpreting any monitoring data related to MPA performance.

In 1998 a group of fishermen, managers and other citizens who were concerned about declining fishery resources such as abalone, lobsters, and nearshore rockfishes, approached the California Fish and Game Commission with a proposal to a set aside areas for protection in the northern Channel Islands, bounding the Santa Barbara channel. This led to a multi-year process that included a Marine Reserves Working Group which included federal and state agencies, commercial and recreational fishermen, environmentalists, and other members of the Santa Barbara community. The focal area has overlapping jurisdiction between the Channel Islands National Park and the Channel Islands National Marine Sanctuary but neither regulates commercial or recreational fishing which falls to the California Fish and Game Commission[3].

In 2003 the California Fish and Game Commission designated 12 MPAs in state waters (0 – 3 nautical miles offshore) within the Channel Islands National Marine Sanctuary. In 2006 and 2007, the network of protected areas was extended into federal waters (3 – 12 nautical miles offshore) by the National Oceanic and Atmospheric Administration (NOAA) to create a total of 11 marine reserves (fully protected) and 2 marine conservation areas (site specific designated take regulations). The legal framework to designate these MPAs included both state and federal laws that grant authority to designate MPAs.

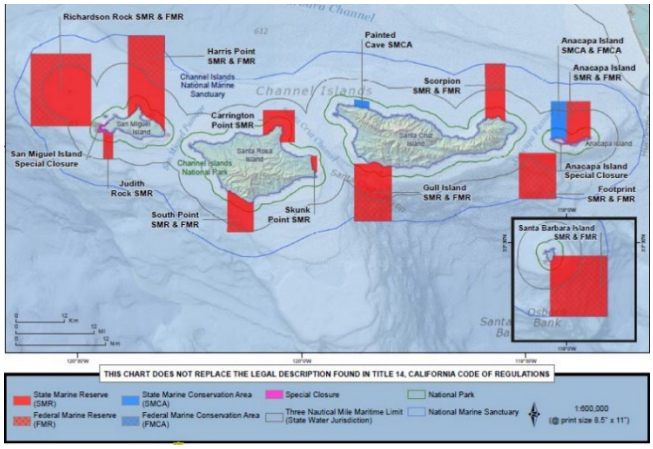

Figure 1. Northern Channel Islands Marine Protected Areas. Map by California Department of Fish and Wildlife.

In federal waters for the Northern Channel Islands, the National Marine Sanctuaries Act, Magnuson-Stevens Fishery Management and Conservation Act (MSFMCA) and National Park Service Organic Act all could be used to provide authority to designate MPAs[4]. In the case of the Northern Channel Islands MPAs and after three years of negotiations between state and federal regulatory agencies, NOAA Fisheries closed the sea floor to benthic fishing under the MSFMCA and the Sanctuary implemented complementary regulation to prohibit all forms of take within the water column not addressed by the MSFMCA regulations[5].

On the state side the Marine Managed Areas Improvement Act (MMAIA) passed in 2000, provides designation authority of marine managed areas (MMAs), including MPAs, to the Fish and Game Commission, Park and Recreation Commission (State Parks Commission) and State Water Resources Control Board (Water Board). The MMAIA also provides direct management authority of adopted MMAs, including MPAs, to CDFW and the Department of Parks and Recreation. However, neither the State Parks Commission nor the Water Board has authority to restrict the take of marine resources[6].

Because the Northern Channel Islands MPAs were not designated as part of a larger network or specifically under the direction of a legislative mandate to create MPAs there was not a comprehensive management or monitoring plan required. However, existing literature at that time on both the science and management of MPAs strongly supported the need for robust monitoring to accompany implementation of MPAs. The CDFW held a workshop in March 2003 of stakeholders and scientists to develop recommendations for biological and socioeconomic monitoring that eventually were combined with other sources to create the Channel Islands MPA Monitoring Plan (Plan)[7].

There were some key elements of MPA monitoring that were developed through this process that are of note. The Plan identified "focal species" that would be used as indicators and examples of change in the area for each habitat. The species chosen had different life history characteristics, varying exploitation histories, and play different roles in the ecosystem. The Plan defined satisfactory MPA performance as when "the biological trends within MPAs approach given estimates of potential change more rapidly than areas outside." Although the Plan clearly states "... levels of potential change listed in this document should not be considered hard targets or performance criteria"; the Plan does include ranges of potential change by species for density and size inside a reserve vs outside. For example, California sheephead density inside a reserve was expected to increase by 50 –150% and size by 15%.

The primary monitoring that was used to assess performance initially was data collected by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and state and federal research programs. PISCO monitoring focused primarily on intertidal and kelp forest habitats. There were also several groups that secured funding from both state and other funding sources to focus on other habitats (e.g. mid-depth rocky reef) and socioeconomic metrics (e.g. change in commercial and recreation fishing patterns). The results were presented at the five-year mark after implementation of the state portion of the MPAs in 2008 at a special session of the California Islands Symposium focused on the monitoring in the Northern Channel Islands MPAs. Initial findings showed that for species targeted by fisherman they had a greater average biomass and density inside the reserves than outside at reference areas. Other findings inside the reserves when compared to outside reference sites included higher proportion of larger lobster and more diverse species assemblages[8].

1.2 MLPA Monitoring and Review Mandates

The MLPA required a comprehensive Marine Life Protection Program (MLPP) be adopted to improve the design and management of MPAs in California. An MLPA Master Plan was mandated to guide, at a programmatic level, the design, adoption, implementation and management of the MLPP created MPA

Network. The MLPP includes all the regulations defining the MPAs boundaries and allowed activities within them which is codified in the Fish and Game Code of Regulations (FGC §632). The other required parts of the MLPP are laid out in the MLPA Master Plan including defining the MPA Management Program components and pillars which are required to be addressed by the MLPA. The required elements include guidance to implement enforcement (FGC §2853(b)5, (c)2, (c)4) and compliance, outreach and education (FGC §2853(c)4), research and monitoring (FGC §2853(c)3) and policy and permitting. A Draft Master Plan was adopted in 2008 focusing on creating sound scientific guidelines for designing and the process for regionally implementing MPAs and included almost no direction on management and monitoring. The adopted 2008 Draft Master Plan called for the development of Regional Management Plans and a Monitoring Plan providing high level guidance for the content of each[9]. Regional management plans were never created and the approach to monitoring has undergone several major changes (see section 1.3 below). An updated Final MPA Master Plan was adopted in 2016[10] focused on managing the MPA Network to meet the goals of the MLPA.

The MLPA does not define nor explicitly require a formal management review. However, the MLPA calls for "...provisions for monitoring, research, and evaluation at selected sites to facilitate adaptive management of MPAs and ensure that the system meets the goals… (FGC §2853(c)3)". The MLPA defines "Adaptive management, "… [as] 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))."

The 2008 Master Plan set forth a 5-year management review cycle for each region based on the best information available at the time and to ensure the management program in place was adequate to support the MPA Network in achieving its goals. The review included regional meetings with stakeholders to receive feedback and disseminate the latest information about the performance of the MPA Network to date. Based on the results of the five-year management review and emerging scientific information about the response of temperate ecosystems to protection, the 2016 Master Plan established a 10-year, network-wide management review cycle. Neither the 2008 nor the 2016 Master Plan describe in detail what the contents of a "Management Review" should include. The 2016 Master Plan states:

> *"The formal 10-year management review will emphasize ecological, socioeconomic, and governance aspects of the network and may include, but not be limited to, a scientific evaluation, public scoping meetings, and panel discussions to determine the status, function, and possible changes to the network. The scientific evaluations that inform the formal 10-year management review will encompass multiple elements, including a scientific assessment of ecological and socioeconomic MPA monitoring results (see Chapter 4.3), together with other data streams such as MPA enforcement data."*

A key point to emphasize is there are no discretely defined thresholds in the goals of the MLPA. There are no numerical targets identified for any commonly used MPA metrics such as those commonly identified for numerical targets for total area protected (e.g. 30% of a country's territorial waters), proportion of the network that is highly protected (e.g. 10% in no-take reserves) or conservation

benefits (e.g. fish biomass improves by 5%). This does not prevent a robust analysis of the performance of the MPA Network, which starts by grouping the six goals into related components.

Goals (1) and (2) are ecologically focused and although they do not define thresholds, they do require the MPA Network demonstrate positive trends related to

- protecting the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems; and
- helping sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.

Goals (3) and (4) set out required elements that informed the creation of the scientific design guidelines and the design of the adopted Network which

- improved recreational, educational and study opportunities in ecosystems subject to minimal human disturbance that are managed in a way that protects biodiversity; and
- protected marine natural heritage, including representative and unique marine life habitats.

Goals (5) and (6) focus primarily on the management of the MPA Network ensuring

- that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines; and
- that the state's MPAs are designed and managed, to the extent possible, as a network.

1.3 The Rise and Fall of the MPA Monitoring Enterprise

After the designation of the Northern Channel Island MPAs both internal state actors and outside advocacy groups were concerned about the lack of a dedicated entity focused on coordinating and managing the MPA monitoring. CDFW was deeply under resourced to both actively participate in the regional planning process and to create and coordinate a baseline monitoring program. MPA performance evaluation requires, ideally, before designation monitoring to establish existing ecological and socioeconomic conditions. This is rarely achieved and monitoring that begins at or near the time of MPA designation is generally the standard practice used. The MLPA was implemented in phases through a regional planning process.

- September 2007: Regulations implemented for Central Coast Study Region
- May 2010: Regulations implemented for North Central Coast Study Region
- January 2012: Regulations implemented for South Coast Study Region
- December 2012: Regulations implemented for North Coast Study Region

CDFW led two failed attempts to implement the MLPA between 2000 –2004[6] which catalyzed a public private partnership known as the Marine Life Protection Act Initiative (MLPAI). The MLPAI was formed in 2004 through a Memorandum of Understanding[11] with the goal of creating the statewide MPA Network and fulfilling the other requirements of the MLPA. It brought in outside funding to pay for CDFW staff and contractors, which were crucially needed. However, the main focus of the MLPAI was to design and create the regulations to implement the redesigned MPA Network. This left unmet the needed focus on creating the wider MPA Management Program including the critical research and monitoring component.

California's 2006 Budget Act appropriated $8 million to the California Ocean Protection Council (OPC) for the implementation of the MLPA and Marine Life Management Act (MLMA). The Budget Act called for these funds to be expended "pursuant to a work plan developed jointly by the OPC and the California Department of Fish and Game (DFG, now California Department of Fish and Wildlife)." An additional $2 million was appropriated to DFG to fulfil these same goals. To maximize the effectiveness of these associated appropriations, OPC and DFG created a joint work plan that set forth priorities for the complete $10 million[12]. Funds related to MPAs were awarded to expand Northern Channel Islands MPA monitoring, conduct baseline monitoring of the Central Coast Region and conduct seafloor mapping and socioeconomic studies in the North Central Region.

Data and results collected as part of this initial coordinated effort to support MPA monitoring and evaluation, was led by the MPA Monitoring Enterprise in collaboration with DFG. The MPA Monitoring Enterprise (Enterprise) was created in 2007 "...to lead the design and implementation of science-based, impartial and cost-effective monitoring of and reporting on the network of marine protected areas established in California under the Marine Life Protection Act." The Enterprise, which was housed within the California Ocean Science Trust which is a 501(c)3 created in 2000 by California Ocean Resources Stewardship Act primarily to "... promote more effective coordination of California ocean resource science useful to management agencies.[13]" Despite not having the in-house expertise nor appropriate levels of staffing, CDFW expressed immediate dissatisfaction with the elevation of OST to the lead role in managing the MPA monitoring effort. OST has no regulatory authority by statute and many in CDFW believed they simply should have been given the resources directed to OST. OPC at that time was directing millions annually to OST to support the Enterprise[14–16].

The Enterprise played a large role in creating an RFP process that was used to select projects for the Central Coast Baseline Projects[17] administered by UC Sea Grant in 2008 to award the funds allocated in 2006. There was no adopted MPA Monitoring Plan at this stage. The RFP provided guidance for Baseline Monitoring from the Adaptive Management and Monitoring and Evaluation Framework (Framework)[18] which was included as Appendix M in 2008 MLPA Master Plan. The Framework contains contributions that were made by a private consultant, stakeholders, government agencies, and MLPA Initiative staff. This document has cascaded forward throughout the development of baseline and long-term monitoring. Although never formally adopted, the Framework contained concepts, scientifically tractable questions tied to the MLPA goals and approaches that have been carried through all Baseline Monitoring.

The length of time of the Baseline Monitoring period in each region varied from two to three years depending on funding availability and researcher capacity in the region. The Baseline Monitoring for the north central, south and north coast came online in the order designation and was not guided by an overarching Monitoring Plan but simply carried forward the concepts included in the Framework document with expansions into additional habitats and to additional sites when funding was available. The principal investigators that received funding all had developed research programs designed to answer specific ecological questions and about the effect of MPAs at the population or ecosystem level. Some of the programs like PISCO were already underway with non-state funding when funding for Baseline Monitoring came online.

When the first Baseline Monitoring funds were being awarded in the spring of 2007 the central coast MPAs were scheduled to come online in September of 2007. There was immense public and political

pressure to get the monitoring underway. Due to chronically being under resourced CDFW was already well behind in standing up the infrastructure to design and manage a monitoring program and the MPA Monitoring Enterprise was just underway and not positioned to create a holistic plan to guide Baseline Monitoring. There was essentially no time to create a coordinated vetted Baseline Monitoring Plan so the approach to Baseline Monitoring became a project-by-project evaluation by RFP reviewers guided by the original concepts set out in the MPA Monitoring Framework included the RFP. Conceptually there was a general agreement that projects that maximized the amount of data collected would be useful and an integration both across the MPA Network and across habitats within a region could be worked out at a later date. The RFP process was repeated in each subsequent region to fund Baseline Monitoring[19–21]. The habitats/ecosystem features within the MPAs were broken down and projects were awarded for priority habitats in each region, not all ecosystem features were monitored in each region:

- Rocky Intertidal Ecosystems
- Kelp & Shallow (0-30m depth) Rock Ecosystems
- Mid-depth (30-100m depth) Rock Ecosystems
- Estuarine & Wetland Ecosystems
- Soft-bottom Intertidal & Beach Ecosystems
- Soft-bottom Subtidal (0-100m depth) Ecosystems
- Deep (>100m) Ecosystems, including Canyons
- Nearshore Pelagic Ecosystems (the water column habitat within state waters deeper than 30m)
- Consumptive Uses
- Non-consumptive Uses

Table 1.Baseline Monitoring Program for California's marine protected area network, to establish conditions at or near the time regulations were implemented, was conducted from 2007 – 2018.

COASTAL REGION	NUMBER OF PROJECTS	DATA COLLECTION PERIOD	ANALYZE, SYNTHESIZE, & SHARE INFORMATION	5-YEAR MANAGE-MENT REVIEW AT FGC
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

After the Central Coast Baseline Monitoring got underway the Monitoring Enterprise was focused on creating regional frameworks and monitoring plans to guide future monitoring in the north central, south and north regions and long-term monitoring statewide. For each region they held a series of workshops to gather input on public priorities and perspectives on monitoring in MPAs. This was used to develop a monitoring framework that had regional specific guidance provided through the public process.

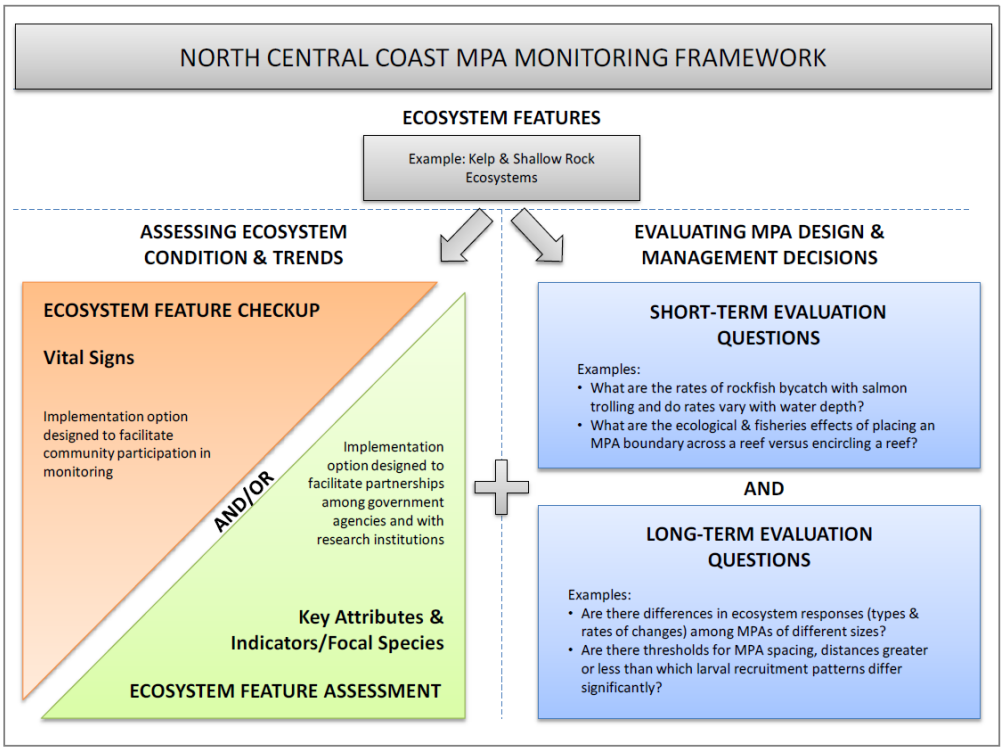

Figure 2. North Central Coast Monitoring Framework created by the MPA Monitoring Enterprise

A core issue that plagued the Regional Monitoring Plans was the approach identified the species and metrics to monitor then subsequently points out what questions could be answered by the data collected. This is a fundamental reversal of the standard scientific approach for designing monitoring programs which identifies the questions to be answered the sensitivity needed to answer the question than uses established statistical procedures to design the appropriate monitoring. A technical panel of MPA Monitoring Experts reviewed the framework pointing out some positive aspects of the approach but also expressing concerns [22]-

- A desire to see the framework in the context of the full monitoring plan to more carefully analyze its potential effectiveness.
- Uncertainty that the data gathered will be sufficient to determine whether oceanic changes are due to MPAs or other factors.
- Suggestion that strengthening of the socio-economic and governance portions of the plan would be useful and necessary.
- A desire for additional clarity regarding why particular attributes and indicators had been selected; or why components had been placed in "vital signs" as opposed to "tier 1 ecosystem assessments" or "tier 2 ecosystem assessments".

- A desire to prioritize certain attributes or indicators that might be more useful for understanding system changes.
- Concern that some of the metrics may not match well with the spatial and temporal scales of detectable responses to MPA implementation.

Despite concerns expressed and general resistance from CDFW behind the scenes the Fish and Game Commission adopted all four Regional Monitoring Plans created by the Monitoring Enterprise. By the time the final two Regional Monitoring Plans were adopted for the North Central and South Coast in 2018 the updated 2016 MLPA Master Plan[10] had begun to lay out a comprehensive Management Program which included laying out an approach to outreach and education, policy and permitting, enforcement and compliance. The 2016 Master Plan remained vague about a holistic approach to monitoring stating, "To date, the statewide monitoring framework has been used primarily to guide baseline monitoring efforts and has served as the foundation for the development of regional monitoring plans and long-term monitoring needs. Moving forward, it will inform the process of building out a more detailed plan for statewide MPA network monitoring." The 2016 Master Plan did contain a high-level framework for monitoring in each region but still failed to link the monitoring metrics to questions linked to the original MLPA goals.

1.4 Post MPA Monitoring Enterprise

The Budget Act of 2013 (SB 96) amended the Marine Life Protection Act to designate the Ocean Protection Council the "responsibility for the direction of policy of marine protected areas (MPAs).[23]" In September 2014 OPC reconfigured their staffing and hired a full-time position to solely focus on the MPA Network and serve as the MPA Policy Advisor to the OPC and Secretary of Natural Resources. Prior to this time OPC staff had served almost solely as grant managers to the Baseline Monitoring Projects in each region and did not actively engage in the development or implementation of the larger MPA Management Program. As the North Central, South and North Baseline Monitoring Projects were ending, it quickly became apparent that little progress had been made on developing a holistic document to guide the launch of statewide long-term monitoring and that there was also not secure funding to support that effort.

With the continued tepid reception of the Regional Monitoring Plans in the stakeholder and scientific community conducting the monitoring and with the clock already ticking for the ten-year management review in 2022; a triage approach was deployed led by OPC in close partnership with the CDFW to secure funds and continue monitoring the key habitats statewide. Concurrently an effort was begun to work with OST to aggregate all existing knowledge and information from all the previous monitoring documents, including the Regional Monitoring Plans in order to link them directly to the goals of the MLPA.

In 2018, using a detailed analysis of the Marine Life Protection Act founding legislation, the information from Baseline Monitoring and in-consultation with scientific and policy experts the California Department of Fish and Wildlife (CDFW) released the MPA Action Plan (Action Plan)[24]. The MPA Action Plan focused on setting up basic standards for monitoring and discretely framing evaluation questions linked to the MLPA goals that would guide long-term monitoring and the upcoming Decadal Management Review (DMR) in 2022. Specifically, the Action Plan prioritized metrics, habitats, sites, species, and human uses for long-term monitoring to inform the evaluation of the MPA Network. In general, the Action Plan took existing data that had already been developed through previous efforts

including prioritization exercises to set concrete standards for monitoring moving forward. The Action Plan did include a new effort to prioritize sites in each region for monitoring. This Action Plan also identified 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) collapsing the four planning regions into a more ecologically and logistically relevant framework. In 2019, the OPC in partnership with the CDFW funded seven statewide studies that reflect Marine Protected Area Action Plan priorities through a competitive bid process. Later in 2019 and 2020, several additional projects were added to the Long-Term Monitoring portfolio bringing the total to 10 projects focused on California's MPA Network.

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1. University of California (UC) Santa Cruz for rocky intertidal habitats
2. UC Santa Cruz for kelp forest/shallow rocky reef habitats
3. San Jose State University for deep rocky reef habitats
4. UC Santa Barbara for sandy beach/surf zone habitats
5. Ecotrust for establishment of a statewide socioeconomic monitoring program for consumptive human uses
6. San Jose State University for continuation of the statewide California Collaborative Fisheries Research Program
7. California Ocean Observing Systems for the integration of oceanographic data
8. San Jose State University Research Foundation for the assessment and monitoring of California's estuary
9. University of California Santa Cruz for the development of model-derived connectivity metrics for the assessment.
10. California Indian Environmental Alliance (CIEA) to support the development of a Tribal Marine Stewards Network pilot program

2 Monitoring and the MPA Management Program

The Marine Managed Areas Improvement Act recognized the cross jurisdictional nature of MMAs and mandated a standing advisory body be convened under the direction of the Secretary for Natural Resources to guide the reclassification and ongoing management of MMAs in California (PRC §36750, §36800). This body is identified as the State Interagency Coordinating Committee (SICC) in the MMAIA includes key coastal regulatory and management agencies (Appendix 2) and allowed for additional members to be added at the Secretary's discretion.

After the reclassification system was adopted in 2000, the SICC was sporadically active in a limited role during the design of the Network and then went inactive around 2012. The SICC was expanded and reconvened in early 2015 by OPC in Partnership with CDFW with a primary focus on California's MPA Network under the new more accurate name of the Marine

Protected Area Statewide Leadership Team. The Marine Protected Area Statewide Leadership Team (Leadership Team) is synonymous with the SICC. Key duties for the Leadership Team include active coordination among regulatory agencies related to activities within the boundaries or that would affect MPAs. The Leadership Team creates a triennial work plan to guide management of the MPA Network known as the Leadership Team Work Plan[25]. Other duties designated by the MMAIA include "…proper and timely routing of site proposals, review [of] any proposed site-specific regulations for consistency with the state system as a whole, and conduct[ing] periodic reviews of the statewide system to evaluate whether it is meeting the mission and statement of objectives (PRC §36800)." California's MPA Management Program (Management Program) highlighted in the MLPA Leadership Team implements the MLPA and MMAIA. The documents that define and guide the Management Program include:

- Marine Protected Area Statewide Leadership Team Work Plan[25]
- Marine Life Protection Act Master Plan 2016[10]
- The California Collaborative Approach: Marine Protected Area Partnership Plan[26]
- Marine Protected Area Monitoring Action Plan[24]
- Marine Life Protection Act Implementation Memorandum of Understanding[27]
- Marine Protected Area Collaborative Network Memorandum of Understanding[28]

Collectively these documents address the roles, responsibilities, partnerships, processes, tasks and resource needs for the Management Program as a whole. Only the Master Plan was legislatively required, however the scale and scope of the MPA Network required the creation of additional documents to further interpret and define both the requirements in the legislation and to direct the actions needed to address them. The Work Plan includes high level programmatic actions for all MPA Management pillars including Monitoring and Research such as to" Prioritize and launch research projects addressing questions highlighted in OPC SAT Working Group C*limate Resilience and California's MPA Network* report"[25].

3 Factors Affecting MPA Response Evaluation

There are both anthropogenic and environmental factors that affect the response of the ecosystem to the implementation of an MPA. In California, the intent was to remove (reserve) or significantly reduce (conservation area, park, recreational management area) fishing impacts. The general framework for evaluating an MPA response is through a localized assessment of a metric (e.g. density or biomass) at multiple replicate MPAs that are paired with a reference site over time across the MPA Network. The majority of individual MPA and reference site pairs do not have comparable replicate pairs. This means although in most cases a closely comparable nearby reference site with similar physical and biological conditions could be found the MPA Network does contain comparable couplets (MPA + comparable nearby reference site) across a region.

Figure 3. Cartoon representation of hypothetical marine protected areas and reference sites with similar conditions and habitats. Notice that although the orange boxes and blue boxes have similar imagined conditions and habitats the orange pair and blue pair of boxes are different limiting or precluding a direct comparison between the two sets of sites.

Even though the MPA Network was designed as an ecologically connected network the ability to evaluate performance as a network, regionally or on a smaller spatial scale (e.g. county level) is limited due to the lack of comparable replicate MPA/reference site pairs across the MPA Network.

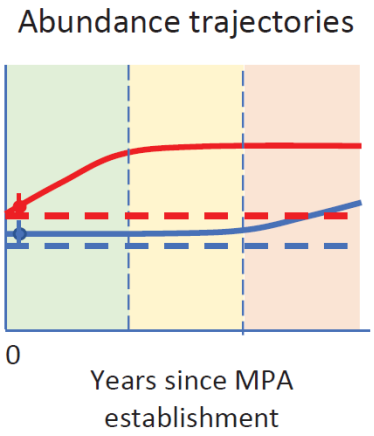
Selected key factors known to affect the performance of a marine protected area include[29–31]:

- Size in relation to home range size or target species
- Level of protection
- Level of fishing pressure (distance to port is sometime used as a proxy for this)
- Connectivity
- Level of compliance with regulation
- Environmental conditions and perturbations (e.g. marine heatwave, die offs, overpopulation)
- Length of time protected (i.e. age of MPA)
- Level of fishing pressure
- Recruitment

The only factor being directly affected by Network implementation is fishing effort within the protected area. The Water Boards adopted Resolution 2010-0057[32] and 2011-0013[33] to direct staff to develop recommendations for new Water Quality Protection Areas to co-locate with MPAs. However, this work

was never completed although the update 2019 Ocean Plan does provide specific implementation guidance for WQPA it does not recommend specific sites[34]. Water quality was not a driving factor in site selection although some MPAs were co-located in Areas of Special Biological significance that are now a subset of WQPA and existed prior to the MMAIA and MLPA[35]. Both in the design of the MPA Network and Monitoring Program assumptions were made about fishing pressure levels both in the MPAs and in their associated reference site. A primary assumption for a reserve is that fishing would stop in the MPA and the associated reference area would receive the same amount of fishing.

Scenario A



Scenario B

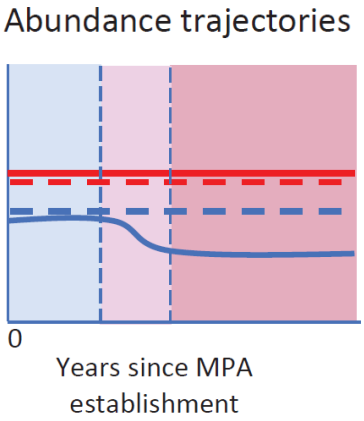


Figure 4. The graphic and explanation below are taken from Carr et al. 2021[36] and shows hypotheses related to how fishing pressure should affect an MPA response. Under Scenario A the expectation is that the response variable like density or biomass for targeted species would increase overtime in the MPA till carrying capacity is reached (solid red line) and in the reference area targeted species would remain relatively staple due to experiencing the same fishing pressure eventually showing an increase from "spillover" from the reserve (solid blue line). Non-targeted species inside the MPA (dotted red line) and in the reference areas (dotted blue line) would remain stable. Scenario B demonstrates the expected response variable trajectories for when an MPA still experiences some amount of fishing within its boundaries after implementation. Fished populations (solid lines) within MPAs and reference sites experience comparable rates of fishing mortality prior to and just after establishment of MPA (blue region). Subsequent onset of fishing outside MPAs causes fishing mortality to increase at reference sites while populations within MPAs continue to experience little fishing mortality (pink region). Population abundances of fished species outside MPAs subsequently level at new population equilibrium (maroon region). MPAs that are not well enforced can limit the impact of MPA designation on populations. Scenario A and B assumes environmental conditions are stable.

The time to detect an MPA response is affected by a host of factors including but not limited to the life history of the species, fishing pressure and recruitment success/failure[37]. In general modeling and empirical observations to date indicate long-lived species with high fishing pressure will show the greatest MPA response but will take at least 10 years and in many cases longer to reach a detectable level. Shorter lived species with a rapid but lower magnitude response will be harder to detect but can be good indicators of initial MPA efficacy. When determining adaptive management actions, it will be critical to assess ecological performance on appropriate time scales in context of existing conditions for key drivers like fishing pressure, recruitment, and life history.

4 Evaluating the MPA Network in relation to the goals of the MLPA

There have been three primary documents created with the intent of laying out objectives and defining performance evaluation questions for the Network:

1. The 2016 MPA Master Plan[10] was required by the MLPA to lay out a Management Program for the Network and included an aggregation of all planning data. The regional stakeholder groups during the Network Planning Process identified objectives that were linked to the MLPA goals (Appendix 1) and are included in the document.

2. The MPA Action Plan[24] was created by CDFW in 2018 to memorialize the monitoring approach to date and set forth a foundation for the long-term monitoring that would inform the 2022 Decadal Management Review and beyond. Appendix B of the MPA Action Plan includes a detailed breakdown of scientifically tractable questions directly linked to MLPA goals and was the first effort by the state to memorialize and link the scientific questions that were underpinning the monitoring to date to the MLPA goals. Appendix B also included additional questions that had not been addressed or were only being partially addressed with current monitoring to help guide the development of future monitoring (Appendix 2 on this document). The MPA Action Plan differs from the Master Plan in the level detail and the sole focus on MPA Monitoring. The Action Plan is as close as the state has come to a holistic overall Monitoring Plan for the Network. Although the document does represent the first time the state has identified priority sites and metrics it falls short in establishing a plan to integrate data collection and analysis across habitats and between baseline and long-term monitoring.

3. During 2020 and early 2021, at the direction of OPC and in partnership CDFW, the OPC Scientific Advisory Team convened a working group to provide scientific guidance in support of DMR building of the Action Plan and addressing the areas where the Action Plan needed to be extended based on the latest scientific information. The Scientific Guidance for Evaluating California's MPA Network report (Evaluation Report)[31] was created working in close collaboration with researchers currently conducting long-term MPA monitoring, and drawing on outside expertise, when necessary. The Working Group was tasked with translating the goals of the MLPA into scientifically tractable questions and associated analytical approaches, and taking a statewide, integrative approach. This report significantly extended the MPA Action Plan Appendix B specifically in question around the human dimensions of MPAs (Appendix 3 this document).

The document driving the DMR is the Evaluation Report. A key contribution to the DMR from the Evaluation Report is a clear and strong mandate to include influencing factors like climate change, fishing pressure and life history characteristics into any evaluation of MPA performance. Another critical contribution is the focus on the need to create integrated analysis across habitats/ecosystem features and across the different kinds of monitoring labelled in the Evaluation Report as Domains.

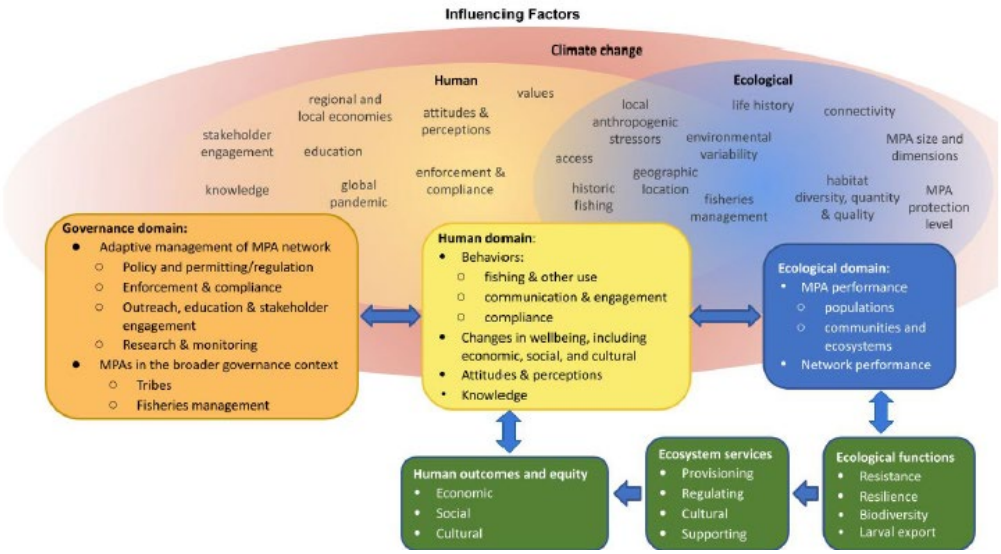


Figure 5. Graphic and caption from Hall-Arber et al 2021[31] a social-ecological system (SES) framework for understanding and evaluating California's MPA network. This framework identifies the three overarching domains of response to MPA implementation: governance, human, and ecological domains and the elements that respond within each (shown in orange, yellow and blue boxes, respectively). Numerous external factors influence multiple elements in the ecological, human and governance domains and how they respond to MPAs and can complicate MPA evaluations; these are represented as influencing factors (shown in clouds behind the domains. Climate change is represented as a ubiquitous influencing factor with impacts on all aspects of the SES. The components withing the ecological domain support a suite of ecological functions and ecosystem services with a variety of human outcomes (shown in green boxes).

The National Center for Ecological Analysis and Synthesis (NCEAS) based at UC Santa Barbara has been tasked with completing an integrative analysis of MPA monitoring data collected to date from multiple monitoring projects, across the state and report in development with no public release date available at this time. This analysis will be accessing all the Long-term Monitoring reports submitted at the beginning of 2022 and is expected in early 2023. It is important to point out that the long-term monitoring reports are simple reports outs of the monitoring completed to date with much flexibility allotted to the principal investigators to determine which analyses they complete. Although some reports include analyses tightly linked to the MLPA goals (e.g., CCFRP project) others have less alignment (e.g. IOOS project) but provide important information on influencing factors. The raw data from all the long-term monitoring projects, in addition to other data sources provided by CDFW and researchers that are part of the NCEAS group are being used to conduct additional analyses that are more tightly linked to the MLPA goals.

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Appendix 1. Regional Goals and Objectives from the Marine Life Protection Act Initiative Planning Process

		North Coast Regional[1]	North Central Coast Regional[2,5]	Central Coast Regional[3,5]	South Coast Regional[4,5]
GOAL 1		To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems	To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.	To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.	To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
OBJECTIVES	1.1	Protect and maintain species diversity and abundance consistent with natural fluctuations, including areas of high native species diversity and representative habitats.	Protect species diversity and abundance consistent with natural fluctuations by including and maintaining areas of high native species diversity and representative habitats.	Protect areas of high species diversity and maintain species diversity and abundance, consistent with natural fluctuations, of populations in representative habitats.	Protect and maintain species diversity and abundance consistent with natural fluctuations, including areas of high native species diversity and representative habitats.
	1.2	Protect areas with diverse habitat types in close proximity to each other.	Include areas with diverse habitat types in close proximity to each other.	Protect areas with diverse habitat types in close proximity to each other.	Protect areas with diverse habitat types in close proximity to each other.
	1.3	Protect natural size and age structure and genetic diversity of populations in representative habitats.	Protect natural size and age structure and genetic diversity of populations in representative habitats.	Protect natural size and age structure and genetic diversity of populations in representative habitats.	Protect natural size and age structure and genetic diversity of populations in representative habitats.

	1.4	Protect natural trophic structure and food webs in representative habitats.	Protect natural trophic structure and food webs in representative habitats.	Protect natural trophic structure and food webs in representative habitats.	Protect biodiversity, natural trophic structure and food webs in representative habitats.
	1.5	Promote recovery of natural communities from disturbances both natural and human induced.	Protect ecosystem structure, function, integrity and ecological processes to facilitate recovery of natural communities from disturbances both natural and human induced.	Protect ecosystem structure, function, integrity and ecological processes to facilitate recovery of natural communities from disturbances both natural and human induced.	Promote recovery of natural communities from disturbances, both natural and human induced, including water quality.
GOAL 2	To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.		To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.	To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.	To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
OBJECTIVES	2.1	Help protect or rebuild populations of rare, threatened, endangered, depressed, depleted, or overfished species and the habitats and ecosystem functions upon which they rely.	Help protect or rebuild populations of rare, threatened, endangered, depressed, depleted, or overfished species, where identified, and the habitats and ecosystem functions upon which they rely.	Help protect or rebuild populations of rare, threatened, endangered, depleted, or overfished species, where identified, and the habitats and ecosystem functions upon which they rely.	Help protect or rebuild populations of rare, threatened, endangered, depressed, depleted, or overfished species, and the habitats and ecosystem functions upon which they rely.
	2.2	Sustain or increase reproduction by species likely to benefit from MPAs and promote retention of large, mature individuals.	Sustain or increase reproduction by species most likely to benefit from MPAs through retention of large, mature individuals.	Protect larval sources and restore reproductive capacity of species most likely to benefit from MPAs through retention of large, mature individuals.	Sustain or increase reproduction by species likely to benefit from MPAs, with emphasis on those species identified as more likely to benefit from MPAs, and promote retention of large, mature individuals.

	2.3	Sustain or increase reproduction by species likely to benefit from MPAs through protection of breeding, foraging, rearing or nursery areas or other areas where species congregate.	Sustain or increase reproduction by species most likely to benefit from MPAs through protection of breeding, foraging, rearing or nursery areas.	Protect selected species and the habitats on which they depend while allowing the harvest of migratory, highly mobile, or other species where appropriate through the use of state marine conservation areas and state marine parks	Sustain or increase reproduction by species likely to benefit from MPAs with emphasis on those species identified as more likely to benefit from MPAs through protection of breeding, spawning, foraging, rearing or nursery areas or other areas where species congregate.
	2.4	Protect selected species and the habitats on which they depend while allowing the commercial and/or recreational harvest of migratory, highly mobile, or other species where appropriate through the use of state marine conservation areas and state marine parks.	Protect selected species and the habitats on which they depend while allowing the commercial and/or recreational harvest of migratory, highly mobile, or other species where appropriate through the use of state marine conservation areas and state marine parks.	-	Protect selected species and the habitats on which they depend while allowing some commercial and/or recreational harvest of migratory, highly mobile, or other species; and other activities.
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	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.	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.		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.

	with protecting biodiversity.				
OBJECTIVES	3.1	Sustain or enhance cultural, recreational, and educational experiences and uses.	Ensure some MPAs are close to population centers, coastal access points, and/or research and education institutions and include areas of educational, recreational, and cultural use.	Ensure some MPAs are close to population centers and research and education institutions and include areas of traditional non-consumptive recreational use and are accessible for recreational, educational, and study opportunities.	Sustain or enhance cultural, recreational, and educational experiences and uses (for example, by improving catch rates, maintaining high scenic value, lowering congestion, increasing size or abundance of species, and protection of submerged sites).
	3.2	Provide opportunities for scientifically valid studies, including studies on MPA effectiveness and other research benefiting from areas with minimal or restricted human disturbance.	Sustain or enhance cultural, recreational, and educational experiences by improving catch rates, high scenic value, lower congestion, or increased size or abundance of species.	To enhance the likelihood of scientifically valid studies, replicate appropriate MPA designations, habitats or control areas (including areas open to fishing) to the extent possible.	Provide opportunities for scientifically valid studies, including studies on MPA effectiveness and other research that benefits from areas with minimal or restricted human disturbance.

OBJECTIVES	3.3	Provide opportunities for collaborative scientific monitoring and research projects that evaluate MPAs while promoting adaptive management and links with fisheries management, seabird and mammals information needs, classroom science curricula, cooperative fisheries research and volunteer efforts, and identify participants.	To enhance the likelihood of scientifically valid studies, replicate appropriate MPA designations, habitats or control areas (including areas open to fishing) to the extent possible.	Develop collaborative scientific monitoring and research projects evaluating MPAs that link with fisheries management information needs, classroom science curricula, volunteer dive programs, and fishermen of all ages, and identify participants.	Provide opportunities for collaborative scientific monitoring and research projects that evaluate MPAs that promote adaptive management and link with fisheries management, seabird and mammals information needs, classroom science curricula, cooperative fisheries research and volunteer efforts, and identifies participants.
	3.4	-	Develop collaborative scientific monitoring and research projects evaluating MPAs that link with fisheries management information needs, classroom science curricula, volunteer dive programs, and fishermen, and identify participants.	Protect or enhance recreational experience by ensuring natural size and age structure of marine populations.	-
GOAL 4	To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters, for their intrinsic value.	To protect marine natural heritage, including protection of representative and unique marine life habitats in north central California waters, for their intrinsic value.	To protect marine natural heritage, including protection of representative and unique marine life habitats in central California waters, for their intrinsic value.	To protect marine natural heritage, including protection of representative and unique marine life habitats in south coast California waters, for their intrinsic value.	

OBJECTIVES	4.1	Include within MPAs key and unique habitats identified by the MLPA Master Plan Science Advisory Team for the north coast study region.	Include within MPAs the following habitat types: estuaries, the intertidal zone at the Farallon Islands, and subtidal waters (including the water column and benthic habitats) around the Farallon Island	Include within MPAs the following habitat types: estuaries, heads of submarine canyons, and pinnacles.	Include within MPAs key and unique habitats identified by the MLPA Master Plan Science Advisory Team for this study region.
OBJECTIVES	4.2	Include and replicate to the extent practicable representatives of all marine habitats identified in the MLPA or the California MLPA Master Plan for Marine Protected Areas across a range of depths.	Include and replicate to the extent possible [practicable], representatives of all marine habitats identified in the MLPA or the California MLPA Master Plan for Marine Protected Areas across a range of depths.	Protect, and replicate to the extent possible, representatives of all marine habitats identified in the MLPA or the Master Plan Framework across a range of depths.	Include and replicate to the extent possible [practicable], representatives of all marine habitats identified in the MLPA or the California Marine Life Protection Act Master Plan for Marine Protected Areas across a range of depths.
GOAL 5	To ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.	To ensure that north central California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.	To ensure that central California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines	To ensure that south coast California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.	

OBJECTIVES	5.1	Provide opportunities for interested parties to help develop objectives and ensure that each MPA is linked to one or more regional objectives.	Minimize negative socio-economic impacts and optimize positive socio-economic impacts for all users, to the extent possible, and if consistent with the Marine Life Protection Act and its goals and guidelines.	Minimize negative socio-economic impacts and optimize positive socio-economic impacts for all users, to the extent possible, and if consistent with the Marine Life Protection Act and its goals and guidelines.	Minimize negative socio-economic impacts and optimize positive socio-economic impacts for all users including coastal dependent entities, communities and interests, to the extent possible, and if consistent with the Marine Life Protection Act and its goals and guidelines.
	5.2	To the extent possible, effectively use scientific guidelines in the California MLPA Master Plan for Marine Protected Areas	For all MPAs in the region involve interested parties to help; develop objectives, a longterm monitoring plan that includes standardized biological and socioeconomic monitoring protocols, and a strategy for MPA evaluation, and ensure that each MPA objective is linked to one or more regional objectives.	For all MPAs in the region, develop objectives, a long-term monitoring plan that includes standardized biological and socioeconomic monitoring protocols, and a strategy for MPA evaluation, and ensure that each MPA objective is linked to one or more regional objectives.	Provide opportunities for interested parties to help develop objectives, a long-term monitoring plan that includes standardized biological and socioeconomic monitoring protocols, a long-term education and outreach plan, and a strategy for MPA evaluation.
	5.3	Ensure public understanding of, compliance with, and stakeholder support for MPA boundaries and regulations.	To the extent possible, effectively use scientific guidelines in the California MLPA Master Plan for Marine Protected Areas	To the extent possible, effectively use scientific guidelines in the Master Plan Framework.	Effectively use scientific guidelines in the California Marine Life Protection Act Master Plan for Marine Protected Areas.
OBJECTIVES	5.4	Include simple, clear, and focused site-specific objectives/rationales for each MPA and ensure that site-specific rationales for each MPA reflect one or more goals and regional objectives.	-	-	Ensure public understanding of, compliance with, and stakeholder support for MPA boundaries and regulations.

	5.5	-	-	-	Include simple, clear, and focused site-specific objectives/rationales for each MPA and ensure that site-level rationales for each MPA are linked to one or more regional objectives.
GOAL 6	To ensure that the California's MPAs are designed and managed, to the extent possible, as a component of a statewide network.	To ensure that the north central coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network.	To ensure that the central coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network.	To ensure that the south coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network.	
OBJECTIVES	6.1	Ensure ecological connectivity within and between regional components of the statewide network.	Develop a process to inform adaptive management that includes stakeholder involvement for regional review and evaluation of management effectiveness to determine if regional MPAs are an effective component of a statewide network	Develop a process for regional review and evaluation of implementation effectiveness that includes stakeholder involvement to determine if regional MPAs are an effective component of a statewide network.	Provide opportunities to promote a process that informs adaptive management and includes stakeholder involvement for regional review and evaluation of management effectiveness to determine if regional MPAs are an effective component of a statewide network.
OBJECTIVES	6.2	Provide for protection and connectivity of habitat for those species that utilize different habitats over their lifetime.	Develop a mechanism to coordinate with future MLPA regional stakeholder groups in other regions to ensure that the statewide MPA network meets the goals of the MLPA.	Develop a mechanism to coordinate with future MLPA regional stakeholder groups in other regions to ensure that the statewide MPA network meets the goals of the MLPA.	Provide opportunities to coordinate with future MLPA regional stakeholder groups in other regions to ensure that the statewide MPA network meets the goals of the MLPA.
	6.3	-	-	-	Ensure ecological connectivity within and between regional components of the statewide network.

6.4	-	-	-	Provide for protection and connectivity of habitat for those species that utilize different habitats over their lifetime.

1. All data taken from "California MLPA North Coast Project Goals, Regional Objectives, Stakeholder Priorities, and Design and Implementation Considerations for the MLPA North Coast Study Region Revised April 26, 2010 ".

2. All data taken from "California Marine Life Protection Act Initiative North Central Coast Regional Goals and Objectives Adopted by the MLPA Blue Ribbon Task Force on February 14, 2008".

3. All data taken from "California Marine Life Protection Act Initiative Central Coast Project Adopted Regional Goals and Objectives Package as Amended by the MLPA Blue Ribbon Task Force November 30, 2005".

4. All data taken from "California MLPA South Coast Project Adopted Regional Goals and Objectives and Design and Implementation Considerations for the MLPA South Coast Study Region February 26, 2009 ".

5. In the Central, North Central and South Regions several Regional Stakeholder Group (RSG) Priorities were mistakenly categorized as objectives under the MLPA goals. Objectives under each MLPA goal must directly contribute to meeting the goal. While the objectives on their own were valid reflections of stakeholder purpose, they were inappropriately ascribed to MLPA goals. In the final region to be sited during the north coast MPA planning process, a category that reflects these local stakeholder objectives was included to supplement the MLPA goals and regional objectives. Stakeholder priorities and objectives may not supersede meeting the MLPA goals and regional objectives but may work congruently with them to ensure regional concerns are addressed while meeting the MLPA goals.

Appendix 2: MPA Action Plan Appendix B - 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]

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 3: MPA Evaluation Report Questions

Questions from Appendix B of the Action Plan that fall within the ecological domain are presented here with proposed wording changes that either refine the questions to more clearly specify response variables and predicted responses, or extend the questions to additional topics of interest for MPA evaluation. Rationale for these question changes are presented, along with potential considerations to be taken into account during analyses. The final column indicates those questions that have been proposed to be addressed by ongoing monitoring programs, and which programs proposed to address them.

MLPA Goal	Original Question	Question Refinement or Extension	Rationale for Question Changes	Considerations	Proposed to be Addressed by Ongoing Monitoring Programs
MPA PERFORMANCE- POPULATIONS					
G1 1a	[Original] Do focal and/or protected species inside of MPAs differ in size, numbers, and biomass relative to reference sites?	[Refined] Does the difference between MPAs and reference sites in the size of individuals of a focal and/or protected species increase over time?	Clarify, rephrase, and focus the question. Focus question on trajectories in the size of individuals of focal and/or protected species.	Inside-outside response ratio trajectories over time. Multiple ways to measure size can be explored: mean, median, distribution, upper quartile, proportion above minimum fished size, etc. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

G1 1b		[Refined] Does the difference between MPAs and reference sites in density (or proportionate cover) of a focal and/or protected	Focus question on trajectories in the abundances (density or cover) of focal and/or	Inside-outside response ratio trajectories over time. Might look not just at total density, but density of mature individuals or those greater than the minimum fished size. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

		species increase over time?	protected species.	establishment fishing data for MPAs and adjacent reference sites.	
G1	1c	[Refined] Does the difference between MPAs and reference sites in biomass of a focal and/or protected species increase over time?	Focus question on trajectories in the biomass of focal and/or protected species.	Inside-outside response ratio trajectories over time. Requires species-specific size-biomass relationships. Might look not just at total biomass, but biomass of mature individuals or those greater than the minimum fished size. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	1d	[Extended] Does the difference between MPAs and reference sites in larval production of a focal and/or protected species increase over time?	Extend question to include the ecological function of larval export.	Inside-outside response ratio trajectories over time. Requires species-specific size-fecundity relationships or biomass of mature individuals for relative larval production. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	1e	[Extended] Does the difference between MPAs and reference sites in genetic diversity of a focal and/or	Extend to include the ecological function of genetic biodiversity.	Inside-outside response ratio trajectories over time. Requires a measure of genetic diversity. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

			protected species increase over time?		establishment fishing data for MPAs and adjacent reference sites.	
G1	1f		[Extended] Does the difference between MPAs and reference sites in the size and age structure of populations of a focal and/or protected species increase over time?	Extend original size question to consideration of population demographics.	Inside-outside response ratio trajectories over time. Similar to 1a except looking at populations of individual species and groups of species. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	1g		[Extended] Does the difference between MPAs and reference sites in overall biomass of focal and/or protected species increase over time?	Extend original biomass question to an aggregation of all focal and/or protected species.	Inside-outside response ratio trajectories over time. Similar to 1c except looking at overall biomass of focal or protected species. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	1h		[Extended] Does the difference between MPAs and reference sites in overall biomass of fished species increase over time relative to species that are not fished?	Extend original biomass question to aggregations of all fished and unfished species.	Inside-outside response ratio trajectories over time. Similar to 1c except looking at overall biomass of fished vs. unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

G1	4a	[Original] Do the abundanc e, size/age structure, and/or diversity of predator and prey species differ inside MPAs, or outside areas of comparabl e habitat?	[Refined] Does the difference between MPAs and reference sites in the density of predators whose prey are fished increase over time?	Clarify that the focus of this question is the relationship between predators and their specific prey and how MPAs can alter this relationship by reducing fishing mortality. Focus question on the density of predators whose prey are fished.	Inside-outside response ratio trajectories over time. Might look at individual species or aggregate by fished/unfished predator species whose prey are fished. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	4b		[Refined] Does the difference between MPAs and reference areas in the density of prey whose predators are fished increase over time?	Focus question on the density of prey whose predators are fished.	Inside-outside response ratio trajectories over time. Might look at individual species or aggregate by fished/unfished prey species whose predators are fished. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

G1	**4c**		[Refined] Does the difference between MPAs and reference sites in the size/age structure of predators whose prey are fished increase over time?	Extend original predator/prey density question to include size/age structure.	Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	**4d**		[Refined] Does the difference between MPAs and reference sites in the size/age structure of prey whose predators are fished increase over time?	Extend original predator/prey density question to include size/age structure.	Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	**4e**		[Refined] Does the difference between MPAs and reference sites in the diversity of predators whose prey are fished increase over time?	Extend original predator/prey density question to include diversity considerations.	Inside-outside response ratio trajectories over time. Calculation of predator diversity and prey diversity (possibly species richness, evenness, and diversity indices). Use biomass or density of each species to calculate taxonomic diversity of either predators or prey. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

G1	**4f**		[Refined] Does the difference between MPAs and reference sites in the diversity of prey whose predators are fished increase over time?	Extend original predator/prey density question to include diversity considerations.	Inside-outside response ratio trajectories over time. Calculation of predator diversity and prey diversity (possibly species richness, evenness, and diversity indices). Use biomass or density of each species to calculate taxonomic diversity of either predators or prey. Might look at individual species or aggregate by fished/unfished species. Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G2	**7a**	[Original] How do species differ in their rate of response to MPA implementation?	[Refined] How does the mean rate of response in abundance and size/age structure differ among species?	Clarify the analytical design of MPA-reference site comparisons over time to include specific response variables.	Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Would benefit from abundance and size/age structure data for targeted species pre-MPA establishment where available. Might look at individual species or aggregate by fished/unfished species. Would benefit greatly from pre- MPA establishment fishing data for MPAs and adjacent reference sites. Would benefit from fundamental life history information associated with population growth rates, including home range size and rates of propagule recruitment, to explain differences in species response rates.	Yes (InterT, KF, ROV, Beach, CCFRP & IOOS)

G2	7b		[Extended] How do changes in abundance and size/age structure differ among species? (assess within an MPA)	Extend question to include consideration of absolute changes in abundance and size/age structure among examined species.	Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or breakout by fished/unfished species. Would greatly benefit from pre- MPA establishment fishing data for MPAs and adjacent reference sites. Would benefit from fundamental life history information associated with population growth rates, including home range size and rates of propagule recruitment, to explain differences in species response rates.	Yes (InterT, KF, ROV, Beach, CCFRP & IOOS)
G2	7c		[Extended]: Are differences in rate of species responses to MPA establishment related to life history (longevity, homerange, dispersal distances) or demographic variables?	Extend question to include consideration of life history differences and demographic variables among examined species.	Inside-outside response ratio trajectories over time. Might look at individual species or breakout by fished/unfished species. Would benefit greatly from pre- MPA establishment fishing data for MPAs and adjacent reference sites. Would benefit from fundamental life history information associated with population growth rates, including home range size and rates of propagule recruitment, to explain differences in species response rates.	Yes (InterT, KF, ROV, Beach, CCFRP & IOOS)
G3	20a	[Original] Are the size/age structure of recreationally valued species increasing in MPAs over time?	[Refined] Has the difference between MPAs and reference areas in the size/age structure of recreationally fished species increased over time?	Clarify the analytical design to include specific response variables. Focus question on size and age	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or breakout by fished/unfished species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP, IOOS & Estuaries)

				structure of recreationally fished species.		
G3	20b		[Refined] Has the difference between MPAs and reference areas in the mean size of recreationally fished species increased over time?	Focus question on mean size of recreationally fished species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Might look at individual species or breakout by fished/unfished species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP, IOOS & Estuaries)
G3	20c		[Extended] Has the difference between MPAs and reference areas in the size/age structure of culturally valued species increased over time? (non-consumptive species)	Extend question to focus on size and age structure of unfished culturally valued species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or breakout by fished/unfished species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP, IOOS & Estuaries)

G3	20d		[Extended] Has the difference between MPAs and reference areas in the mean size of culturally valued species increased over time? (non-consumptive species)	Extend question to focus on mean size of unfished culturally valued species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Might look at individual species or breakout by fished/unfished species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP, IOOS & Estuaries)
G4	23a	[Original] Have endangere d species and/or culturally significant species benefited from the presence of California's MPAs? (See list of endangere d and culturally significant species in column D of notes tab)	[Refined] Has the difference between MPAs and reference areas in the abundance of endangered species increased over time?	Clarify the analytical design to include specific response variables. Focus question on abundance of endangered species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Likely evaluate by individual species. [This question is the same as Question 1b but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G4	23b		[Refined] Has the difference between MPAs and reference areas in the abundance of culturally significant species increased over time? (e.g. species used by the Tribes)	Focus question on abundance of culturally significant species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Likely evaluate by individual species. [This question is the same as Question 1b but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

G4	23c		[Refined] Has the difference between MPAs and reference areas in the size/age structure of endangered species increased over time?	Focus question on size/age structure of endangered species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Likely evaluate by individual species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G4	23d		[Refined] Has the difference between MPAs and reference areas in the size/age structure of culturally significant species increased over time? (e.g. species used by the Tribes)	Focus question on size/age structure of culturally significant species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Likely evaluate by individual species. [This question is the same as Question 1a but applied to particular species.]	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G5	32a	[Original] Do State Marine Reserve (SMR)/Stat e Marine Conservati on Area(SMC A) clusters provide greater protection than stand-alone SMRs?	[Refined] Is there an increase over time in the difference between MPAs and reference sites in abundance (density, cover, biomass) of focal species and if so is the difference in combined SMR/SMCA clusters greater than in stand-alone MPAs of similar size and protection?	Clarify the analytical design to include specific response variables. Focus question on abundance of focal species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Test for differences in responses between stand-alone MPAs and clusters. Might look at individual species or aggregate by fished/unfished species.	Yes (InterT, KF, ROV, Beach, CCFRP & Rec CPUE)

	32b		[Refined] Is there an increase over time in the difference between MPAs and reference sites in size/age structure of focal species and if so is the difference in combined SMR/SMCA clusters greater than in stand-alone MPAs of similar size and protection?	Focus question on size/age structure of focal species.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or aggregate by fished/unfished species.	Yes (InterT, KF, ROV, Beach, CCFRP & Rec CPUE)
	32c		[Refined] Is there an increase over time in the difference between MPAs and reference sites in abundance (density, cover, biomass) of focal species and if so are there differences between SMR and SMCAs of similar size?	Extend question to consider differences in abundances of focal species between SMRs and SMCAs.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Might look at individual species or breakout by fished/unfished species. Consider using "level of protection" for SMCAs.	Yes (InterT, KF, ROV, Beach, CCFRP & Rec CPUE)

	32d		[Refined] Is there an increase over time in the difference between MPAs and reference sites in size/age structure of focal species and if so and if so are there differences between SMR and SMCAs of similar size?	Extend question to consider differences in size/age structure of focal species between SMRs and SMCAs.	Would benefit from pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to consider size/age structure. Might look at individual species or breakout by fished/unfished species. Consider using "level of protection" for SMCAs.	Yes (InterT, KF, ROV, Beach, CCFRP & Rec CPUE)
MPA PERFORMANCE – COMMUNITIES & ECOSYSTEMS						
G1	2a	[Original] Does functional diversity differ in MPAs relative to reference sites?	[Refined] Does the difference between MPAs and reference sites in species diversity within any given functional group increase over time?	Clarify the analytical design to include specific response variables. Focus question on diversity within functional groups.	Would benefit from pre- and post-MPA establishment diversity and fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to calculate diversity (species richness, evenness, or diversity indices). Multiple ways to consider functional group categorization. Might look at fished/unfished species where appropriate.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)
G1	2b		[Refined] Does the difference between MPAs and reference sites in the diversity of functional groups increase over time?	Focus question on the diversity of functional groups.	Would benefit from pre- and post-MPA establishment diversity and fishing data for MPAs and adjacent reference sites. Inside-outside response ratio trajectories over time. Multiple ways to calculate diversity (species richness, evenness, or diversity indices). Multiple ways to consider functional group categorization.	Yes (InterT, KF, ROV, Beach, CCFRP & Estuaries)

					Might look at fished/unfished species where appropriate.	
G1	3a	[Original] Do MPAs that include multiple habitat types harbor higher species abundanc e or more diverse communiti es than those that encompass a single habitat type or less diverse habitat types?	[Refined] Is there a positive relationship between the density (cover or biomass) of any given focal species and habitat diversity across MPAs of similar protection levels?	Clarify the analytical design to include specific response variables. Focus question on density (cover or biomass) of focal species.	Inside-outside response ratio trajectories over time. Requires data on habitat diversity of appropriate scale. Might look at fished/unfished species where appropriate. Multiple ways to calculate habitat diversity (richness or diversity). Could benefit from pre- and post-MPA establishment density data for MPAs and adjacent reference sites. Test for relationship (regression) between species abundance and richness or diversity of habitats across MPAs.	Yes (InterT, KF, ROV, Beach & CCFRP)
G1	3b		[Refined] Is there a positive relationship between species diversity and habitat diversity across MPAs of similar protection levels?	Focus question on species diversity.	Inside-outside response ratio trajectories over time. Requires data on habitat diversity of appropriate scale. Might look at fished/unfished species where appropriate. Multiple ways to calculate species and habitat diversity (richness or diversity). Could benefit from pre- and post-MPA establishment diversity data for MPAs and adjacent reference sites. Test for relationship (regression) between species richness or diversity and diversity of habitats across MPAs.	Yes (InterT, KF, ROV, Beach & CCFRP)

G1	3c		[Refined] Is there a positive relationship between species diversity within a habitat/ecosystem and habitat diversity across MPAs of similar protection levels?	Focus question on species and habitat diversity.	Inside-outside response ratio trajectories over time. Requires data on habitat diversity of appropriate scale. Might look at fished/unfished species where appropriate. Multiple ways to calculate species and habitat diversity. Could benefit from pre- and post-MPA establishment diversity data for MPAs and adjacent reference sites.	Yes (InterT, KF, ROV, Beach & CCFRP)
G1	5a	Does the nature or timing of recovery of natural communities from disturbance events differ in different types of MPAs relative to outside areas?	[Refined] Does the nature of recovery of natural communities from disturbance events differ in MPAs relative to outside reference sites?	Clarify the analytical design to include specific response variables. Focus question on the nature of community recovery.	Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from pre- disturbance community level data for MPAs and adjacent reference sites. Consider definition and metrics of recovery.	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)
G1	5b		[Refined] Does the timing of recovery of natural communities from disturbance events differ in MPAs relative to outside reference sites?	Focus question on the rate of community recovery.	Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from pre- disturbance community level data for MPAs and adjacent reference sites. Consider definition and metrics of recovery.	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)

G1	5c		[Refined] Does the nature of recovery of natural communities from disturbance events differ in MPAs with different levels of protection?	Focus question on the nature of community recovery and level of protection of MPAs.	Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from pre- disturbance community level data for MPAs and adjacent reference sites. Consider definition and metrics of recovery.	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)
G1	5d		[Refined] Does the timing of recovery of natural communities from disturbance events differ in MPAs with different levels of protection?	Focus question on the rate of community recovery and level of protection of MPAs.	Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from pre- disturbance community level data for MPAs and adjacent reference sites. Consider definition and metrics of recovery.	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)
G1	5e		[Extended] Do MPAs contribute to the recovery of impacted ecosystems?	Focus question on the community recovery in impacted ecosystems.	Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from pre- disturbance community level data for MPAs and adjacent reference sites. Consider the nature of impacted ecosystem and definition of recovery.	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)
G4	21	[Original] Have unique habitats been adequately represented and protected by the current distribution and designation of MPAs?		No changes	Consider definition of unique habitats. Requires spatial data on distribution of unique habitats.	Yes (ROV, IOOS, Estuaries & Connectivit y)

G4	**22**	[Original] Does the abundanc e or quality of habitat (geologic, oceanogra phic, biogenic) increase or remain the same within an MPA?	[Refined] How has the abundance or quality of habitat (geologic, oceanographic, biogenic) changed within MPAs?	Clarify and rephrase the question for greater specificity.	Consider definition of habitat quality. Requires spatial data on distribution of geologic, oceanographic and biogenic habitats.	Yes (InterT, KF, ROV, Beach, Estuaries & Connectivit y)
G4	**24**	[Original] Do MPAs limit the spread of invasive species?	[Refined] Is the rate of invasion (i.e. increase in population size) of invasive species lower in MPAs compared to reference areas?	Clarify and rephrase the question for greater specificity.	Requires identification of invasive species and their abundances in and outside of MPAs. Inside-outside response ratio trajectories over time. Might look at fished/unfished species and their community roles where appropriate. Would benefit from historical data on species abundances for MPAs and adjacent reference sites.	Yes (KF, ROV, Beach & Estuaries)
NETWORK PERFORMANCE - POPULATIONS						
G2	**10a**	[Original] What is the rate and distribution of adult spillover of targeted fishery species from MPAs	[Refined] Is adult abundance of targeted fishery species higher in areas adjacent to MPAs than areas farther from MPAs? (distribution of adult spillover)	Clarify, focus, and rephrase the question. Focus question on spatial differences in spillover with reference to MPAs.	Requires data on targeted fishery species across a spatial gradient representing distance from MPAs. Could look at mean rate of movement of tagged animals both directions across MPA boundaries to test for net directional movement, or cohort analysis of untagged animals. Might look at fished/unfished species	Yes (CCFRP)

G2	10b	into adjacent areas?	[Refined] How has adult abundance of targeted fishery species changed over time in relationship to distance from MPAs? (rate of adult spillover)	Focus question on abundances of fishery species (spillover) over time in relation to distance from MPAs.	Requires time series data on targeted fishery species across a spatial gradient representing distance from MPAs. Might look at aggregate fished and unfished species.	Yes (CCFRP)
G2	10c		[Extended]: How does adult spillover vary with species density inside MPAs?	Focus question on variations in spillover of fishery species as a function of density inside MPAs.	Requires density data on targeted fishery species inside MPAs and also across a spatial gradient representing distance from MPAs. Might look at aggregate fished and unfished species.	Yes (CCFRP)
G6	34a	[Original] What are the demographic effects of siting MPAs in larval source or sink locations,	[Refined] What are the metapopulation dynamic consequences of siting MPAs in locations associated with high larval export vs. high larval import?	Clarify, focus, and rephrase the question. Focus question on areas of high larval export and low larval import.	Requires data on the demographics of species. Requires data on degree of larval export and import. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed and efficacy of larval production and range of larval distribution. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS & Connectivit y)

G6	34b	and how do demographic responses to MPAs contribute to larval production and connectivity?	[Refined] How does MPA siting affect the value or contribution (in terms of metapopulation growth rate or resilience) of that MPA to the MPA network?	Focus question on contributions of specific MPAs to the network based on connectivity expectations.	Requires time series data the demographics of species in order to calculate growth rate. Requires data on degree of larval export and import. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed and efficacy of larval production and range of larval distribution. Data from multiple MPAs required to estimate the value of an individual MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS & Connectivity)
G6	34c		[Refined] How do demographic responses of populations within MPAs contribute to larval production?	Focus question on how population demographics affect larval export in specific MPAs.	Requires data on the demographics of species and how these demographics change in relation to MPA protection. Consider inside and outside MPA responses. Requires data on degree of larval production as a function of population demography. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed. Data from multiple MPAs required to estimate the value of an individual MPA.	Yes (InterT, IOOS & Connectivity)

G6	34d		[Refined] How do demographic responses of populations within MPAs contribute to larval connectivity?	Focus question on how population demographics in specific MPAs affect larval connectivity in the network.	Requires data on the demographics of species. Consider inside and outside MPA responses. Requires data on degree of larval production as a function of population demography. Requires data on connectivity among assessed MPAs. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed. Data from multiple MPAs required to estimate the value of an individual MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS & Connectivity)
G6	39	[Original] Do MPAs with higher connectivity have lower variability in population trends compared to more isolated MPAs?	[Refined] Do high-connectivity populations within MPAs have lower temporal variability compared to low-connectivity populations within MPAs?	Clarify, focus, and rephrase the question.	Requires time series data on species populations (abundance, demographics) and related data on the magnitude of connectivity for these populations within an MPA. Consider inside and outside MPA responses. Requires data on degree of larval import to population within an MPA. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed. Data from multiple reference sites and MPAs required to estimate the role of connectivity and larval supply in structuring populations within an individual MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS, Estuaries & Connectivity)

NETWORK PERFORMANCE - ECOSYSTEMS						
G6	35a	[Original] How does the distance and larval contributio n between a source MPA and sink MPA influence the ecosystem response inside the sink MPA?	[Refined] How does the larval contribution between an origin and destination MPA influence the structure of ecological communities inside the destination MPA?	Clarify, focus, and rephrase the question. Focus question on structural attributes of ecological communities inside an MPA.	Requires data on the structure of ecological communities and related data on the magnitude of connectivity of populations in these communities from one MPA to another. Consider inside and outside MPA responses. Requires data on degree of larval export from one MPA and degree of larval import to a destination MPA. Consider the number of populations within the community to be sampled. Data from multiple MPA pairs required to estimate the role of connectivity and larval supply in structuring communities within a destination MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS & Connectivit y)
G6	35b		[Refined] How does the larval contribution between an origin and destination MPA influence the dynamics, including resilience, of ecological communities inside the destination MPA?	Clarify, focus, and rephrase the question. Focus question on the dynamics of ecological communities, including their resilience, inside an MPA.	Requires data on the structure of ecological communities and related data on the magnitude of connectivity of populations in these communities from one MPA to another. Consider inside and outside MPA responses. Requires data on degree of larval export from one MPA and degree of larval import to a destination MPA. Consider the number of populations within the community to be sampled. Consider method of measuring and expressing resilience. Data from multiple MPA pairs required to estimate the role of connectivity and larval supply in structuring communities within a destination MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, IOOS & Connectivit y)

G6	37a	[Original] Are MPAs with higher connectivit y more resilient to sudden environme ntal disturbanc e as compared to more isolated MPAs with higher self-retention?	[Refined] Do high-connectivity populations within MPAs have greater resilience to spatially discrete short-term disturbances than low-connectivity populations?	Clarify, focus, and rephrase the question. Focus question on the resilience of ecological communities in response to short term spatially discrete disturbances.	Requires data on the populations and related data on the magnitude of connectivity of populations from one MPA to another. Consider inside and outside MPA responses. Consider obtaining demographic data on populations of interest. Requires data on degree of larval export from one MPA and degree of larval import to a destination MPA. Consider the number of populations to be sampled. Consider method of measuring and expressing resilience. Data from multiple MPA pairs required to estimate the role of connectivity and larval supply in structuring populations within a destination MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, KF, ROV, CCFRP, IOOS, Estuaries & Connectivit y)

G6	37b		[Refined] Do populations with greater self-recruitment in MPAs exhibit greater resilience to spatially discrete short-term disturbances than populations with less self-recruitment?	Focus question on the role of self-recruitment in MPAs and resilience in response to short term spatially discrete distrubances.	Requires data on the populations and related data on the magnitude of connectivity of populations and the proportion of recruitment within an MPA (self-recruitment) and from one MPA to another. Consider Inside and outside MPA responses. Consider obtaining demographic data on populations of interest. Requires data on degree of larval export from one MPA and degree of larval import to a destination MPA and amount of self-recruitment within an MPA. Consider the number of populations to be sampled. Consider method of measuring and expressing resilience. Data from multiple MPA pairs required to estimate the role of connectivity and larval supply in structuring populations within a destination MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (InterT, KF, ROV, CCFRP, IOOS, Estuaries & Connectivit y)

Questions posed in this report that fall within the human and governance domains are presented here. Some questions are newly proposed (indicated as [New]), while others originate in Appendix B of the Action Plan with some wording refinements or extensions. Rationale for these question changes are presented, along with potential considerations to be taken into account during analyses. As many of the human and governance questions from Appendix B of the Action Plan were narrowly focused on specific stakeholder groups, these are indicated as "Example subquestions". The final column indicates those questions that have been proposed to be addressed by ongoing monitoring programs, and which programs proposed to address them.

Question #	Proposed Human and Governance Questions	Rationale for Question Changes	Considerations	Subquestion #	Example Subquestions from Action Plan Appendix B and Beyond	Proposed to be Addressed by Ongoing Monitoring Programs
HUMAN DOMAIN						
CHANGES IN BEHAVIOR AND USE						
N1	[New] Which stakeholder groups are accessing MPAs and adjacent non-MPA reference sites?	MPA and coastal access is of interest across a diversity of stakeholder groups, and this broadens the scope to	Potential data sources will depend on the stakeholder group in question: - MPA watch data could provide information about some user groups and will be especially useful if there is adequate data from non-MPA reference sites. - Scientific collecting permit data (from CDFW) should reveal information about research inside and outside MPAs, but	14	[Original] Are researchers accessing MPAs, and has research increased over time in MPAs?	No
				14a	[Refined] Are researchers accessing MPAs?	No

		include that diversity.	there may be spatial mismatches, and only consumptive research that results in take of organisms will be reflected in these data. - Surveys could also prove useful here. - There is likely a need for new data collection efforts to answer this question.	N1a	[New] Are coastal residents (and non-coastal residents) accessing MPAs? For what types of activities?	No
N2	[New] Has use of MPAs and reference sites changed over time, and why?	Changes in use of MPAs and reference is of interest across a diversity of stakeholder groups; this unites a number of similar questions from Appendix B to ask broadly about changes in use.	Assessing changes in use over time is especially challenging due to differences in the quantity and quality of use data available from different time periods. Metrics of use should be carefully considered, will depend on characteristic of the source data, and should consider influencing factors (e.g., ease of access, weather, etc.); this is especially true with respect to changes over time. Unless the "why" is analyzed, there is no way to determine what caused changes over time. Potential data sources will depend on the stakeholder group in question: - MPA Watch could provide information about some user groups. - "Big data" techniques should be considered including using social media to quantify tourism and recreation uses in MPAs and other areas (e.g., Wood et al. 2013). - Scientific collecting permit data (from CDFW) should reveal information about	14b	[Refined] How has MPA use by researchers changed over time?	No
				15	[Original] Has the magnitude and variety of recreational/educational use increased over time in MPAs?	Yes (CDFW non-consumptive)
				15a	[Refined] Has the magnitude and variety of recreational use in MPAs changed over time? Why?	
				15b	[Refined] Has the magnitude and variety of educational use in MPAs changed over time? Why?	Yes (CDFW non-consumptive)
				16	[Original] 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	Yes (CDFW non-consumptive)

			research inside and outside MPAs, but there may be spatial mismatches, and only consumptive research that results in take of organisms will be reflected in these data. - Surveys could also prove useful here. - There is likely a need for new data collection efforts to answer this question.		been implemented changed due to their presence?	
				16a	[Refined] How has non-consumptive use of marine ecosystems (in MPAs) changed since MPA implementation?	Yes (CDFW non-consumptive)
N3	[New] How do the demographics of those who use MPAs and reference sites compare to state demographics?	This focuses on how equitably (or not) use of MPAs is distributed across California's citizens.	Existing census data are already collected at various spatial scales to summarize state demographics, and this could be compared to demographic data gathered from those who use MPAs.			No
N4	[New] Are there groups that disproportionately access or don't access MPAs and reference sites, and why?	This focuses on why MPA use may not be equitably distributed.	Comparison of state demographics and demographics of MPA users will be key to answering this question. The "why" question is essential for evaluation and to know what action to take to encourage more equitable MPA use.			No
N5	[New] What stakeholders engage with CDFW and the MPA management	This focuses on engagement as a conversation between	Focused qualitative research is needed. CDFW may have records from public meetings that could be mined for information about stakeholder participation/engagement and might	N5a	[New] What recreational non-consumptive users enage with CDFW and the MPA management program, how do they engage, and why?	Possibly (CDFW)

	program, how do they engage, and why?	stakeholders and managers and seeks to identify factors that are correlated with stakeholder engagement	provide insight into the some of the concerns about how stakeholder engagement did or did not work and provide a foundation for future research. In the Ecotrust monitoring project, reponses in the focus groups summaries offer some information, but do not fully answer these questions. Advisory groups could be surveyed to learn whether they are representative of other users and stakeholders.	N5b	[New] What stakeholders on the North coast engage with CDFW and the MPA management program, how do they engage, and why?	Possibly (CDFW)
N6	[New] How does CDFW communicate with stakeholders about MPAs, which stakeholders do they reach, and is the communication effective?	This focuses on communication as a one-way transmission from CDFW to stakeholders and seeks to identify the effectiveness of different strategies for different stakeholder groups.	CDFW almost certainly has records of public outreach and communication strategies, including investments in those strategies. To understand effectiveness, those data must be connected to stakeholder responses. This could be an interesting project for a graduate student in policy and/or communication.	N5a N5b	[New] How does CDFW communicate with the conservation community about MPAs, and is the communication effective? [New] How does CDFW communicate with coastal residents about MPAs and is the communication effective?	Possibly (CDFW) Possibly (CDFW)
CHANGES IN WELLBEING						
N7	[New] What are the direct and indirect economic consequences of MPAs for	Economic consequences of MPAs are of interest across a diversity of	Socio-economic focused research is needed, which could include both gathering new data or using existing secondary data sources. Broadening the current focus from fishing stakeholders to the broader coastal	12	[Original] What are economic effects of MPA placement; specifically, distance from ports and location relative to fishing grounds?	Yes (CCFRP, Ecotrust & Rec CPUE)

	relevant stakeholders and coastal communities?	stakeholder groups, and this broadens the scope to include that diversity.	community and other communities of interest is needed. Existing monitoring programs may allow assessment of (mostly) direct economic consequences of MPAs, but additional research is likely needed to assess indirect consequences.	12a	[Refined] What are the economic costs and benefits of MPA placement for relevant user groups? (examples distance from ports and locations relative to fishing grounds, diversity of livelihoods in the community)	
N8	[New] How have MPAs affected dimensions of social and cultural wellbeing for relevant stakeholders and coastal communities?	Wellbeing consequence s of MPAs are of interest across a diversity of stakeholder groups, and this broadens the scope to include social and cultural (non-economic) wellbeing and a diversity of stakeholders.	Wellbeing is a fairly recent consideration. NOAA social scientists have taken the lead in research on this topic and likely have information of use for California.	8d	[Extended] What are the fisheries-related changes to dimensions of social and cultural wellbeing?	Possibly (Rec CPUE)
				12b	[Extended] How has MPA placement affected dimensions of social and cultural wellbeing for relevant user groups?	No
CHANGES IN ATTITUDES AND PERCEPTIONS						
18a	[Refined] Have attitudes towards and perceptions of individual MPAs and the MPA	This focuses on changing attitudes towards and perceptions of MPAs	While the existing monitoring projects do elicit some changing attitudes and perceptions toward MPAs, they are focused on a small subset of stakeholders, and this focus should be broadened. Understanding changing	18	[Original] How are knowledge, attitudes, and perceptions regarding the MPAs changing overtime?	Yes (CCFRP, Ecotrust & CDFW non-consumptive)

	network as a whole by stakeholders changed over time and why?	across a diversity of stakeholders, thus uniting several questions from Appendix B.	attitudes and perceptions will require a project or two specifically focused on recreational and/or non-consumptive users.	19	[Original] 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?	Yes (CDFW non-consumptive)
				19a	[Refined] Are non-consumptive recreational experiences in MPAs improving?	
				19b	[Refined] How have the attitudes of non-consumptive users towards MPAs changed over time?	Yes (CDFW non-consumptive)
				19c	[Refined] How have the perceptions of the recreational experience in MPAs among non-consumptive users changed over time?	Yes (CDFW non-consumptive)
N9	[New] Is there a difference in the perceived value of, and desire to visit MPAs as compared to non-MPA reference sites?	This focuses on whether perceptions of MPAs drive changes in behavior, including MPA access and use.	Answering these questions will probably require a focused qualitative research project. Selection of appropriate non-MPA reference sites relative to human visitation will be key to answering this question.	16b	[Refined] How has enjoyment of marine ecosystems (in MPAs) by non-consumptive users changed since MPA implementation?	Yes (CDFW non-consumptive)
				16c	[Refined] Has the perceived value of, and desire to visit MPA areas changed over time? (evaluate by user group)	Yes (CDFW non-consumptive)

				19d	[Extended] How do non-consumptive recreational experiences in MPAs compare to experiences in adjacent non-MPA areas?	Possibly (CDFW non-consumptive)
18b	[Refined] Has knowledge of MPAs by stakeholders changed over time and why?	This refinement of question 18 focuses on changing knowledge of MPAs across a diversity of stakeholders.	As with all the questions pertaining to change vis a vis human use, the lack of "pre-MPA" knowledge makes comparison reliant on stakeholder's memories. Qualitative analysis can help reveal knowledge, attitudes, and perceptions.			Yes (CCFRP, Ecotrust & CDFW non-consumptive)
18c	[Extended] How does stakeholder knowledge of MPAs influence attitudes toward and perceptions of MPAs?	This refinement of question 18 focuses on how knowledge of MPAs influences attitudes and perceptions.	Answering this question will probably require a focused qualitative research project.			Possibly (CCFRP, Ecotrust & CDFW non-consumptive)
MANAGEMENT DOMAIN						
N10	[New] What is the level of compliance with MPA regulations by stakeholder groups?	Broadens question to ask about MPA compliance across a diversity of stakeholders.	Analysis of non-compliant use data (e.g., from MPA Watch or similar) and enforcement actions supplemented with qualitative research among different stakeholder groups may reveal differing levels of compliance by stakeholder group.	27 27	[Original] Is monitoring of human activity and enforcement adequate for preventing illegal take in MPAs? [Refined] Is current wildlife enforcement capacity adequate for preventing illegal take in MPAs?	No No

29a	[Refined] How has compliance changed over time since MPA implementation ?	Refinement of question 29 focuses on changes in compliance.	Analysis of non-compliant use data (e.g., from MPA Watch or similar) and enforcement actions may reveal changes in the levels of compliance over time. Changing enforcement policies (e.g., warnings vs. citations) could complicate analyses. This could be an interesting project for a graduate student in law/ criminal justice.	29	[Original] 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?	No
29b	[Refined] What factors (e.g. penalties, wildlife enforcement, warden presence) influence differences in compliance within and among MPAs?	Refinement of question 29 focuses on the factors that influence compliance. This unites several questions from Appendix B in a simple and informative way.	Analysis of non-compliant use data (e.g., from MPA Watch or similar) and enforcement actions supplemented with qualitative research among different stakeholder groups may reveal differing levels of compliance in MPAs across the Network. Considering the influencing factors that correlate with those differences may help inform CDFW about what incentives or enforcement actions have the largest influence on compliance.	28	[Original] Do penalties for non-compliance deter users from violating regulations?	No
				28a	[Refined] How do penalties influence compliance with MPA regulations?	No
				28b	[Extended] What types of penalties have the largest influence on compliance?	No
				28c	[Extended] What management actions are most likely to increase compliance?	No
				30	[Original] Does locating a boat ramp or other access point affect the level of enforcement and compliance with MPA regulations?	Possibly (Rec CPUE)
				30	[Refined] How does the accessibility of an MPA (nearby boat ramp or other access point) relate	Possibly (Rec CPUE)

					to warden presence and compliance?	
				31	[Original] Are there incentives that can help reduce noncompliant behavior inside MPAs?	No
				31	[Refined] Do incentives influence compliance with MPA regulations?	No
				33a	[Original] Does the level of compliance differ between SMRs and SMCAs?	No
				33b	[Extended] Does compliance differ for MPAs with different levels of protection?	No
N11	[New] How do outreach and education activities influence compliance with MPA regulations by stakeholders?	This focuses on the influence of outreach and education activities on compliance with MPA regulations.	Research to answer this question would likely need to connect specific outreach and education activities (e.g., signage, information kiosks, wildlife enforcement officer contact, park docent activities) with user compliance data, both spatially and temporally.	29e	[Extended] How is knowledge of MPA regulations related to compliance?	No
N12	[New] How do outreach and education activities influence knowledge, attitudes, and perceptions of	This focuses on the influence of outreach and education activities on knowledge of MPAs.	A focused survey could shed light on this (possibly integrate some questions into IPCC survey). This work should build on CDFW's ongoing efforts to evaluate communication tools to different groups and any research efforts should be connected to answering question N6.			No

	MPAs by stakeholders?					
25	[Refined] Are efforts to collect long-term monitoring data coordinated sufficiently to fully evaluate MPA Network performance?	Minor wording changes for clarity.	Comprehensive answers to these related questions would likely require a review of the MPA Management Program. Recommendations and approaches provided in this report indicate areas of opportunity to improve the effectiveness of MPA and Network evaluation and better inform adaptive management.	25	[Original] Are efforts to collect long-term monitoring data coordinated sufficiently such that cohesive conclusions can be formed about MPA Network performance?	Yes (InterT, KF, ROV, Beach, CCFRP, Ecotrust & Estuaries)
26	[Refined] Does the MPA Monitoring Action Plan produce sufficient information to evaluate Network performance and inform adaptive management?	Minor wording changes for clarity.		26	[Original] Does the MPA Monitoring Action Plan produce sufficient information that enables the evaluation of Network performance and informs adaptive management?	Yes (InterT, KF, ROV, CCFRP, IOOS & Estuaries)

Questions from Appendix B of the Action Plan that integrate across domains are presented here with proposed wording changes that either refine the questions to more clearly specify response variables and predicted responses, or extend the questions to additional topics of interest for MPA evaluation. Rationale for these question changes are presented, along with potential considerations to be taken into account during analyses. The final column indicates those questions that have been proposed to be addressed by ongoing monitoring programs, and which programs proposed to address them.

MLPA Goal	Question #	Original Question	Question Refinement or Extension	Rationale for Question Changes	Considerations	Proposed to be Addressed by Ongoing Monitoring Programs
FISHERIES INTEGRATION - ECOLOGICAL PERSPECTIVE						
G2	6a	[Original] 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?	[Refined] Are differences in the magnitude of change in abundance of focal species in response to MPA establishment related to differences between MPAs in the level of pre- MPA fishing mortality (or effort)?	Clarify that the focus of this question is on changes resulting from fishing effort and fishing mortality rates. Focus question on changes in abundance due to fishing effort and fishing mortality prior to MPA establishment.	Requires fishing effort or take data inside of MPAs and at reference sites both pre- and post-MPA establishment. Would benefit from abundance data pre-MPA establishment where available. Test for relationship (regression) between spatial variability in pre-MPA fishing effort or fishing mortality rates versus abundance of harvested species. IPM can enable use of ecological timeseries Might look at individual species or aggregate by fished/unfished species.	Yes (CCFRP & Rec CPUE)

G2	6b		[Refined] Are differences in the magnitude of change in size/age structure of focal species in response to MPA establishment related to differences between MPAs in the level of pre-MPA fishing mortality (or effort)?	Focus question on changes in size/age structure due to fishing effort and fishing mortality prior to MPA establishment.	Requires fishing effort or take data inside of MPAs and at reference sites both pre- and post-MPA establishment. Would benefit from size/age structure data pre-MPA establishment where available. Might look at individual species or aggregate by fished/unfished species. Multiple ways to consider size/age structure.	Yes (CCFRP & Rec CPUE)
G2	6c		[Refined] Are differences in the magnitude of change in abundance of focal species in response to MPA establishment related to differences between MPAs in the level of MPA-adjacent fishing mortality (or effort)?	Extend original question to examine effects of level of MPA-adjacent fishing effort and fishing mortality on abundance changes following MPA establishment.	Requires fishing effort or take data inside of MPAs and at reference sites both pre- and post-MPA establishment. Would benefit from abundance of targeted species data pre-MPA establishment where available. Might look at individual species or aggregate by fished/unfished species.	Yes (CCFRP & Rec CPUE)
G2	6d		[Refined] Are differences in the magnitude of change in size/age structure of focal species in response to MPA establishment	Extend original question to examine effects of level of MPA-adjacent fishing effort and fishing mortality on size/age	Requires fishing effort or take data inside of MPAs and at reference sites both pre- and post-MPA establishment. Might look at individual species or aggregate by fished/unfished species. Multiple ways to consider size/age structure.	Yes (CCFRP & Rec CPUE)

			related to differences between MPAs in the level of MPA-adjacent fishing mortality (or effort)?	structure changes following MPA establishment.		
G2	9a	[Original] 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?	[Refined] Is there a relationship between the relative change in abundance of focal species inside and outside of MPAs and the level of fishing mortality (or effort) prior to MPA establishment?	Clarify the analytical design of MPA-reference site comparisons over time to include specific response variables. Focus question on abundance changes of focal species and fishing mortality and/or effort.	Requires pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites and inside-outside response ratio trajectories over time. Test for relationship (regression) between abundance of focal species and the rate of pre-MPA fishing effort or mortality. Might look at individual species or aggregate by fished/unfished species.	Yes (ROV, CCFRP, IOOS & Rec CPUE)
G2	9b		[Refined] Is there a relationship between the relative change in size/age structure of focal species inside and outside of MPAs and the level of fishing mortality (or effort) prior to MPA establishment?	Focus question on size/age structure changes of focal species and fishing mortality and/or effort.	Requires pre- and post-MPA establishment fishing data for MPAs and adjacent reference sites and inside-outside response ratio trajectories over time. Test for relationship (regression) between size/age structure of focal species and the rate of pre-MPA fishing effort or mortality. Multiple ways to consider size/age structure. Might look at individual species or breakout by fished/unfished species.	Yes (ROV, CCFRP, IOOS & Rec CPUE)

G6	36a	[Original] How does the level of connectivity and larval supply from an MPA to areas outside of MPAs affect fisheries?	[Refined] Does the degree of connectivity and magnitude of larval supply from an MPA to a fished (non-MPA) site support additional potential fisheries yield at the fished site?	Clarify, focus, and rephrase the question. Focus question on role of an MPA in contributing larvae to an unfished reference sites and increasing fisheries yield.	Requires data on species demographics and related larval production inside an MPA. Consider inside and outside MPA responses. Requires data on connectivity between MPA and adjacent assessed MPAs. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed. Data from multiple MPAs required to estimate the value of an individual MPA. Iterative integration of empirical and modeling studies is recommended when possible.	Yes (IOOS, Estuaries, Connectivit y)
G6	36b		[Extended] Does the degree of connectivity and magnitude of larval supply from fished (non-MPA) sites to an MPA influence the structure and dynamics of populations within an MPA?	Extends question to focus on role of a fished areas in contributing larvae to an MPA and influencing its population demographics and dynamics.	Requires data on species demographics and related larval production outside an MPA. Consider inside and outside MPA responses. Requires data on connectivity between adjacent unprotected reference site and MPA. Multiple ways to collect and analyze demographic data. Consider the number of populations to be analyzed. Data from multiple reference sites and MPAs required to estimate the value of an unprotected site to an individual MPA. Iterative integration of emipiral and	Yes (IOOS, Estuaries, Connectivit y)

					modeling studies is recommended when possible.	
FISHERIES INTEGRATION - HUMAN PERSPECTIVE						
G2	**8a**	[Original] 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?	[Refined] Did the distribution of fishing effort change following MPA implementation?	Separate, clarify, and rephrase the question. Focus question on changes in the distribution of fishing since MPA implementation.	Requires pre-MPA and post-MPA fishing distributional data for areas adjacent to MPAs expressed as fishing effort. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)
G2	**8b**		[Refined] Did overall fishing effort/mortality rates and yield change following MPA implementation?	Focus question on changes in fishing effort and mortality rates since the MPA implementation.	Requires pre-MPA and post-MPA fishing data for areas adjacent to MPAs, including fishing effort, and catch (mortality) data. Could look at individual species to compare effort/mortality rates. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)

G2	8c		[Extended] What are the fisheries-related economic changes that accompany changes in the distribution of fishing effort/mortality following MPA implementation?	Extend question to address the fisheries-related economic changes related to changes in fishing distribution and fishing effort/mortality since MPA implementation.	Requires pre-MPA and post-MPA fishing data for areas adjacent to MPAs, including fishing effort, and catch (mortality) data. Requires data that translate catch into economic metrics, including changes in costs related to fishing (e.g., travel time, vehicle or vessel operation, fishing effort, etc.), value of catch to fishermen (e.g., market prices, handling costs, etc.). Could look at individual species to compare translation of catch into economic metrics. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)
G3	17a	[Original] 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?	[Refined] Are recreational consumptive users fishing the edges of MPAs?	Separate, clarify, focus, and rephrase the question. Focus question on the amount and distribution of recreational consumptive use (effort/take) in areas immediately adjacent to MPAs following MPA implementation.	Requires post-MPA data on patterns of recreational consumptive use for areas adjacent to MPAs, including fishing distribution, effort, and catch (mortality) data. Would benefit from similar pre-MPA data to determine changes resulting from MPA implementation. Could look at changes in recreational consumptive users for individual species. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)

G3	17b		[Refined] Is recreational take from MPA edges similar to historical take from the MPAs?	Focus question on changes in recreational consumptive use (effort/take) in areas immediately adjacent to MPAs following MPA implementation.	Requires pre- and post-MPA data on patterns of recreational consumptive use for areas adjacent to MPAs, including fishing distribution, effort, and catch (mortality) data. Also requires effort/catch data for MPA prior to establishment to determine changes resulting from MPA implementation. Requires ability to categorize and measure forms of consumptive recreational use. Could look at changes in recreational consumptive users for individual species. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)
G3	17c		[Refined] Based on current patterns, are edge effects likely to provide long term benefits to consumptive recreational users?	Focus question on identifying benefits (economic, social) to consumptive recreational users from changes in use (effort/take) in areas immediately adjacent to MPAs following MPA implementation, including the time course for	Requires time series post-MPA data on patterns of recreational consumptive use for areas adjacent to MPAs, including fishing distribution, effort, and catch (mortality) data. Requires definition of 'beneifts' (e.g., well-being, economics, etc.) and time course attributed to 'long-term'. Requires ability to categorize and measure forms of consumptive recreational use. Would benefit from similar pre-MPA data to determine changes resulting from MPA implementation. Could look at changes in recreational consumptive users for individual species. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)

				obtaining these benefits.		
G3	17d		[Extended] Do recreational consumptive users percieve benefits from MPA edge effects?	Extend the question to focus on whether consumptive recreational users identify benefits (economic, fishing success, well being) from changes in use (effort/take) in areas immediately adjacent to MPAs following MPA implementation.	Requires post-MPA data on perceptions of benefits obtained by recreational consumptive use for areas adjacent to MPAs. Requires definition of 'beneifts' (e.g., well-being, economics, etc.). Requires ability to categorize and measure forms of consumptive recreational use. Would benefit from time series data and from pre-MPA data to determine changes resulting from MPA implementation. Could look at changes in recreational consumptive users for individual species. Focus can be on individual MPAs or groups of MPAs.	Possibly (Rec CPUE)
G3	17e		[Extended] How does recreational consumptive use of MPAs that prohibit commercial use differ from MPAs that don't make this distinction?	Extend the question to focus on determining whether differences exist as a function of level of protection in the activities (effort/take) and benefits (economic, fishing success,	Requires post-MPA data on patterns of recreational consumptive use for areas within and adjacent to MPAs, including fishing distribution, effort, and catch (mortality) data for MPAs that do and do not allow commercial take. Requires ability to categorize and measure forms of consumptive recreational use. Would benefit from time series data and from pre-MPA data to determine changes resulting from MPA	Possibly (Rec CPUE)

				wellbeing) of consumptive recreational users in areas within and immediately adjacent to MPAs. Question focuses on MPAs that do and do not allow commercial use.	implementation. Could look at changes in recreational consumptive use for individual species. Focus can be on individual MPAs or groups of MPAs. Would benefit from comparisons that include no-take MPAs as well as MPAs that allow recreational but not commercial use.	
GOVERNANCE AND MANAGEMENT INTEGRATION						
G2	**11a**	[Original] 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?	[Refined] Is catch more sustainable for a targeted fishery species before or after MPA implementation?	Clarify, focus, and rephrase the question. Focus question on the whether catch is more sustainable for a targeted fishery following MPA implementation.	Requires pre- and post-MPA data on fishing distribution, effort, and catch (mortality) data for targeted fishery species for MPAs and reference sites. Inside-outside response ratios over time. Requires setting of time to answer sustainability question. This also means having time series of historical fishing data for targeted species before and after MPA establishment. Requires ability to identify targeted species and treat these individually and collectively. Could look at fished and unfished species. Focus can be on individual MPAs or groups of MPAs.	No

G2	**11b**		[Refined] Is catch more sustainable for fishery species deemed likely to benefit from California's MPAs than for species that are less likely to be influenced by the MPAs?	Focus question on the whether catch is more sustainable for fished species likely to benefit from MPA protection following MPA implementation.	Requires pre- and post-MPA data on fishing distribution, effort, and catch (mortality) data for species likely to benefit from MPA protection for MPAs and reference sites. Inside-outside response ratios over time. Requires setting of time to answer sustainability question. This also means having time series of historical fishing data for species likely to benefit before and after MPA establishment. Requires ability to identify species likely to benefit and treat these individually and collectively. Could look at fished and unfished species. Focus can be on individual MPAs or groups of MPAs.	No
G6	**38**	[Original] How do other stressors impact the management of MPAs over time?	[Refined] How do non-fishing stressors impact the management of MPAs over time?	Clarify, focus, and rephrase the question.	Requires identification and measurement of non-fishing stressors and link the distribution and magnitude of these stressors with management considerations/actions. Would benefit from pre- and post- MPA metrics for non-fishing stressors for MPAs and reference sites. Inside-outside response ratios over time. Requires identification of what constitutes management actions. Might want to treat non fishing stressors collectively as well as individually. Focus can be on individual MPAs or groups of MPAs.	Yes (InterT, KF, ROV, Beach, CCFRP, IOOS, & Estuaries)

ECOSYSTEM SERVICES						
G2	**13a**	[Original] What is the value of the ecosystem services provided by California MPAs?	[Refined] What are the ecosystem services provided by ecosystems represented in the MPA network?	Clarify, focus, and rephrase the question. Focus question on identifying and quantifying (or some qualitative metric) of the ecosystem services provided by MPAs in the MPA network.	Requires identification and quantification (or some qualitative metric) of ecosystem services as a function of each ecosystem for MPAs in the MPA network. Requires ability to categorize and measure (quantitatively or qualitatively) forms of ecosystem services. Would benefit from time series data and from pre-MPA and post-MPA data to determine changes in ecosystem services resulting from MPA implementation. Would benefit from comparable data for ecosystems outside MPA boundaries. Focus can be on individual MPAs or groups of MPAs. Would benefit from comparisons that include no-take MPAs as well as MPAs that allow some form of take. To fully answer question, requires multiple lines of data collection and	Yes (CCFRP, Estuaries)

					translation of data into 'ecosystem service' metrics.	
G2	13b		[Refined] How has the flow of these ecosystem services changed following MPA implementation?	Focus question on how the identified ecosystem services provided by MPAs in the MPA network have changed (quantitatively or qualitatively) since MPA implementation.	Requires identification and quantification (or some qualitative metric) of ecosystem services as a function of ecosystem for MPAs in the MPA network. Requires ability to categorize and measure (quantitatively or qualitatively) forms of ecosystem services. Requires time series data from pre-MPA and post-MPA establishment to determine changes in ecosystem services resulting from MPA implementation. Would benefit from comparable data for ecosystems outside MPA boundaries. Focus can be on individual MPAs or groups of MPAs. Would benefit from comparisons that include no-take MPAs as well as MPAs that allow some form of take. To fully answer question, requires models parameterized by multiple lines of data collection and translation of data into 'ecosystem service' metrics.	Yes (CCFRP, Estuaries)

G2	13c		[Refined] What are the short- and long-term economic values of these services?	Focus question on determining the short and long-term economic values of the ecosystem services provided by MPAs in the MPA network following MPA implementation.	Requires identification and quantification (or some qualitative metric) of ecosystem services as a function of ecosystem for MPAs in the MPA network. Requires ability to categorize and measure (quantitatively or qualitatively) forms of ecosystem services and to translate these services into economic metrics. Requires definition of 'short-term' and 'long-term'. Would benefit from time series data from pre-MPA and post-MPA establishment to determine changes in ecosystem services resulting from MPA implementation. Would benefit from comparable data for ecosystems outside MPA boundaries. Focus can be on individual MPAs or groups of MPAs. Would benefit from comparisons that include no-take MPAs as well as MPAs that allow some form of take. To fully answer question, requires models parameterized by multiple lines of data collection and translation of data first into 'ecosystem service' and then into economic metrics.	Yes (CCFRP, Estuaries)

	13d		[Refined] What are the short and long term social and cultural values of these services?	Focus question on determining the short and long-term socio-cultural values of the ecosystem services provided by MPAs in the MPA network following MPA implementation.	Requires identification and quantification (or some qualitative metric) of ecosystem services as a function of ecosystem for MPAs in the MPA network. Requires ability to categorize and measure (quantitatively or qualitatively) forms of ecosystem services and to relate these services to socio-cultural (attitude, behavior, perception, etc.) values. Requires definition of 'short-term' and 'long-term'. Would benefit from time series data from pre-MPA and post-MPA establishment to determine changes in socio-cultural values related to ecosystem services resulting from MPA implementation. Would benefit from analyses of comparable socio-cultural and ecosystem services data for ecosystems outside MPA boundaries. Focus can be on individual MPAs or groups of MPAs. Would benefit from comparisons that include no-take MPAs as well as MPAs that allow some form of take. To fully answer question, requires models parameterized by multiple lines of data collection and translation of data first into 'ecosystem service' and then the relationship of these services to socio-cultural values.	Yes (CCFRP, Estuaries)