Appendix D:

RECOMMENDATIONS FOR HUMAN USES MONITORING

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

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1. INTRODUCTION

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

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

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

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

1.1. Overarching Approach to Monitoring Human Uses in the Context of MPA Monitoring

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

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

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

2. OVERARCHING RECOMMENDATIONS

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

2.1. Engaging Tribes in MPA Monitoring and Evaluation

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

2.2. Data Accessibility and Visualization

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

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

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

2.3. The Role of Technology in MPA Monitoring

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

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

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

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

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

Modernizing fisheries data collection programs will not only streamline data collection and delivery but also allow MPA and fishery managers to quickly update data collection forms to respond to changing information needs and emerging uses. Digital data collection allows for the flexibility needed to develop, test, and refine fisheries data collection programs that can be integrated across fishing sectors as well as

with biological and ecological data. This ability to quickly and iteratively adapt data collection programs will be key to developing the robust socioeconomic fisheries data needed to explore bio-economic linkages and dynamics that are foundational to ecosystem-based and adaptive management approaches.

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

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

3. HUMAN USE MPA MONITORING PROGRAM RECOMMENDATIONS

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

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

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

3.1. TIER 1

3.1.1. Commercial Fisheries

Annual License Renewal & Vessel Registration

Annual license and vessel registration renewal is an excellent opportunity to gather basic information from commercial fishermen. When purchasing or renewing a license, the California Department of Fish and Wildlife (CDFW) can require fishermen to provide information in order to receive their license or vessel

registration. It is a touch point with fishermen that CDFW should maximize that could serve as a springboard to additional survey efforts to gather census data on commercial fishermen.

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

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

Landing Receipts

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

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

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

Commercial Fishery Specific Logbook Data

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

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

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

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

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

Annual and Semi-Annual Surveys

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

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

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

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

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

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

- Operating costs

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

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

3.1.2. CPFV Fisheries

Annual License Renewal & Vessel Registration

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

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

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

CPFV Logbooks

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

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

- Port of departure and return

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

Annual & Bi-Annual Surveys

An annual in-depth survey of CPFV operators can provide additional information necessary to fully understand the socio-economic health of the CPFV fleet. Specifically, surveys can be conducted where

more in-depth information needs to be gathered that cannot be captured quickly (e.g. during license renewal) or needs to be captured at an annual or semi-annual time scale.

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

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

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

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

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

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

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

3.1.3. Recreational Fisheries

License Purchase

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

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

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

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

California Recreational Fishing Survey (CRFS)

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

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

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

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

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

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

Fishery Specific Report Card Data

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

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

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

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

Online Surveys

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

Gathering recreational fishing expenses is a prime example of where a semi-annual survey is necessary. Currently, no economic information is captured for recreational fisheries - leaving a large gap in understanding the economic contribution of saltwater recreational fishing compared to commercial and CPFV sectors. Gathering this type of information is beyond the scope and design of the CRFS program as recreational fishing expenditures occur both on a per-trip basis but also on an annual basis (e.g. boat

maintenance, gear purchase, etc.). A survey conducted every 2-3 years will allow managers and researchers to gain an understanding of the economic aspects of recreational fishing and how they may change over time.

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

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

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

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

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

3.1.4. Coastal Recreation and Tourism

Online Surveys

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

From a statewide representative sample, analysts can generate high-level robust summary statistics aggregated to the state level, including: statewide coastal recreation participation rates; statewide spatial

distributions of coastal visits; robust estimates of spatial distributions of coastal recreational activities; demographic patterns and trends in coastal recreation (by age, gender, race/ethnicity, household income, etc.), and other important statewide summaries of coastal recreational activity.

Sampling Strategy

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

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

Key Metrics

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

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

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

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

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

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

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

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

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

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

Citizen Science Programs

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

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

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

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

<u>Data Validation</u>

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

<u>Refinement</u>

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

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

Overall, MPA managers and research should be integrally involved in guiding and refining the design of citizen science methodologies and protocols in order to maximize their utility in long term MPA

monitoring. Furthermore, there may be synergies between citizen science data program that focus on monitoring specific sites and a statewide online survey effort (as detailed above) that could be utilized together to extrapolate site level citizen science data and enable comparison across citizen science program sites. It is recommended in Tier 1 that these efforts are implemented in order to maximize the utilize of citizen science data collection programs.

3.2. TIER 2

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

3.2.1. Commercial Fisheries

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

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

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

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

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

We would like to note that if the primary objective of these in-person interviews is to map fishing patterns that interviews would be significantly streamlined (and thus require less resources) from past in-person

interview efforts as much of the data that were gathered in those interviews are recommended to be gathered in other methods mentioned in this report (e.g. online survey).

Annual and Semi-Annual Surveys

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

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

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

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

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

3.2.2. CPFV Fisheries

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

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

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

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

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

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

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

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

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

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

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

3.2.3. Recreational Fisheries

License Purchase

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

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

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

Accounting for Unlicensed Fishing Effort

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

Capture of Spatial Fishing Data

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

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

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

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

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

Annual and Semi-Annual Surveys and/or Focus Groups

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

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

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

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

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

3.2.4. Coastal Recreation and Tourism

General Online Surveys

Online surveys can be an important data source for estimating econometric models of MPA impact. Section 3.1.4 above outlines the basics of online surveys, their sampling strategy and the benefits of conducting

them regularly to derive summary statistics about coastal recreation at the state, regional, or local levels. Below we discuss two important econometric models and identify the variables that must be collected to estimate them: contingent valuation and travel cost.

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

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

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

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

Travel Cost Models

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

Variables

- **Transportation Variables.** The implementation of travel cost models requires the collection of transportation variables. Knowing the distance traveled, time involved in traveling, and mode of transportation chosen by the visitor allows the analyst to estimate total travel cost based on plausible assumptions. Collecting these variables thus allows researchers to identify and measure users' preferences for various attributes of recreational sites, and ultimately derive measures of the non-

market economic value that users place on specific recreational sites or site attributes. The transportation-related variables that should be collected for a travel cost modeling study include:

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

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

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

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

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

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

identifying potentially omitted variables from travel cost model estimates, as well as probing non-economic motivations or reasons for coastal visitation behavior.

3.3. TIER 3

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

3.3.1. Commercial Fisheries

Digital Mobile Based Landing Receipts

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

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

Digital Mobile Based Logbooks

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

Specifically, digital logbooks can:

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

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

3.3.2. CPFV Fisheries

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

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

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

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

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

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

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

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

3.3.3. Recreational Fisheries

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

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

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

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

3.3.4. Coastal Recreation and Tourism

Online Surveys

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

Overnight or Multi-Day Visits

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

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

Out-of-State Visitors

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

Choice Experiments

In addition to the uses identified above, online surveys can be used to conduct more sophisticated forms of stated-preference studies, such as **choice experiments.** Choice experiments are a form of stated preference

study wherein the analyst asks members of a population to choose their most preferred alternative from a series of bundles of attributes, provided at varying levels, and associated with varying prices. Estimating the results of choice experiments requires the use of a discrete choice modeling framework, such as logit. For more information about choice experiments, please see Section 4, Economic Modeling, below.

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

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

Citizen Science Programs

Utilizing Mobile Applications

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

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

Tracking Phenology

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

Place Attachment and Place Identity

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

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

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

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

4. ECONOMIC MODELING

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

4.1 Economic models

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

4.2 Input-Output Models

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

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

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

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

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

4.3 Non-Market Valuation Techniques

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

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

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

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

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

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

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

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

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

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

4.4 Revealed Preference Studies

The main alternative to a stated preference study, such as contingent valuation or a choice experiment, is a revealed preference study. Revealed preference studies use observed market behavior to identify and measure implicit values of the attributes of goods and services. Hedonic price studies are the most common forms of revealed preference studies. A hedonic price study measures statistically the relationship between the market prices of goods/services and the attributes of those goods/services. For instance, a study might measure the relationship between the price of a house and attributes such as floor space, heating source,

roof condition, and/or the quality of local schools, parks, and amenities. Hedonic price studies can also be applied to environmental goods or services that are not for sale, such as local air quality or water quality. For environmental goods with multiple attributes, however - such as recreation sites - the appropriate revealed preference framework is the *travel cost model,* which is discussed below.

4.5 Travel Cost Models

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

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

4.6 Random Utility Models (RUMs)

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

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

4.7 Other Frameworks

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

4.8 Comparison Group Evaluations

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

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

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

4.9 Data Considerations

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

4.10 Additional Research Questions

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

5. CONCLUDING REMARKS

State agencies are faced with the mandate to manage MPAs using ecosystem-based and adaptive management measures to ensure the ecological and economic sustainability of coastal communities into the future. To do so, requires cost-effective and innovative approaches to collecting robust, fine-scale, and

spatially explicit socioeconomic human use data that will better enable managers to design, monitor, and adapt the targeted management measures needed to effectively reach sustainability goals.

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

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