Assessing Socio-economic and Biophysical Indicators to Improve their Usefulness for Resource Management in the U.S. Pacific Islands

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Executive Summary

This project investigated the availability, awareness, and gaps of socio-economic and biophysical information needed in the Pacific Island Region for effective coastal and fisheries management that takes human well-being into consideration. Main methods included secondary data review of existing socio-economic and biophysical data, online survey, and focus groups. Both of the latter methods were conducted with key individuals involved in monitoring efforts in the Pacific Island Region and in the National Coral Reef Monitoring Program (NCRMP), and included both current and possible data users. The project examined the NCRMP and non-NCRMP efforts in the Pacific Island Region. This document summarizes the main study results and provides recommendations regarding integrated monitoring efforts across the region and for regional socio-economic monitoring efforts.

Introduction

Long-term monitoring can help provide information that is useful for management. The Coral Reef Conservation Program (CRCP), developed under the authority of the Coral Reef Conservation Act of 2000 (P.L. 106-562; 16 U.S.C. 6401 et seq.), launched the National Coral Reef Monitoring Program (NCRMP in 2012. The goal of the NCRMP is to track socio-economic[1] and biophysical changes to improve coral reef management. NRCMP monitors island-level changes among the U.S.-affiliated islands in the Pacific, including Hawaii, Guam, the Commonwealth of Northern Marianas, and American Samoa. Most of the ecological and oceanographic observations of the Pacific Reef Assessment and Monitoring Program (RAMP) are now collected every 3 years (formerly every 2 years). Island-wide NCRMP socio-economic monitoring examines the relationships of jurisdictional households in coastal areas with coral-reef resources, as well as their knowledge, attitudes, and perceptions regarding coral reefs and coral-reef management. CRCP works with local partners to reduce key threats to coral reefs, including climate change, land-based sources of pollution, and impacts from fishing. While the NRCMP focuses on data relevant to reef management at the island level, other state- and site-based long-term monitoring efforts generate various data types relevant to fisheries management and coastal management. While the biophysical monitoring is ongoing, numerous socio-economic surveys and assessments have been conducted in the eastern Pacific as initial baselines and to track changes over time. These include ongoing monitoring of socio-economics related to regional and island fisheries by the staff of the NOAA Pacific Islands Fisheries Science Center (PIFSC), along with site-based socio-economic assessments by the Socio-economic Monitoring Guidelines for Coastal Managers in Pacific Island Region (SEM-Pasifika), launched by NOAA and the Secretariat of the Pacific Regional Programme for the Environment (SPREP) in 2009. The NOAA PIFSC socio-economic monitoring efforts date back as far the 1980s and have produced multiple data sets, particularly in the area of the costs and earnings of different fisheries types. The SEM-Pasifika site-based assessments and monitoring training have been supported by the CRCP and the Pacific Islands Managed and Protected Areas Community (PIMPAC), the National Ocean Service (NOS), and regional and local conservation and resource management partners. To date, there are nearly 20 assessments in the Pacific region.

In the last decade, social-ecological systems (SES) have become recognized in natural resource management (Berkes and Folke 1998, Berkes 2016), and an ecosystem approach is increasingly being adopted and replacing conventional management focused only on single species or single sectors (e.g., see NOAA initiatives below). SES, however, is not clearly defined (Colding and Barthel 2019), and often the social and biophysical aspects of SES are not given equal weight. There are also growing needs to integrate biophysical and social monitoring to generate more comprehensive information to better inform ecosystem-based management decisions and to safeguard the ecological and social systems of island communities. Integrated monitoring (IM) is a coordinated, long-term process in which scientists from multiple disciplines collect and analyze social and biophysical data to meet shared objectives of tracking, assessing, and understanding changes over time within social and ecological systems, as well as changes in their interactions

[1] The term socio-economic in this document is used to include economic, socio-cultural, and other human dimensions of resource management.

(Folke et al. 2005, Gove et al. 2019, Heenan et al. 2016, Kendall and Moore 2012, Kittinger et al. 2012, Lindenmayer et al. 2011, Samhouri et al. 2014, Wongbusarakum et al. 2019). Through clearly defined, interdisciplinary monitoring objectives and implementation, and through merging datasets derived from varying methods, the goal of IM is to inform managers and policy makers about systemic changes and linkages among them to achieve holistic natural-resource management, while simultaneously promoting ecological health and human well-being (Wongbusarakum et al. 2019).

In recent years, IM has increasingly received attention among monitoring teams at both site and island levels. Recent NOAA initiatives, such as the Integrated Ecosystem Assessment (IEA) and Ecosystem Approach to Fisheries Management (EAFM), all require better integration of biophysical and socio-economic monitoring data. Social sciences have become increasingly applied in this context. Initiatives also involve reviewing and revisiting indicators of the different datasets, as well as considering best practices (including stakeholder engagement and discussions among different monitoring teams) to enhance both data accessibility and usefulness for planning and adaptive management. To inform this type of indicator-refinement process, we assessed how well socio-economic and biophysical data collected to date have met the needs of management users throughout U.S. jurisdictions in the Pacific Island Region; investigated the feasibility of integrating biophysical and socio-economic data; and provided input for potential future modifications of the indicators, data-collecting tools and approaches. Specifically, we sought to understand: (1) the perceived importance associated with each indicator, (2) existing needs for additional types of data considered useful for management, and (3) known challenges when integrating biophysical and socio-economic monitoring and suggestions for improvement. Although the scope of this study was focused on informing the NCRMP, PIFSC Ecosystem Sciences Division (ESD), and the PIRO PIMPAC, these results may also be useful to other partners in management and conservation of coastal and marine resources.

Methods

The survey design and materials, including the questionnaire (Appendix A) and focus group guide (Appendix B), were developed by the PIFSC ESD staff.

Survey questionnaire

Data types and indicators

We reviewed data types and variables collected by the following data-collecting instruments, and they were used to design the list of existing data in the survey questionnaire. For the biophysical data, the Pacific Reef Assessment and Monitoring Program (Pacific RAMP) field collection, led by the Ecosystem Sciences Division (ESD) of the NOAA Pacific Islands Fisheries Science Center (PIFSC), was the focus of the review. Its methodologies produce an extended time series of interdisciplinary, integrated ecosystem observations of coral reefs around approximately 40 islands, atolls, and shallow-water banks of the Mariana Archipelago, American Samoa, the Hawaiian Archipelago, and the Pacific Remote Islands Marine National Monument (PRIMNM). Pacific RAMP data collections are designed to characterize the status and trends of the distribution, abundance, diversity, and size of corals, other macro and cryptic invertebrates, microbes, algae, and fishes in the context of their benthic habitats and varying oceanographic conditions. The NCRMP establishes consistent and comparable survey and analytical methods and provides a context for comparing surveys across time and space for biological, oceanographic, and socio-economic metrics (NOAA NCRMP 2014). The RAMP variables are the same as those collected by the Micronesia reef monitoring program led by the University of Guam Marine Lab for the Micronesia Challenge countries.

For socio-economic data, we reviewed the 13 core data types used in the NRCMP socio-economic monitoring; 27 PIFSC socio-economic and fisheries surveys which were primarily conducted in Hawaii, Guam, CNMI, and American Samoa; and 19 SEM-Pasifika assessments conducted in the Micronesia Challenge countries (Appendix C). Following is a summary of the existing socio-economic and biophysical data types. These were used in the survey questionnaire to find out the respondents' awareness and perceived importance of each data type.

Existing socio-economic and biophysical data types used in the survey questionnaire

Existing socio-economic data types

1. Demographics, incl. general communities, fishers, and vulnerable populations
2. Community well-being, including health
3. Types and proportions of community livelihoods, employment, and income
4. Livelihood sustainability, (occupational) diversity and flexibility
5. (Equitable) access to resources/assets
6. Resource dependency for provisioning ecosystem services (including livelihoods, e.g. commercial and subsisting fisheries)
7. Personal disruption due to unemployment, poverty level or interrupted education
8. Housing (rent, number of rooms, with plumbing)
9. Labor force
10. Physical infrastructure and coastal development
11. Resource governance, management, and institution

12. Attitudes towards coastal and fisheries management
13. Understanding of environmental regulations
14. Attitudes towards coastal and fisheries enforcement and compliance
15. Awareness of and attitude towards marine protected areas
16. Community participation in resource stewardship
17. Participation in recreational and tourism marine activities
18. Ability of communities to decide and act in order to create change
19. Economic/monetary value of marine and coastal species and resources
20. Economic impact of dive/snorkel tourism
21. Non-monetary/non-extractive value of marine and coastal species and resources by communities
22. Perceived conditions of coastal and marine resources
23. Awareness and knowledge of marine and coastal resources
24. Perceived anthropogenic threats to natural resources
25. Perceived climate threats and natural hazard risks to communities
26. Learning and knowledge to adapt to climate change impacts
27. Participation in fishing activities, (including gear, effort and catch)
28. Fisher classification based on purpose of fishing (e.g. commercial, recreational, subsistence, cultural, etc.)
29. Proportion of population being reliant on commercial and recreational fisheries
30. Commercial fisheries economic data (cost/expenses and revenue) and impact assessment
31. Recreational fisheries economic data and assessment
32. Seafood industry economic trends and impacts, incl. fish trade (dealer, amount and value of fish sold)
33. Participation in seafood markets (catch disposition, sales, market utilization, perceptions of market conditions)
34. Perceived fishing conditions
35. Social and cultural uses of fishing

Existing biophysical data types

36. Coral size structure
37. Coral condition
38. Benthic percent cover
39. Coral growth
40. Rugosity
41. Fish abundance
42. Fish size structure
43. Occurrence of protected species
44. Occurrence of macroinvertebrate key species
45. Microbial biodiversity
46. Cryptobiota diversity (i.e., small marine organisms that live predominantly within the complex reef structure)
47. Sea level rise
48. Water temperature
49. Water chemistry (e.g., DIC, TA, DO, pH, dissolved inorganic nutrients, chlorophyll-a, salinity, fluorescence)
50. Light (irradiance from remote sensing)

51. Benthic accretion/bioerosion
52. Meteorology (air temperature, wind speed, wind direction, humidity, etc)
53. Large-scale climate forcing (El Niño/La Niña, Pacific Decadal Oscillation)
54. Physical oceanography (e.g., ocean currents, wave metrics including height, period, power, and direction)
55. Marine debris (sightings of man-made debris)

To help address data gaps and make recommendations, a limited literature review was conducted. The areas encompassed in the review were: integrated monitoring; resilience, vulnerability, adaptive capacity, and other social dimensions of climate change; cultural ecosystem services; biocultural approaches and indicators; and human well-being. Lists were developed for types of sociocultural and economic and biophysical data that were suggested by the literature and scientific experts as being potentially useful for management but, to the best of our knowledge, had not been not collected in any long-term monitoring program by the time of this study. The lists that follow were then used in the survey questionnaire for the respondents to rate how important they thought each of these data types could be to inform management. The literature used can be found in the Reference section.

Potential socio-economic and biophysical data types in the survey questionnaire

Potential useful sociocultural and economic data types not currently collected by long-term monitoring

1. Cultural heritage and connection to place
2. Spiritual connection to nature and species
3. Connection and sense of place and identity
4. Social relations and network
5. Existence value of resources (including nature as being a source of inspiration, creativity, and aesthetics)
6. Gender issues (division of resource use, management, and gender equity)
7. Willingness-to-pay for coral reef protection/conservation
8. Community resilience to climate impacts and natural disasters
9. Application and impact of aquaculture
10. Access to information on coastal and marine resources

Potential useful biophysical data types not currently collected by long-term monitoring

11. Reproduction or fecundity of organisms
12. Recruitment or connectivity of organisms
13. Mortality rates of organisms
14. Metabolic performance of organisms
15. Land-based sources of pollution, water quality, sedimentation, nutrient inputs
16. Other measures of habitat/structural complexity
17. In situ measurements of light (e.g., irradiance of photosynthetically active radiation [PAR])
18. Regulating ecosystem services (e.g., carbon sequestration and storage, erosion prevention, moderation of extreme events)

Questionnaire format

The survey had 2 parts (Appendix A). Part 1 (Section A) was designed to be completed by all participants. Part 2 had 3 sections (B, C, and D) and each respondent was asked to select and fill out only one section that was most relevant to their work. In all sections, the aim was to collect information about the types of monitoring data that are known and deemed important by those involved in coastal and marine resource management, but also to identify and help fill data gaps with the aim of improving integrated monitoring. Details of the sections are as follows.

Section A was to understand the background of the survey respondents, awareness of monitoring data that is available, their use of such data, and the perceived importance of each of the data types specifically for management purposes. It also examined the participants' opinions about how useful the new types of biophysical and social data suggested by literature and relevant scientific experts could be for management.

Section B was only for the survey participants involved in biophysical monitoring. It examined their main role in monitoring; their purposes for conducting biophysical monitoring; the extent to which they work across disciplines or collaborate with social scientists and resource managers; their opinions about the usefulness for management decision-making of existing data gathered from long-term biophysical monitoring programs, both in general and in relation to the specific programs that they are involved with; and, lastly, the most important and useful types of biophysical data for sociocultural and economic monitoring, and vice versa.

Section C was to be completed only by the survey participants involved in sociocultural and economic monitoring. It examined their main role in monitoring; the purpose of their sociocultural and economic monitoring; their level of working across disciplines or collaborating with biophysical scientists and resource managers; their opinions about the usefulness for management decision-making of existing data gathered from long-term sociocultural and economic monitoring programs, both in general and in the specific programs that they are involved with; and, lastly, the most important and useful types of sociocultural and economic data for biophysical monitoring, and vice versa.

Section D was for the survey participants involved in management and in all other types of work except biophysical and sociocultural and economic monitoring. The purpose of this section was to examine opinions about the following: overall usefulness of the existing data from long-term monitoring programs for informing management decision making; their level of work with those who design or implement long-term monitoring to make sure the data meet management needs; the importance of collaboration across social and natural scientific disciplines; and the types of existing and additional data that would be most useful for their work.

Survey participants

Purposive sampling and snowball sampling were used to recruit the two target participant groups. The first group was possible users of socio-economic and biophysical data, and the second group was people involved in monitoring design and implementation. As there had been no previous studies describing the populations of these groups and we did not know the total possible numbers, the purposive sampling design process was used. It started with consultations with known data users identified by relevant institutions as the most appropriate people to participate in the survey. These became the first target samples. The criteria of our target respondents were that they be adults, 18 years or older, who could represent agencies, organizations, programs or groups that may use long-term biophysical and socio-economic data collected in the Pacific Island Region, and/or who were involved in designing and implementing such monitoring. The people who participated in the first round of surveying were asked to recommend other appropriate participants who were then invited to also participate in the survey.

These data users came from fisheries and coastal resource management agencies, conservation organizations, and community groups in the Pacific Island Region. These included the Western Pacific Regional Fishery Management Council (WPRFMC), National Marine Monuments in the Pacific Island Region, the Guam Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR), the American Samoa Department of Marine and Wildlife Resources (DMWR), the CNMI Department of Lands and Natural Resources, Division of Fish and Wildlife (DFW), the NOAA Pacific Island Regional Office, The Nature Conservancy, Conservation International, the Micronesia Conservation Trust, Kua, and Kai Kuleana.

For those who were involved in monitoring, we started with leads for physical and biological monitoring teams (such as fish, coral and benthic, and ocean and climate change teams) at the PIFSC ESD, Global Socio-economic Monitoring Coordinator at CRCP, the NCRMP tool developers and data analysts, research partners (such as University of Guam Marine Lab, University of Hawaii, and researchers from conservation organizations), key individuals involved in socio-economic monitoring efforts in the Pacific islands and other regions (such as PIFSC Socio-economic and Human Dimension team staff, NOS Hollings Lab socio-economic team members, socio-economic monitoring (Global Socio-economic Monitoring Initiative for Coastal Management [SocMon]/SEM-Pasifika) regional coordinators and island points of contacts, Micronesia Challenge[2] technical and monitoring advisors, and other partners involved in biophysical and socio-economic monitoring, including NGOs such as The Nature Conservancy, Conservation International, and Micronesia Conservation Trust.

Questionnaire implementation

A pretest with 6 data users or people who had done monitoring-related work was conducted prior to the official survey to allow for refinement and correction of any methodological issues identified. The final survey was administered online by Survey Monkey from May 5 through June 30, 2019. To minimize non-response to internet surveys, a variety of techniques were incorporated to maximize response rates. Firstly, the participants received a personalized email invitation to participate in the survey. The message informed them that they had been recommended by a colleague who believed their participation would be important for the survey. The survey topics and questions are within the areas of familiarity or expertise of the respondents, and the introduction explained the project purpose and why a response would be

[2] Micronesia Challenge (MC) is a conservation commitment by the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, Guam, and the Commonwealth of the Northern Marianas Islands to preserve the natural resources that are crucial to the survival of Pacific traditions, cultures and livelihoods. The overall goal of the Challenge is to effectively conserve at least 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia by 2020. For this commitment, biophysical (marine and terrestrial) and socio-economic monitoring have been conducted to track the ecological and social conditions of different sites in the MC countries.

important. Secondly, it was made clear that this survey had the potential to yield results that could directly benefit respondents (i.e. creating understanding of needs for data types and adapting future monitoring efforts so that they meet respondents' needs and enable them to better understand social-ecological systems). Thirdly, it included a statement indicating that all personal information will be protected and confidentiality guaranteed. Fourthly, the surveys were designed to be user-friendly, with clear, easy-to-comprehend instructions and questions that enabled the questionnaire to be completed in approximately 30 minutes. Lastly, the invitation set a reasonable due date (3 weeks after the invitation receipt) and a reminder was sent.

Out of a total of 168 invitations, 112 people (67%) voluntarily participated in the survey. Highly limited personal data were collected, most of which were work-related (such as geographical or thematic areas the respondents' work focus on) to allow for sorting and categorizing the survey results and for comparing sub-groups if applicable.

Focus groups

Four focus groups were conducted in May 2019 in conjunction with meetings where potential data users and monitoring team members were present (Appendix D). These included 2 focus groups (with 12 and 9 participants) at a meeting for Atlantis[3] modeling, a group of 18 participants at the National Integrated Ecosystem Assessment, and a group of 15 participants at the indicator meeting with the DAR 30 × 30 initiative[4]. The group discussion participants were current and potential data users, monitoring team members, as well as community facilitators and community representatives from Hawaii in the last group. The questions in the focus groups (Appendix B) were developed to be complementary to the survey.

Data analysis

Survey Monkey provided descriptive statistics. The raw data and verbatim were also downloaded for further analyses in SPSS Version 24 (IBM SPSS Statistics). Descriptive statistics were performed to find out results and differences among the difference sub groups such as those who worked in the Pacific islands, those who worked in NCRMP areas, fisheries managers (federal and jurisdiction), social scientists, and biophysical scientists. Given that we used a non-probability sampling approach, our results will be presented in a qualitative, rather than a quantitative manner. The percentages of helped guide our understanding of answers more

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[3] Atlantis is a deterministic biogeochemical and biophysical modeling system that simulates the functioning of marine food webs and fisheries to serve as a policy exploration tool for ecosystem-based management. It is an "end-to-end" model, in that it represents ecosystem components from marine bacteria to apex predators and human beings. Sub-models include consumption, biological production, waste production, reproduction, habitat dependency, age structure, mortality, decomposition and microbial cycles. The spatial domain is resolved in three dimensions using irregular polygons to represent biogeographic features. Exchange of biomass occurs between polygons according to seasonal migration and foraging behavior, while water movement, heat and salinity flux across boundaries can be represented by a coupled hydrodynamic model.

[4] The 30 × 30 initiative has a goal to effectively manage at least 30% of Hawaiʻi nearshore marine areas by 2030 to ensure a healthy nearshore ecosystem and fisheries that sustain the people and economy of Hawaiʻi. Meetings were held in 2019 to identify and prioritize biophysical and social indicators and institutionalize monitoring and data analysis.

frequently mentioned by the survey respondents but are not reported in this document. On all tables, the rankings from 1 to 5 represents the 5 answers in descending sequence that received the greatest numbers of responses out of the total possible choices. If there is a tie, this is reflected in the items having the same ranking. Input from the focus groups provided a very wide range of opinions by the participants. They were used to complement the results of the survey data and helped in formulating some of the recommendations made later in this document.

Results

Participant profiles

The focal areas of work among the respondents were as follows: 34% fisheries management, 39% socio-economic research or monitoring, and 27% biophysical research or monitoring. Seventy-five people worked in the Pacific Islands (Hawaii, American Samoa, CNMI, Guam, FSM, Palau, RMI, PRIAs), and 84 worked in NCRMP areas (Hawaii, American Samoa, CNMI, Guam, Southeast USA, Caribbean). There is considerable overlap between the 2 geographical groups, with 62% of the respondents working in both the Pacific islands and NCRMP areas.

Awareness of existing data

We analyzed the awareness of data of all respondents, the geographical sub-groups (Pacific island and NCRMP areas), and the group of respondents who manage fisheries to determine their awareness of the different types of data that have been collected and are available for their use.

Socio-economic data

Extremely high numbers of respondents across all groups of different geographical focal areas were most aware of demographics (including general communities, fishers, and vulnerable populations); participation in fishing activities (including gear, effort and catch); types and proportions of community livelihoods, employment, and income; and commercial fisheries and economic data (cost/expenses and revenue and impact assessment; Table 1). The respondents in the Pacific Islands were uniquely aware of the labor force, while the NCRMP respondents were most attuned to the physical infrastructure and coastal development. Managers and most respondents were also aware of various fisher classifications based on the purposes of fishing (e.g. commercial, recreational, subsistence, cultural, etc.).

In all tables, for ease of interpretation, if it looks like a number is skipped (e.g., 2 and 3 in the "manager (federal)" column of Table 3, this is due to a tie. In the provided example, three data types are tied for first and the next data type is listed as 4th since there are three other data types for which federal managers reported higher levels of awareness.

Table 1. Socio-economic data types with highest awareness levels.

Socio-economic data most aware of among 35 data types	All	Pacific islands	NCRMP	Manager (all)	Manager (federal)	Manager (jurisdictional)
Demographics, including general communities, fishers, and vulnerable populations	1	1	1	1	1	1
Participation in fishing activities, (including gear, effort and catch)*	2	2	2	2	1	2
Types and proportions of community livelihoods, employment, and income	3	3	3	3	4	
Commercial fisheries economic data (cost/expenses and revenue) and impact assessment	4	5	5	4	4	2
Labor force		4				5
Physical infrastructure and coastal development	5		4			
Fisher classification based on purpose of fishing				3	4	
Resource governance, management, and institution					1	
Attitudes towards coastal and fisheries management						2

The majority of the respondents were least aware of the following: the ability of communities to decide and act to create change (agency); issues of equitable access to resources/assets; learning and knowledge in adapting to climate change impacts, personal disruptions due to unemployment, poverty, or interrupted education (Table 2). The respondents in the Pacific islands were, however, least aware of the non-monetary/non-extractive value placed on marine and coastal species and resources by local communities. Awareness regarding perceptions of fishing conditions was lowest among NCRMP respondents and managers. Federal and jurisdictional managers differ in their awareness levels in a few areas. Federal managers report being more aware of "Types and proportions of community livelihoods, employment, and income" and "Resource governance, management, and institution" when compared to jurisdictional managers. Jurisdictional managers report being more aware of "Attitudes towards coastal and fisheries management" when compared to federal managers.

Table 2. Socio-economic data types with lowest awareness levels.

Socio-economic data least aware of among 35 data types	All		NCRMP	Manager (all)	Manager (federal)	Manager (jurisdictional)
Ability of communities to decide and act in order to create change	1		1	1	2	1
(Equitable) access to resources/assets	2		2	1	1	
Learning and knowledge to adapt to climate change impacts	3		3	3	4	
Personal disruption due to unemployment, poverty level or interrupted education	4		5	4	5	
Non-monetary/non-extractive value of marine and coastal species and resources by communities						1
Perceived fishing conditions	5		4	4		1
Community participation in resource stewardship					3	
Perceived climate threats and natural hazard risks to communities						1
Recreational fisheries economic data and assessment						5

Biophysical data

The top four types of biophysical data that all respondents (including with NCRMP and the Pacific Islands) were most aware of were water temperature, large-scale climate forcing, fish abundance, and sea level rise (Table 3). The fifth most well-known data set among respondents in the Pacific Islands focused on coral condition, whereas people associated with NCRMP were more familiar with data sets about fish size structure. Managers exhibited levels of awareness in response to only data sets of water temperature and large-scale climate forcing, whereby all but one respondent were aware of such existing data. Jurisdictional managers report higher levels of awareness for meteorology and physical oceanography when compared to federal managers. There was considerable consistency among the groups of respondents in relation to the data sets about which they were least aware: the diversity of cryptobiota and microbes, benthic accretion/bioerosion, and marine debris (Table 4).

Table 3. Biophysical data types with highest awareness levels.

Biophysical data most aware of among 20 data types	All	Pacific islands	NCRMP	Manager (all)	Manager (federal)	Manager (jurisdictional)
Water temperature	1	1	1	2	1	1
Large-scale climate forcing	3	2	2	1	1	1
Fish abundance	2	3	2	4	4	
Sea level rise	4	4	4	3	1	4
Coral condition		5				
Fish size structure	5		5		4	
Occurrence of protected species				5		
Meteorology (air temperature, wind speed, wind direction, humidity, etc.)						1
Physical oceanography (e.g., ocean currents, wave metrics including height, period, power, and direction)						4

Table 4. Biophysical data types with lowest awareness levels.

Biophysical data least aware of among 20 data types	All	Pacific islands	NCRMP	Manager (all)	Manager (federal)	Manager (jurisdictional)
Cryptobiota diversity	2	1	2	2	2	1
Microbial diversity	1	2	1	1	1	1
Benthic accretion/bioerosion	3	3	3	3	3	1
Marine debris	4	4	4	4		4
Light (remote sensing: irradiance)		5		5		5
Coral growth	5		5		3	
Rugosity					3	

Perceived importance of existing data

Jurisdictional managers tended to be more focused on localized issues and federal managers tend to be more focused on macro issues. Federal managers found more importance in commercial fishing and resource governance data than jurisdictional managers. Jurisdictional managers found more importance in fishing reliance, awareness of regulations, and community participation in management data than federal managers. Federal managers found more importance in sea-level rise and water-temperature data than jurisdictional managers. Jurisdictional managers found more importance in physical oceanography and benthic cover than federal managers.

Socio-economic data

For all groups of respondents the most important type of socio-economic data was resource dependency for provisioning ecosystem services (including livelihoods, e.g., commercial and subsisting fisheries; Table 5). But when breaking down managers into federal and jurisdictional groups, the most important data types were fisher classification and participation in fishing activities/reliance on fishing, respectively. For the Pacific island group, participation in fishing activities was also the most important, followed by demographics, proportion of population being reliant on commercial and recreational fisheries, and social cultural uses of fishing. Similar results held true for the NCRMP respondents. The only difference was that Pacific islands focused respondents also considered "socio-cultural uses of fishing," and "fisher classification based on purposes of fishing" as being highly important. Jurisdictional managers also identified "Understanding of environmental regulations" and "Community participation in resource stewardship" as very important data types.

Particularly interesting observations included the following:

- Data on governance and fisher classification made it to the manager group's 2nd and 3rd "very important" categories, but not for social scientists or biophysical scientists.
- Data on commercial fisheries economic data (cost/expenses and revenue) and impact assessment* made it into the top 5 "very important" category of all groups, but managers.
- Biophysical scientists tend to find data on resource extraction and fishing participation as most important.
- Social and cultural uses of fishing are rated "very important" by Pacific island group and managers.
- Commercial fisheries economic data is more important to federal managers than it is to jurisdictional managers.

Table 5. Socio-economic data types with highest importance rating.

Most important existing socio-economic data among 35 data types	All	Pacific islands	NCRMP	Manager (all)	Manager (federal)	Manager (jurisdictional)	Social scientist	Biophysical scientist
Resource dependency for provisioning ecosystem services (including livelihoods, e.g., commercial and subsisting fisheries)	1	1	1	1	2	3	1	1
Demographics, incl. general communities, fishers, and vulnerable populations*	3	3	3	4	4	3	3	2
Participation in fishing activities, (including gear, effort and catch)*	2	1	2	2	2	1	1	4
Proportion of population being reliant on commercial and recreational fisheries	4	4	4	4		1	5	2
Fisher classification based on purpose of fishing (e.g., commercial, recreational, subsistence, cultural, etc.)	5			2	1	3		
Commercial fisheries economic data (cost/expenses and revenue) &impact assessment*	5		5		4		3	5
Types and proportions of community livelihoods, employment, and income*	5							
Resource governance, management and institutions				3	4			
Social and cultural uses of fishing		5		5		3		
Perceived climate threats and natural hazard risks to communities				5				
Understanding of environmental regulations						3		
Community participation in resource stewardship						3		

* High awareness of data availability among all respondents.

For the open-ended question about the most useful data types, both existing or only potential, in relation to their work, more than half of the managers chose Resource use/fishing reliance/fishing frequency/Livelihoods, while just under half selected Economic information (Table 6). The following types of socio-economic data collected but considered the least important by more than three quarters of the people: housing (rent, number of rooms, with plumbing), Personal disruption due to unemployment, poverty level or interrupted education, and labor force.

Table 6. Socio-economic data types considered most useful by managers.

Most useful socio-economic data for managers (open-ended question)	Ranking
Resource use/fishing reliance/fishing frequency/Livelihood	1
Economic information	2
Participation in management/governance	3
Cultural heritage	4
Attitudes toward management	4
Perceived resource conditions	4

Biophysical data

Regardless of whether they were part of the Pacific Islands or NCRMP, all groupings of respondents agreed on the top five most important types of biophysical data that currently exist for the purpose of coastal and fisheries management (Table 7): measures of fish populations (abundance and size structure), followed by coral condition and then measures of environmental conditions (water temperature and large-scale climate forcing). These same metrics were also the datasets that respondents tended to know about as existing information resources (Table 3). The relative importance of these same or similar types of indicators all remained the highest when responses were summarized by profession (managers, social scientists, and biophysical scientists): fish-related metrics, coral condition, and various measures of oceanic conditions, including physical oceanography and water chemistry. Notably, all three groupings of professions agreed that all fish-related metrics were either moderately or very important for management purposes. Social scientists also appeared to value data on sea level rise greater than the other professions, with all social scientists considering such datasets to be moderately or very important. Biophysical scientists also seemed to value the indicator of coral condition less than managers and social scientists, with the top five most important metrics consisting only of measures of fish populations and oceanic conditions. Federal managers also identified sea level rise and rugosity data as important, while jurisdictional managers identified benthic cover data as important.

Table 7. Biophysical data types with highest importance rating.

Most important existing biophysical data among 20 data types	All	Pacific islands	NCRMP	Manager (all)	Manager (federal)	Manager (jurisdic-tional)	Social scientist	Bio-physical scientist
Fish abundance	1		1	1	1	1	1	4
Fish size structure	2		2	2	2	1	3	1
Coral condition	3		3	5			1	
Water temperature	4		4		4		4	5
Large-scale climate forcing (El Niño/La Niña, Pacific Decadal Oscillation)	5		5	3	3	1		1
Physical oceanography (e.g., ocean currents, wave metrics including height, period, power, and direction)				4		1		
Water chemistry (e.g., DIC, TA, DO, pH, dissolved inorganic nutrients, chlorophyll-*a*, salinity, fluorescence)							5	1
Rugosity					5			
Sea level rise					5			
Benthic percent cover						1		

When asked the open-ended question about the types of biophysical data that are most useful for their work, the majority of managers that responded indicated that data about fish and benthic communities were useful (e.g., measures of abundance, size structure, recruitment, and condition/health; Table 8). Other types of data mentioned by multiple respondents included fisheries-related data, metrics of land use and water quality, insight on climate change (e.g., sea level rise and warming events), and an understanding of the life histories of organisms (e.g., connectivity patterns, early-life stages, and reproduction). Measures of climate and weather, physical oceanography and seawater conditions, and habitat (e.g., mapping, rugosity, reef accretion) were also listed by a few respondents. Two respondents found data about the location and presence of ESA-listed species to be useful, and one respondent mentioned that data on invertebrate populations was useful.

Table 8. Biophysical data types considered most useful by managers.

Most useful biophysical data for managers (open-ended question)	Ranking
Benthic community: cover, coral recruits, coral health	1
Fish community: abundance, sizes	2
Land use, water quality, sedimentation	3
Fishery-related data	4
Life history: connectivity, early-life stages, reproduction	4
Climate change: sea level rise, warming events and thermal stress	6

The five least important biophysical datasets for coastal and fisheries management were similar among respondents across geographic regions (Pacific Islands and NCRMP; Table 9): diversity of microbes and cryptobiota, light (remote sensing of irradiance), marine debris, and meteorological measurements. With the exception of meteorological metrics, respondents were also least aware of such indicators, perhaps due to their perceived lack of importance. Managers and biophysical scientists appeared to value microbial and cryptobiota diversity the least, whereas those metrics were not among the five most cited metrics that social scientists indicated were least important. Social scientists further differed from managers and biophysical scientists in their perceptions of meteorology and coral growth, which the other two professions seemed to value more (one of the top five considered least important). Managers and social scientists found less value in metrics of benthic accretion/bioerosion than biophysical scientists, and biophysical scientists found data about coral size structure less valuable than did the other two professions.

Table 9. Biophysical data types with least importance rating ("not at all important" plus "slightly important").

Least important existing biophysical data among 29 data types	**All**	**Pacific islands**	**NCRMP**	**Manager (all)**	**Manager (federal)**	**Manager (jurisdictional)**	**Social scientist**	**Biophysical scientist**
Microbial biodiversity	1		2	2	1			1
Cryptobiota diversity (i.e., small marine organisms that live predominantly within the complex reef structure)	2		3	1	2	4		2
Light (irradiance from remote sensing)	3		4	4	5	1	1	4
Benthic accretion/bioerosion				3	5	2	5	
Marine debris (sightings of man-made debris)	4		1	5	4	3	2	3
Meteorology (air temperature, wind speed, wind direction, humidity, etc.)	5		5		3		3	
Coral size structure								5
Coral growth							4	
Water chemistry (e.g., DIC, TA, DO,pH, dissolved inorganic nutrients, chlorophyll-*a*, salinity, fluorescence)						5		

When we asked managers to rank existing biophysical and socio-economic data sets collected by long-term monitoring programs in terms of their usefulness in making management decisions, more than half of them gave high or very high rankings to biophysical data, while a much smaller number of managers identified the socio-economic data as being most useful. Nearly half of the people surveyed chose "little" and "moderately" useful in ranking existing types of socio-economic data. More than half of the managers gave high and very high ranking in relation to the extent to which sociocultural and economic data might be improved to better inform management decisions. The social scientist respondents gave a higher rating in regard to the management usefulness of existing types of sociocultural and economic data collected by long-term monitoring programs in general. However, more than half of them gave ratings of "little" and "moderate" usefulness for existing data in the monitoring programs with which they are themselves involved. This differs from the results with the biophysical scientists, among whom half considered the usefulness to be high or very high.

Suggested additional indicators and data types useful for management

Socio-economic data

Top mentioned additional data types considered most important but are not yet collected were "Community resilience to climate impacts and natural disasters," followed by "Cultural heritage and connection to place" and "Connection and sense of place and identity" for multiple groups (Table 10). For the specific groups, access to information on coastal and marine resources was rated high for the respondents working in the Pacific Island Region, managers and biophysical scientists. The biophysical scientist group also rated willingness to pay for coral reef protection/conservation high.

Table 10. Most important types of sociocultural and economic data that are not yet collected.

Most important type of socio-cultural and economic data that are not yet collected among 10 data types	All		NCRMP	Manager (all)	Manager (federal)	Manager (Jurisdictional)	Social scientist	Bio-physical scientist
Community resilience to climate impacts and natural disasters	2		1	1	1	1	1	1
Cultural heritage and connection to place	1		2			2	2	
Connection and sense of place and identity	3		2	3	3	2	3	
Access to information on coastal and marine resources				2	2	4		3
Willingness to pay for coral reef protection/conservation								2

Biophysical data

All analyzed groupings of respondents agreed on the three most important types of biophysical data that are not currently being collected (Table 11) land-based sources of pollution, recruitment or connectivity patterns of organisms, and mortality rates of organisms. However, when breaking down managers into federal and jurisdictional, federal managers also identified a need for regulating ecosystem services and reproduction of organisms. Jurisdictional managers did not identify data on land-based sources of pollution as a top need.

Given the conventional methods for testing in situ levels of land-based sources of pollution are dependent on water samples collected during Pacific RAMP sampling, those data provide a snapshot of a single point in time and are not likely to capture the temporal variability in pollutants (which may further depend on rainfall patterns, levels of development, land use, etc.) and the impacts on the near-shore habitats. Recruitment is considered very important because it helps identify areas with weak recruitment that are less likely to recover from disturbance or stressors. Currently, proxy indicators are being used, including coral estimates of juvenile density and size classes of fish. To explore connectivity between populations would entail using techniques such as biophysical modeling or genetic approaches. Suggestion is to have a combined sampling design with not only stratified random sampling but also fixed sites so that we can monitor rates, like recruitment rate and mortality rate. (B. Huntington, pers. comm., October 2, 2019).

Table 11. Most important types of biophysical data that are not yet collected.

Most important type of biophysical data that *are not yet collected among 8 data types*	All		NCRMP	Manager	Manager (federal)	Manager (jurisdictional)	Social scientist	Bio-physical scientist
Land-based sources of pollution, water quality, sedimentation, nutrient inputs	1		1	1	1		1	2
Recruitment or connectivity of organisms	2		2	2		1	2	1
Mortality rates of organisms	3		3	3		2	3	3
Reproduction or fecundity of organisms					2	3		
Regulating ecosystem services (e.g., carbon sequestration and storage, erosion prevention, moderation of extreme events)					2			

Missing useful data in better managing resources and addressing human well-being

When managers were asked to report any missing data that could be useful in the simultaneous management of resources and human well-being, 20 out of 31 managers answered this open-ended question. The most mentioned answer for social data was community well-being. Several respondents were specifically interested in identifying both the sources and destination markets of fishery catches. More biophysical data on effects of marine protected areas (MPAs) and restoration on fish, and fish function (e.g., herbivory), habitat use, and connectivity were listed as needed by multiple respondents.

Collaboration among managers, natural scientists and social scientists

Most managers felt that it is important for the monitoring teams to work across social and natural scientific disciplines and to collaborate with one another. They also expressed high interest in working with monitoring teams to make sure that the data produced address their management needs. Roughly half of the managers participating in the survey reported that they had already worked at high and very high levels directly with people who design or implement long-term biophysical monitoring, while the majority reported that they were doing so with people engaged in socio-economic monitoring. This is confirmed by the majority of social and biophysical scientists who perceived their work to be collaborative with resource managers. While nearly all managers thought that it was important for monitoring teams to work across social and natural scientific disciplines and to collaborate with one another, slightly more than half of them also thought that the difficulty is high and very high in combining biophysical and socio-economic data in ways that are informative for management decisions.

Among social scientist respondents, half of them rated collaborative work with natural scientists as being at moderate levels, while one out of four said that collaboration is high or very high. The rating is different in the perceived collaboration among the natural scientists, with about half of them indicated that they had little or no collaboration with social scientists.

Concerns about the level of community engagement are highly integrated into managers’ work, moderately so into the work of social scientists, and relatively much lower into the work of biophysical scientists.

Discussion

Usefulness of current biophysical and socio-economic data for management for the Pacific Island region

The fisheries-related socio-economic and biophysical data types that were ranked high for their importance are quite complementary to one other. Their levels of awareness ratings were also high. While there was a wide range of existing socio-economic data that was considered important, the findings show that managers do not rank sociocultural and economic data very highly for usefulness and rank its utility as being much lower than biophysical data. Additionally, the extent to which sociocultural and economic data can be improved is also regarded as very high. While there is not much information from this study as to why socio-economic data are not rated highly for their usefulness, a couple discussion points may be relevant. First, many agencies mandate reporting and recommendations that are based on biophysical data (e.g. stock assessment), yet it is rare to find explicit mandates regarding socio-economic data. This may have the effect of causing perceptions about the usefulness of the socio-economic data to be comparatively lower. And second, currently existing socio-economic data types may not adequately address recent and rapidly forming demands for data on different human well-being domains and on evidence of linkages among natural resource management, conservation, and societal well-being across all regions and biomes (McKinnon et al 2017, Cheng et al., In review). This same demand is happening in the Pacific Island Region, and in this study it was confirmed by respondents whose work is related to managing resources when they identified community well-being as the single highest missing data type that is useful for managing resources and human well-being. It is also confirmed by the regarded importance of several existing social data types related to resource dependency for provisioning ecosystem services, reliance and participation in fisheries of different types (e.g. commercial, recreational, subsistence, cultural, etc.), and types and proportions of community livelihoods. One implication of this is that social indicators need to be expanded to track community well-being data needs, including social resilience and such intangible aspects of well-being as culture and safety.

Recommendations to strengthen integrated monitoring and socio-economic monitoring in the Pacific Island Region

Results of the existing data and data gaps point to three main areas that could be focused on in conducting integrated monitoring in the Pacific Island Region: 1) reviewing and understanding the potential uses and limitations of existing data types; 2) establishing better linkages between biophysical and socio-economic data sets, possibly through specific research agendas or sites; and 3) addressing the identified socio-economic and cultural data needs. We kept these areas in mind as we developed the recommendations to strengthen integrated monitoring and to outline activities towards generating a regional socio-economic monitoring plan. While the recommendations are primarily written for ESD, they are based on an assumption that integrated monitoring is supported by the PIFSC leadership (mentioned as critical in focus groups), as well as by collaborative partners from related research and resource governing institutions, as a means to sustaining and improving the resilience of social-ecological systems. They are also based on the assumption that the knowledge generated by integrated monitoring will help strengthen linkages between ecosystems (including people) and management practices.

The recommendations will focus on four following aspects:

- Long-term research strategies, IM projects and objectives
- Standardized and place-based types of socio-economic data and data-collecting instruments
- Socio-economic data gaps and additional data collecting instruments
- Collaboration

In each, we recommend what to achieve (objective), who to lead, how to act with examples of activities and reasons for doing so. While it is preferred that the first and second aspects precede the others, it is possible for the different aspects to be addressed in different orders. That is, these recommendations are not associated with any particular time line since each of these aspects should be discussed and scheduled as appropriate.

Long-term research strategies, IM projects, and objectives

An important purpose of integrated monitoring is to yield better understanding of social-ecological systems (SES) and of linkages among their sub-systems. However, although the SES framework increasingly considers equal importance between social and ecological components (Berkes and Folke 1998, Berkes et al. 2016), our study indicates it remains relatively uncommon for those working in the field of conservation to strategically link socio-economic monitoring with biophysical monitoring. We thus recommend as an important first step a "top-down," leadership confirmation of support for integrated monitoring by setting specific long-term research strategies and by committing to provide the needed resources to implement these strategies. It is crucial that these strategies clearly foster stronger linkages between conventional biophysical ecosystem research and social scientific research in order to provide information that is of use in ecosystem-based management. The potentials for socio-economic monitoring to significantly improve several initiatives at the PIFSC should be understood and must be reflected in the strategies by taking carefully into account the mandates and needs of the data users. Otherwise, the social dimension of the integrated monitoring will not receive the long-term commitment and support needed to secure substantial levels of contribution, even when useful datasets or indicators are identified.

LONG-TERM RESEARCH STRATEGIES, IM PROJECTS AND OBJECTIVES	
What	Develop a long-term research strategy that clearly defines what integrated monitoring (IM) means, for what purpose, and what scale(s) would the application be. Decide how to balance the social and ecological components on IM to support ecosystem approach to management with clear role and contribution of social sciences. Identify and develop objectives/agenda for a selected pilot (learning) long-term IM project(s) for which the lessons can be applied in other research projects across jurisdictions.
Who to lead	PIFSC leadership with leads of other relevant programs and partners.
How	Designated ESD facilitating coordinator organizing the meeting(s) with leadership representatives, monitoring team leads and collaborative partners, and summarizing the agreed purposes, strategies, and research objectives for selected project(s).
Why	Clear long-term strategies, and objectives are needed to guide different teams of scientists on activities and implementation in selected project. Differences of scale of different data sets need to be considered and solutions agreed on. The value and contribution of sociocultural and economic information need to be explicit to gain support, commitment, and resources.

Once the strategies are in place, we recommend that a specific pilot project (or projects) be selected that is consistent with management scope and scale, under which integrated monitoring can be designed, implemented, and learned from. This will enable scaling up lessons learned and applying them in other islands/jurisdictions/regions. These projects can be a part of or build on the ecosystem approach to fisheries management (EAFM) initiative, the Integrated Ecosystem assessment, Atlantis modeling, and other place-based initiatives. These projects can also be new initiatives to address the data gaps identified in this project, namely “community resilience to climate impacts and natural disasters” and “land-based sources of water quality, sedimentation, and nutrient inputs.” All of these proposed research projects require both biophysical and socio-economic data and their integration in realizing more holistic management practices. These projects are in line with the 5-year top research priorities (2014-2019) for social science of the Western Pacific Regional Fishery Management Council, including “Pursue integrated social, ecological, and biophysical research efforts to inform ecosystem-based fisheries management” and “Understand impacts of climate change (or other large-scale changes that result in an uncertain future) on fisheries and fishing communities for adaptive management,” under which robust indictors for community resilience is a potential activity.

For the selected projects, it is critical to identify the scope and scale of objectives and specific research questions in order to inform the methods employed to collect the necessary biophysical and socio-economic data at spatial and temporal scales that enable integration. Existing data sets that are informative should be considered in order to leverage data already collected, and to incorporate or maintain time series. The extent of overlap in sampling between biophysical and socio-economic data will ultimately be limited by available resources, which may need to be distributed between the two components in an uneven manner in instances of disparate costs associated with collecting the necessary data. Thus, prioritizing indicators based on the degree to which they are informative and complementary when incorporated into an SES framework will remain an important and reiterative process in integrated monitoring.

Standardized and place-based types of socio-economic and data-collecting instruments

This recommendation specifically addresses socio-economic data since biophysical data currently collected by the Pacific RAMP uses collection methods and instruments that are already relatively standardized. Both standardized and place-based (or non-standardized) data types have their distinct merits and serve different purposes. When possible, these data types should be bridged and used for more holistic understandings of ecosystems. The objective is to consider data of different types and scales might be standardized across a region so that data sets from different sites can be usefully compared and so that data and lessons learned can be scaled up to and applied at regional levels. Additionally, we recommend maintaining place-based data in ways that are useful for site management.

At present the collected data can be classified at the following scales:

1. Regional scale (data that are important for all sites)
2. Island scale (data that are important for some sites)
3. Local scale (data that are important uniquely for particular sites, but not relevant for others

STANDARDIZED AND INDIVIDUALIZED EXISTING DATA	
What	Standardize data with the same purposes across region Strengthen place-based data for site management
Who to lead	ESD Socio-economic and human dimension team leads
How	Designated ESD staff organizing workshops with people who design and implement instruments to decide on what and how to standardize or tailor to site-based management
Why	Uniform data allow for comparison across site and scaling up to the regional level Place-based data support local management

Data of type 1 feature shared purposes and variables across different target groups and fisheries types, can be compared across sites and fisheries types, and/or can be scaled up to the regional-level data. Data of type 2 will have limited application at the regional scale but are relevant for sub-groups, and data of type 3 is collected at the local scale specifically to address site or special interest management needs.

For data type 1, if there is a need to standardize data sets in order to allow for comparability across sites and regional scaling up, we would suggest hosting a workshop with people who design and implement these tools in all jurisdictions and sectors. It is important for everyone involved in developing different instruments to be represented since most people are not aware of either what other people's data entails or the purposes for which it is collected. This would provide an opportunity for them to come to together to review each of the data collecting instruments, understand their differences and similarities, and, if needed, revise them in a way that will streamline how data for the same variables are collected (see differences of data collecting tools for similar variable in Figure 1). This will help increase comparability across data sets.

Hawaii Cost-Earnings Survey of Charter Boat Fishing

Q62 How would you describe yourself as a fisherman? *(please check all that apply)*

__**Purely Recreational** (I fish only for sport or pleasure)

__**Recreational Expense** (I fish primarily for sport or pleasure, but I also sell a few fish to recover trip expenses)

__**Subsistence** (I fish primarily to catch fish to feed myself/my family)

__**Cultural** (I enjoy fishing, but I am even more concerned about keeping traditional practices alive, such as using traditional fishing gear and sharing fish with the community)

__**Part-time Commercial** (Fishing pays some of my bills, but I still have to work at another job)

__**Full-time Commercial** (Fishing brings in most or all of the money I make in a year)

__**Other** (please specify):

Mariana Cost-Earnings Survey of Boat-Based Fishing

11. What is your primary motivation for fishing? (if multiple applies to you, put 1 as primary and 2 as secondary)

- ☐ **Purely Recreational** (I fish only for sport or pleasure)
- ☐ **Recreational Expense** (I fish primarily for sport or pleasure, but I also sell a few fish to cover trip expenses)
- ☐ **Subsistence** (I fish primarily to catch fish to feed myself/my family/my community)
- ☐ **Cultural** (I enjoy fishing, but I am even more concerned about keeping traditional practices alive, such as using traditional fishing gear)
- ☐ **Part-time Commercial** (Fishing pays some of my bills, but I still have to work at another job)
- ☐ **Full-time Commercial** (Fishing brings in most or all of the money I make in a year)
- ☐ **Other,** please specify:____

Hawaii Recreational Fishing Attitudes and Preference Survey (boat and shore distinction)

3. **Please indicate which of the following primarily motivates you to go fishing.** *(choose one)*

- ☐ Purely recreational (only for sport or pleasure)
- ☐ Subsistence (primarily to catch fish to feed myself / my family)
- ☐ Cultural (I enjoy fishing, but I am even more concerned about keeping traditional practices alive, such as using traditional methods and sharing fish with the community)
- ☐ Expense (primarily recreational or subsistence but I also sell some catch to recover trip expenses)
- ☐ I consider myself a commercial fisherman (more than half of my income comes from fishing)

Figure 1. Example of how data for the same variable being collected in slightly different ways on 3 different instruments.

Several materials from this project can be used to support such workshops. These include: 1) the summary list of the existing data types collected by PIFSC (Appendix C), 2) data types that have been rated important in Section 6 (Key Findings).The product of the process should be standardized instruments that can be used for all sites in the region and their future modification should be done at the regional level. There are currently more than 20 economic surveys that are meant to be long-term. Many of these tools can be grouped in terms of the types of data collected through them, including, for example, cost earning surveys, recreational fishing surveys, and boat-based surveys. Most of the data collecting instruments for a particular type of survey are modified based on learning from previous surveys or on needs to acquire information without comparison or attempts to standardize across similar instruments for other fisheries types and geographies.

The challenge with standardization is that jurisdictions are associated with a wide range of socio-economic conditions; and fisheries resources and habitats are subject to a wide range of stressors, governance, and use. The lack of availability for certain variables across all jurisdictions and inconsistencies in existing secondary data throughout the US affiliated islands could be used as criteria of what is not appropriate for inclusion in the Data 1 group. For example, in 2017/2018, during the social vulnerability indicator project, the US mainland indices and variables were used to guide the secondary data review among HI, Am Samoa, Guam and CNMI. It was found that many of the variables were only applicable in HI (e.g. median rent, household income < US$ 10,000, % unemployed, % female single headed households; Kleiber et al. 2018) Data for commercial fisheries reliance and engagement are only available in Hawaii and not in other jurisdictions. Therefore, the proposed workshop would enable the various jurisdictions to reach agreement on which indicators are most relevant. In Micronesia, specific workshops have already been organized that brought all of the Micronesia Challenge jurisdictions together, first, to identify indicators and variables that all jurisdictions could agree are relevant for all sites, and secondly, to commit to monitoring long-term. Common indicators identified include the availability of locally sourced marine and terrestrial foods, and indicators related to resource governance (e.g., level of participation in management planning and decision, and change in violations and illegal activities related to fishing, harvesting and use of natural resources) (Nevitt and Wongbusarakum 2013; Wongbusarakum 2018)

A workshop on type 2 data sets which are specifically shared by particular sites or islands/jurisdictions should maintain the same process as above, but should be restricted to relevant participants.

In relation to type 3 data which is specifically relevant to particular sites, islands/jurisdictions, or particular types of fisheries/target groups, workshop participants should be drawn from specific places, sectors or targets. Among the indicators and variables that can be added onto the standardized instruments and marked clearly for their special relevance are geographies, fisheries types, or target samples. This step ensures that the development of place- or sector/target-based socio-economic indicators builds on existing shared standard data types. At the same time, it ensures that the regional socio-economic monitoring plan is responsive to the needs of specific islands and sites, that the local values and needs are taken into consideration, and that the data can be used to informed specific sector or site management decisions. SEM-Pasifika (Wongbusarakum and Pomeroy 2008) offers community-based socio-economic monitoring guidelines that engage communities and local stakeholders to develop indicators and data collecting instruments for site-based monitoring.

Based on the analyses in this study, the sources of the majority of the data are CRCP, NCRMP, PIFSC-PIRO, each with a different emphasis in data collection objectives, targets and scales (Table 12). The NCRMP's coral reef-related data type provide insights into the most critical issues for fisheries and other ecosystem services, including recreation and shoreline protection, and provide information on the relationship between humans and the reef systems over time within specific island settings in ways allowing for regional comparison. NCRMP also generates data that are important for climate resilience strategies, which other data sources do not cover, and which can be used to inform and complement their own data collection. The PIFSC fisheries socio-economic data are focused and critical for fisheries industry and management, while the SEM-Pasifika data are community-based and, unlike the others, address specific needs at the site management level. Given that each of these data sources have been established and big changes are most likely not possible, we would like to propose capitalizing on their differences, using the data in complementary fashions and as resources in the deepening of coordination and collaboration aimed at more holistically informed applications of the ecosystem approach, both through addressing multiple scales and utilizing multiple data types. The differences can also be considered advantageous. Currently, most NCMRP biophysical and socio-economic data are at the island/jurisdictional scale, while the PIRO-supported SEM-Pasifika data focus primarily on community-level scale. PIFSC covers various scales from particular focus/sector (e.g. recreational, commercial, small boat fishing, bottom fish), site (West HI), islands (e.g. cost earning), up to regional (e.g. long-line) data. Therefore, each of the data types can be used for different purposes and help complement one another. As there can be a wide range of social variables for the same indicators in different geographies, these may need to be interpreted based on local standards and norms. Common indicators such as incomes, and access to resources, fisheries skills, and ownership of boats, home, tools and levels of infrastructure can vary hugely from island to island, making it difficult to interpret and use the data generated in comparisons with data generated in other US regions. The issue of various scales must also be addressed in the workshops if the existing data is inadequate and does not provide the quality needed to support sound management.

Table 12. Comparison of main socio-economic data sources.

	CRCP-NCRMP	PIFSC	PIMPAC-PIRO
Focal area/objectives	Coral reef management	Fisheries management	Community-based resource management and community well-being
Target samples	Households	Special interest groups (long-line fishers, bottom fishers, small boat fishers, and resource users of particular sites)	Households
Scale	Island and regional scales	Individual site, island, Census County Division, regional scales	Local communities
Geographical focus	Hawaii, American Samoa, Guam, CNMI	Hawaii, American Samoa, Guam, CNMI	American Samoa, Guam, CNMI, RMI, FSM, Palau, potentially HI through collaboration with DAR
Data collecting Method	Survey and secondary data	Survey and secondary data	Survey, key informant interviewing, and focus groups
Data collecting approach	"Core" module of standardized questions across jurisdictions for comparability, and a jurisdictionally-specific questions to address more localized management questions	Similar questions for same purposes. Individual instruments modified separately based on experiences. Temporal comparison of the same survey	Assessment objectives and questions tailored to local management plans and local context and informational needs. SEM-Pasifika framework and steps
Level of consistency in data collecting instruments across sites	Very high	High	Medium to low
Frequency of monitoring (year started)	1st based assessment (Am Samoa 2014, Hawaii 2015, Guam and CNMI 2016)	Some on-going and as old as 1985 (cost-earning boat-based fisheries), others 1st assessment	Most sites have 1st baseline assessment (varies in the past 10 years depending on sites)

Socio-economic data gaps and additional data collecting instruments

In addition to providing a summary of existing data types and their importance (Appendix C), this study also identified data not currently available that managers would like to have collected in the region (Appendix E). To ground truth the results, we recommend the PIFSC organizes and holds a series of consultation meetings with stakeholders from each of the different islands/jurisdictions who are using the data to manage fisheries, coastal, and marine resources. The meetings should be used to examine, first, if and how the existing data could be improved fill the data gaps (including the needed scale levels), and, secondly, to validate the needed missing data.

This is a process similar to those of our partners. The National Marine Fisheries Service (NMFS) used a stakeholder engagement process when they addressed a gap in existing sustainable development indices in the U.S. Southeast and Northeast communities to evaluate the derived social vulnerability and fishing-dependent indices (Colburn and Jepson 2012; Colburn et al. 2016). The DAR 30 × 30 held a series of workshops in early 2019 to consult with external experts, review existing tools, and gather input from different stakeholder groups to decide on social indicators. The NCRMP socio-economic monitoring revision in 2019 also had a process of stakeholder engagement to receive input from the different partners and the jurisdictions where their surveys are conducted. The SEM-Pasifika assessments have a mandatory step to include stakeholder consultation in its development of the objectives and input on the data collecting instruments and the field data collection. It also has a mandatory step to share the key results back to the communities from which data are collected from and to use discussion findings in management planning and adaptive management. We want to recommend that differences in scales and stakeholder groups are also taken into consideration, including special interest groups/sectors, communities, and islands. These are all appropriate ways to make sure that the indicators selected are responding to the additional needs of specific management areas.

This step should be tackled by a working group and co-led by PIFSC ESD team lead, the NCRMP coordinator, the SEM-Pasifika regional coordinator, and the DAR 30 × 30 coordinator. It could include key representatives from each of the jurisdictions, as well as representatives from the funders of data collection. Once the data gaps are confirmed, the task would be to generate a big picture view of who is most appropriate to engage in filling the data gaps identified in both this study and in the consultative meetings. Balancing NCRMP household survey results with PIFSC near-shore and coral reef fisher surveys supports effective management by understanding fishing communities and elucidating the role of fisheries in these communities.

SOCIO-ECONOMIC DATA GAPS AND DATA COLLECTING INSTRUMENTS	
What	To ground truth data needs of the region, review and assess quality of existing data gaps and confirm additional data types and indicators To address additional data gaps via improving existing data collection or start additional collection
Who to lead	Designated ESD scientists with NCRMP coordinator, SEM-Pasifika regional coordinator/regional advisor, and DAR 30 × 30 coordinator
How	Designated ESD staff organizing consultative workshops with stakeholders and subject area experts Working group(s) to develop data collecting instruments
Why	Data needs to support ecosystem approach management should be filled

The top two socio-economic gaps that were identified to be filled were (1) community resilience to climate impacts and natural disasters and (2) cultural heritage and connection to place. For the NOAA context, Ecosystem-Based Fisheries Management Policy identifies maintaining community resilience and evaluating community well-being as essential parts of the resilient ecosystem guiding principles of the EBFM Roadmap (NMFSI 01-120-01). For the broader context, this identified gap fits the current situation in most coastal and island sites where climate events are becoming increasingly noticeable and where their impacts have become more severe and frequent over the past decade. The area of cultural heritage can also be used to link with connection to place, sense of place and sense of identity, all of which were mentioned as important, but currently missing, data that should be collected. As stated earlier, community wellbeing was the most frequently mentioned answer by people involved in management as a missing data type that would be useful for better and simultaneously managing resources and addressing human well-being. The identified importance of community resilience and cultural heritage is in line with the increased recognition of human well-being, particularly those dimensions of well-being that are more difficult to capture as they are fully or partly intangible (Dacks et al. 2019). Both areas are also identified as gaps of research in cultural ecosystem services and human well-being domains. Additional gaps that are rated as most important, but are not yet collected, also include access to information on coastal and marine resources and willingness to pay for coral reef protection and conservation. The additional data gaps identified in this study for both socio-economic and biophysical data sets are experienced at the local scale and appropriate indicators for one local site might not be appropriate for the others.

Community resilience

The socio-economic monitoring data gap regarding community resilience to climate impacts and natural disasters provides an excellent opportunity for integrated monitoring efforts in which data from multiple disciplines are needed to better understand and track its change (Figure 2). A project on social-ecological resilience could indeed serve as a research priority and pilot an integrated monitoring. Resilience recognizes social systems and ecological (biophysical) systems as “coupled, interdependent and co-evolving” (Berkes 2015, p. 51). Community resilience can be defined as the ability of a community to cope with and absorb shocks and disturbances, to resist shifts, and to respond and adapt in ways that the community can maintain their essential functions, identity, and social structure (adapted from Berkes and Folker 1998, and Sterling et al. 2017). The presence of such abilities in coastal communities in the Pacific is highly dependent on the biophysical conditions of the coastal and marine environments as well as ocean and climate conditions. The results of this project confirm that ongoing biophysical monitoring has confirmed changes in ocean and climate conditions and in factors that influence habitat conditions and species. These include fish abundance and size, coral conditions, water temperature, large-scale climate forcing (including El Niño/La Niña, Pacific Decadal Oscillation), water chemistry, and others. Data on these factors help managers detect conditions and changes in habitats and species that the community is reliant on for all ecosystem services, which in turn enables better understanding of communities' vulnerability to potential disturbances to their socio-economic conditions. At the same time, it makes evident to managers and communities the types of adaptation that will be needed to lessen their levels of vulnerability and increase their resilience.

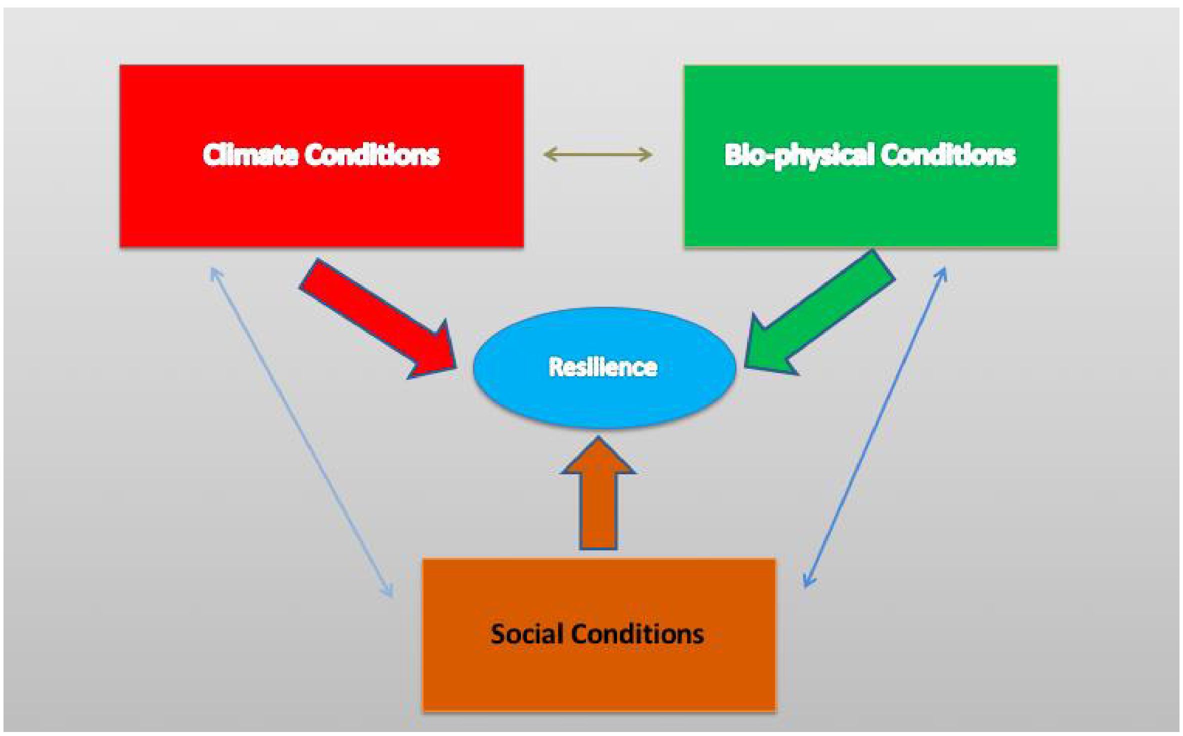

Figure 2. Community resilience depending on climate, biophysical and social conditions. (Source: Wongbusarakum 2019)

Conventional climate vulnerability assessments have focused mainly on biological and physical aspects. Therefore, it is understandable that the social aspect is missing and the gap is identified. The ability of people to cope with, respond to, and adjust to impacted physical environments and ecosystems play a fundamental role for a holistic understanding of vulnerability to climate change. To integrate the biophysical data that have been collected in an on-going manner with the additional socio-economic data, an interdisciplinary team comprising members who possess relevant biophysical and social scientific expertise, must be established. Such a team would be charged with working together, not only to design and identify the indicators and how they can complement one another in a larger picture of resilience, but also to analyze and bring the different existing data sets together. For example, to understand exposure of climate events and impacts, ocean and climate change data from biophysical monitoring can be used to help predict the magnitude and areas of impacts. Water temperature could predict the level of mass coral bleaching and impacts on coral reefs and reef inhabitants while sea level rise could contribute to better understanding of coast erosion. Socio-economic data could provide evidence of the types and levels of impacts on different fisheries, on the activities of relevant households and communities, and on infrastructure. It can also help identify groups that are most vulnerable to certain climate events and impacts. A more holistic understanding of this kind could help in prioritizing management strategies and adaptation activities to mitigate climate impacts.

In building community resilience, the word "community" will need to be more precisely defined. Is it fisheries communities, or a coastal community with some groups being dependent on fisheries? Or, if it is fisheries communities, is it a particular sector (recreational, commercial, small boats, long-line, etc.)? The kinds of resilience that are most important in various sectors may differ in reflection of particular kinds of climate impacts and disturbances. General resilience of the coastal and island community encompasses coping with multiple stressors (Folke et al. 2005). Efforts to apply integrated monitoring to better understand general resilience may be more beneficial in the long term, since a focus on individual sectors runs the risk of failing to address impacts from shocks to other sectors; adaptation strategies may unintentionally cause the SES as a whole to lose resilience in critical ways (Folke et al. 2003). To develop a complete understanding of the level of vulnerability and the resilience of a community, it is important that social exposure to climate impacts, community sensitivity to the impacts, and the adaptive capacity of the community are both assessed and tracked over time. The following table provides examples of existing biophysical data and added social indicators for each of these categories for general resilience (Table 13). We used the social adaptive capacity frameworks by from Cinner et al. (2018) and Whitney et al. (2017), which focus on coastal and fishing communities, to help guide the selection of indicator categories, and have complemented them by drawing on other relevant literature.

Table 13. Indicators for climate resilience and vulnerability (Source: Wongbusarakum 2019).

Indicator categories *(literature)*	**Example of variables**	**How information might be used**
EXPOSURE **Purpose:** Understand types and levels of perceived impacts of different climate events on coastal households and communities Prioritize adaptation efforts to address the groups of people, activities and infrastructure that are most threatened by climate impacts and events		
Biophysical data types: All related to climate events and impacts on biophysical conditions, including meteorology, oceanic conditions, large-scale climate forcing, physical oceanography, etc.		
Perceived climate change impacts *(Wongbusarakum & Loper 2011; McLeod et al. 2016)*	Perceived climate impacts on communities, resources, livelihood types and activities, community infrastructure	Understand specific impacts and their levels on different components
Vulnerable groups to climate impacts and threats *(Wongbusarakum and Loper 2011; Jepson & Colburn 2013)*	Proportion of vulnerable demographic groups, including socially or economically marginalized groups Proportion of vulnerable groups in high risk/impact areas (e.g. household living or conducting livelihoods in the areas)	Identify who may need the most attention/assistance in climate change adaptation
SENSITIVITY **Purpose:** Understand levels of negative effects on social-ecological systems by changes in climate events and impacts		
Biophysical data types: All related to conditions of the physical environment, habitats and species that the society are dependent on, including coral condition, fish abundance and size structure, key species, biodiversity, etc.		
Dependence on coastal and marine resources *(Wongbusarakum and Loper 2011; Jepson and Colburn 2013)*	Types and levels of ecosystem services Proportion of households with livelihoods (income and subsistence) dependent on impacted/threatened resources Types of industries dependent on impacted/threatened resources Proportion of those with cultural connection, sense of place, or sense of identity	Identify livelihoods, economic, and security sensitivity to climate threats Prepare for impacts on changed ecosystem services and how human well-being may be affected (e.g. livelihood alternatives)
Perceived resource conditions, habitat health, and ecological health *(Wongbusarakum & Pomeroy 2008)*	Perceived conditions of key resources coastal households depend on	Provide information on natural resource condition and ability to absorb impacts When considered with exposure, understand ecological vulnerability

Indicator categories *(literature)*	**Example of variables**	**How information might be used**
SOCIAL ADAPTIVE CAPACITY Understand potential or capability of a society to respond and adjust to impacts of changing climate		
Diversity and flexibility *(Wongbusarakum and Loper 2011; Allison & Ellis 2001; Whitney et al. 2017; Kalikoski 2010; Cinner 2012; Cinner 2013; Cinner et al. 2018; Jones and d'Errico 2019*	Livelihood/occupational diversity/ multiplicity (e.g. current livelihood structures, income diversity of household, economic opportunities) Alternative and supplementary livelihoods Occupational mobility (e.g. changes of employment/livelihoods within last 5 years; perceived availability of and willingness to take on or move to new occupations or alternative livelihoods) Diversity of livelihood methods/gears/technology/locations Place attachment Migration patterns Willingness to change Flexibility to change strategies	Identify current and future possibilities and needed resources (especially for livelihoods) for adaptation to climate change or other exogenous shocks
Learning and knowledge *(Wongbusarakum and Loper 2011; Whitney et al. 2017; Cinner 2018; McLeod et al. 2016; Kalikoski 2010; Cinner 2012; Gomez-Baggethun, et al. 2012; Berkes, et al. 2016; Jones and d'Errico 2019*	Knowledge and perception of climate hazards Access to, and use of, climate-related knowledge Information sources Knowledge, practices, tactics and mechanisms used to anticipate, respond or adapt to climate impacts, and effectiveness of these elements Perceived solutions Recognition of causality and human agency Capacity to generate, absorb, and process new information about climate change, adaptation options, and ways to live with and manage uncertainty Ability to recognize and respond to change Traditional or local and current practices among community members and fishers to respond to climate impacts and other stressors. Intergenerational learning capacity Innovation	Make use of existing knowledge (traditional, local, scientific) and means of knowledge transmission Identify current and possible uses of climate information. Tailor types of outreach and education program to address climate hazards Fill gaps in informational content, communication tools, learning approaches, and networks

Indicator categories *(literature)*	**Example of variables**	**How information might be used**
Leadership, governance and institutions *(Wongbusarakum and Loper 2011; Whitney et al. 2017; Wongbusarakum & Pomeroy 2008; McLeod et al. 2016; Jones and d'Errico 2019*	Presence of and access to institutions that support risk management and adaptation Effectiveness of community leaders in addressing climate hazards and adaptation planning Effectiveness of coastal management in achieving environmental and social goals (including policies, tools, rules and regulations, enforcement) Levels of participation and quality of decision-making processes Accountability of managers and governance bodies	Understand strengths, weaknesses, opportunities, effectiveness and gaps of governance, leadership and institutions in natural resources (esp. fisheries) and climate adaptation Utilize local support from community leaders in adaptation work Understand level of stakeholder participation in management and decision-making
Availability and access to resources/ assets/capitals *(Whitney et al. 2017; Kalikoski 2010; Cinner 2013; Cinner 2018; Pollnac & Crawford 2000; IPCC 2007; Himes-Cornell and Kasperski 2015; Wongbusarakum and Loper 2011*	Presence of material assets/possessions (e.g. general household material assets and fishery specific, e.g., boats, gear) Human capital (knowledge, skill) Financial capital (money, sources of credits) Natural capital Social capital Levels of trust Social cohesion or Ability to act collectively Social networks Gender and race relations Physical capital (infrastructure, housing, tools and technology, energy and water supplies, markets)	Understand types and levels, and gaps of resources/assets/ capitals needed for adaptation and levels of access to them. Indicate overall level of community adaptation (higher equity = higher adaptive capacity). Identify potential networks to serve as conduit for climate-related information and assistance. Collaborate with existing networks that might support adaptation and planning.
Determining agency *(Cinner 2018; Brooks, Adger & Kelly 2005; Kalikoski 2010; Tompkins et al. 2005; Wongbusarakum & Loper 2011*	Agency to determine whether to change or not to change Capacity to anticipate change and develop response strategies. Response of fishers to a hypothetical 50% decline in catches due to climate-related stress Capacity to plan, learn, change and reorganize in response to climate hazards (similar to one in learning and knowledge) Ability of community to (self) (re)organize	Better understand (and as a reminder) how (social and cultural) local values drive decisions on changes and take into consideration and incorporate local knowledge and practices in planning and management. Understand the degree to which community is able and willing to reorganize and restructure in the face of impacts. Determine level of self-reliance within a community. Identify areas that need to be strengthened for adaptation work, including empowering people and removing barriers.

Cultural heritage and connection to place

The other area that was identified as one of the most important types of sociocultural data that is not yet collected was cultural heritage and connection to place. Another identified gap, “sense of place and identity,” can also be categorized under this area. These types of data all contribute to better understanding of community well-being and cultural ecosystem services (CES) (The Millennium Ecosystem Assessment 2005). In the focus groups conducted for this project, representatives from the communities emphasized the importance of considering cultural resources as no less critical that natural resources, and of acknowledging that local knowledge can be as useful as scientific knowledge. Connection to place has a “strong bearing on cultural identity, rootedness and belonging, sense of responsibility and stewardship, social engagement, and natural resource management. Connectedness to place encompasses historical, physical, emotional, and/or spiritual bonds between people and their local environment” (Dacks et al. 2019).

In the Pacific Islands, where even the most recently established communities have been in place for centuries or millennia, connectedness to place is often informed and driven by knowledge of genealogy, historical events, and multi-generational experiences of survival and thriving in place (Morishige et al. 2018, Dacks et al. 2019). These make understanding of the history and historical ecology of the place critical for any type of monitoring design. As community well-being is culturally-mediated and context-specific, we propose that biocultural approaches are applied in the monitoring process to define “cultural heritage” and “connection to place”, and to identify indicators that are locally relevant, starting with and building upon local cultural perspectives to fill existing gaps in indicators as required to measure locally-defined definitions of success (Sterling et al. 2017). Several frameworks have been developed to address how to collect data for cultural heritage and connection to place in Hawaii (Table 14). These include Gould et al. (2014), Pascua et al. (2017), Morishige et al. 2018, Dacks et al. (2019), and Leong et al. (2019).

Table 14. Possible indicators for cultural heritage, connection to place, sense of place and sense of identity from the West Hawaii Project.

Domains	Attributes	Potential Indicators	Sources
Cultural heritage and connection to place	Multi-generational interactions/connections with natural resources	Level of knowledge being transmitted Level of participation by multiple generations in traditional practices Level of religious or spiritual practices and connections to entities (living and non-living)	Gould 2014, Dacks et al. 2019, Leong et al. 2019
	Cultural and social norms	Level of knowledge and practice of social and cultural norms related to place-based practices Level of connection to ancestors Level of intergenerational connections including practices of respect.	Dacks et al. 2019
	Important historical and cultural sites and storied landscape	Their existence Level of awareness Level of visitation, gathering, harvesting Knowledge of traditional place names species names, or landscape/environmental terms in local language (e.g., rain names, wind names); transmission of existing or creation of new cultural proverbs to describe these observations	Pascua et al. 2017, Leong et al. 2019
	Traditional practices and performances	Trend in the number of people who carry out or perform [a locally important cultural performance with embedded local ecological knowledge]	Dacks et al. 2019
	Reciprocity between people and place	Level of stewardess of land and sea where one lives	Dacks et al. 2019
	Presence on and interaction with lands that will remain secure (formally or informally) for future generations	Presence by lease, physical access, ownership, and/or occupation; customary rights and tenure	Leong et al. 2019
Sense of place and sense of identity	Sense of self, community, and/or home related to the coastal and marine environment	Activities on the landscape; heritage, social, and emotional connections to places Effects of environmental, social, and cultural change on identity	Leong et al. 2019, Dacks et al. 2019
	Engagement of families in coastal and marine resource based activities	Existence and availability of activities such as fishing or harvesting for livelihood or enjoyment	Leong et al. 2019
	Place-related individual and collective rights and obligations	Level of knowledge and practice of individual and collective rights and obligations towards people and place	Dacks et al. 2019
	Migration	Make up and extent of migration, diaspora and other forms of mobility	Dacks et al. 2019

At the PIFSC, efforts to work with communities and partners to identify salient indicators to help track cultural ecosystem services began in 2018 in West Hawaii under the IEA work (Leong et al. 2019). The work is ongoing, with interview data currently being analyzed. The results of this work should be presented to the communities and partners, and the indicators for tracking changes in cultural heritage and connections to place for the West HI IEA should be finalized and integrated into existing instrument when possible. Based on existing frameworks and the West HI human dimension IEA work today, a list of possible indicators are developed as in the following tables. Tailoring the indicators to a particular community or island will require involving appropriate cultural advisors at the place, e.g., Papahānaumokuākea Marine National Monument working with the Native Hawaiian Cultural Working Group in HI, and Samoa Cultural Affairs in American Samoa.

Currently, the NCRMP socio-economic monitoring survey has a question on a Likert scale (on agreement level) for people to rate how important coral reefs are to the jurisdiction's cultures. Similar place-based household SEM-Pasifika surveys in multiple sites in Micronesia also generally include statements for people to rank their levels of agreement. Examples below are statements that were developed with local partners at the sites.

- Fishing is important for my household. It is a part of who we are.
- The children in my family would like to live the same way of life we have had here.
- The reefs and the ocean are a part of my life and my home.
- In my family, local and traditional knowledge for managing and sustaining fisheries are passed on from elders and parents to young people.
- My household still uses traditional skills in fishing and harvesting marine resources.

Suggestions from the focus group participants from the DAR 30*30 include:

- Are people still making songs about these places?
- Do kids still draw pictures of these places?
- Does your community share food with one another?
- To what extent are Hawaiian place names still used?
- To what extent kupuna still consulted?

If PIFSC decides to develop and add questions related to cultural heritage and connection to place, we could possibly add these questions to existing tools that already have questions of this type. Currently, a number of PIFSC cost earning surveys have questions regarding catch dispositions, such as the percentage of fish catch "caught for community and cultural events." Also, surveys often inquire —"Are the fish you catch an important source for food for your family?"—that addresses pelagic fish, bottom fish, and nearshore/reef fish each, as well as self-identified fisher type (purely recreational, recreational expense, subsistence, cultural, part-, and full-time commercial). The South Kohala, West Manui Knowledge, Attitude and Preference survey has a series of questions for people to rate different types of ecosystem services, including sense of community, aesthetic value, and recreational benefits. Similar to PIFSC cost earning surveys, it includes a question for people to identify the type of fishing they do, but instead of self-identifying the type of fishers they are, the question instead concerns motivations for fishing, with a similar range of choices. It also includes a question about the frequency with which fish is used for special occasions and cultural events, as well as for sharing with families and friends.

Since there are multiple methods for studying culture, we would recommend that community members, anthropologists, and other academic experts be consulted and that other more "in-depth" considerations are given to place-based monitoring of cultural heritage and other aspects of culture.

Collaboration

COLLABORATION	
What	To work collaboratively among different disciplinary teams
Who to lead	A dedicated facilitating coordinator working with team leads
How	Decide how to work together and do that to link different indicators and different sets in an ecosystem
Why	Collaboration needed for successful integrated monitoring

Integrated monitoring involves high levels of collaboration involving scientists from different disciplines, data users (such as managers, policy makers, and communities), and those who provide resources to support collaborative work. The interaction levels among the different team members may vary depending on the level of integration. This can range from isolative, to collaborative, to integrated (Table 15). Engaging scientists of different disciplines in a collaborative effort requires sustained and effective interaction from the design stage through data analysis and interpretation. Based on experiences with integrated monitoring in the NOAA Manell-Geus Habitat Focal Area (MGHFA) project in Guam, we managed the epistemological differences between the natural and social sciences by adopting a stance of mutual respect and trust among team members, and by recognizing that all team members had different disciplinary expertise to offer. A dedicated coordinator is recommended to facilitate communication within the multidisciplinary team, establishing regular meetings. The team meetings promote cross-disciplinary dialogue, underscore the value of diverse data streams, allow experts to examine and leverage differences in monitoring approaches, and discuss conflicts (Wongbusarakum et al. 2019).

Table 15. Levels of integrated monitoring (Source: Wongbusarakum and Heenan 2019).

Elements of monitoring system	Levels of Integration		
	Low	Medium	High
	ISOLATIVE	COLLABORATIVE	INTEGRATIVE
Monitoring objectives	Are addressed via data from singular disciplines	Are addressed via data from multiple disciples	Are addressed via data from multiple disciplines and objectives are linked across disciplines
Indicators	Monitored independently	Monitored independently with an intent to integrate but the degree to which is variable	Monitored together, in a systematic and linked manner
Sampling design	Design is optimized for each discipline independently	Design informed through consultation and potentially involves compromise across disciplines	Design optimized to maximize multi-disciplinary (whole system) understanding at the cost of higher resolution single discipline data
Data collection methods	Mono-method and single disciplinary approach	Mixed-method and interdisciplinary approaches	Mixed-method and multidisciplinary approaches
Data analysis and reporting	Data analyzed and reported on separately	Data analyzed separately (or together) but interpreted/analyzed together	Data co-analyzed and reported to examine linkages across ecosystem indicators
Team interaction	Disciplinary experts work separately throughout entire monitoring cycle	Disciplinary experts work together under a shared monitoring goal, data sharing and interpretation can range from limited or frequent	Multi-disciplinary team members bring specific expertise, devise goals and objectives together, share leadership and decision-making authority and responsibility to report on data.

In an integrated monitoring, everyone would work beyond their disciplinary perspectives to understand the complex interlinked SES. The integrated monitoring objectives can be met, not only through making use of the different data sets already being produced, but also through planning how best the different disciplinary teams can contribute to bringing these data sets together and understand linkages among the different systems. Discussions about how to combine data for a more holistic understanding of management issues is crucial to tracking and understanding changes in, and interactions among, social-ecological systems. For example, monitoring reef conditions alone is simply tracking changes in biophysical conditions. The information that results can only be part of integrated monitoring if it is explicitly linked to activities by people and how they influence each other. In another example, changes in sea surface temperature and mass coral bleaching can become a part of integrated monitoring only if both the impacts of the bleaching on people and the mitigation efforts made by people are brought into the analysis. The same applies to fish abundances and sizes. Unless these can be linked to fisheries and livelihoods, as well as to other impacts from biophysical or social factors, they cannot, by themselves, be considered elements of integrated monitoring. Likewise, demographic studies cannot by themselves provide information to better understand social-ecological systems unless the demographic changes in, for example, population and in types of jobs are used to help explain changes in ecological systems.

In the MGHFA there are several lessons that can be useful for integrated monitoring efforts in the Pacific Island Region. These include the following (Folke et al. 2005, Gove et al. 2019, Heenan et al. 2016, Kendall and Moore 2012, Kittinger et al. 2012, Lindenmayer et al. 2011, Samhouri et al. 2014, Wondolleck and Yaffee 2000, Wongbusarakum et al. 2019):

1) Engaging players early in the planning process to ensure monitoring objectives align across multiple interest groups and scientific disciplines. This streamlines subsequent decisions, such as prioritizing SES indicators and selecting strategies and target audiences for communication efforts.
2) Triangulating biophysical and social data whenever possible to generate more complete knowledge and implications for adaptive management.
3) Learning and adapting the IM process and SES conceptual models based on insights from the process. This may involve adjustments to team composition, conceptual models, monitoring questions and indicators, sampling design, data collecting methods, data analysis and interpretation, or communication of results.
4) Evaluating appropriate monitoring timescales as changes in biophysical conditions, ecosystem services, and human well-being are seldom simultaneous. Since some impacts could be sudden and have severe impacts on both ecological and social systems (e.g., mass coral bleaching), it is important to balance a long-term monitoring plan against the flexibility needed to address unexpected short-term needs.

Activity outline for a regional socio-economic monitoring plan

Based on the above mentioned recommendations for integrated monitoring efforts across the Pacific Island Region, an outline for a regional socio-economic monitoring activity plan for SES research that support an ecosystem approach is proposed as follows:

For the ESD socio-economic and human dimension team lead and 2 facilitating coordinators (biophysical and socio-economic) to work with PIFSC leadership to development a regional socio-economic monitoring strategy that clearly defines social scientific roles and the capacity and resources required to implement the strategy, and that contributes to realizing integrated monitoring results that will support ecosystem approaches to fisheries management. Consider addressing EBFM road map.

For the ESD socio-economic and human dimension team lead and ESD facilitating coordinators to work with PIFSC leadership and PIRO to identify a regional long-term integrated monitoring pilot project that will generate information for improving ecosystem-based management in a particular area. Identify and develop research objectives. Decide on multidisciplinary team members for the project. Consider low hanging fruits such as the West Hawaii IEA project.
For the team to review existing data relevant to the selected management and research project scope based on the defined objectives. Decide whether and which data need to be standardized and which can be place-based. If scales among different data sets are different, determine what needs to be adjusted and how.

For the team to ground truth decisions made with the local community and stakeholders regarding which data types to standardize and which data types should be place-based. If additional socio-economic data are needed, apply a biocultural approach to decide together with the communities and local stakeholders how to fill the need. Consult and work with biophysical team members on how socio-economic and biophysical data can mutually support an ecosystem approach for the managed project. Consider those areas that have been identified in this project, including land-based pollution, community resilience, and cultural heritage and connection to place.

For the ESD socio-economic and human dimension team lead and ESD facilitating coordinators to review resources and funding allocations, and to discuss and get support from the PIFSC leadership if adjustments to the original strategies are needed.

For the social scientists in the team to streamline data collecting instruments for those efforts in the project that require standardization, extending this if possible across all regional tools, and to develop and/or modify additional data collecting instruments for the place-based data types to serve the project objective. Socio-economic facilitating coordinator to organize workshops as needed.

For the two coordinating facilitators to lead and support the sub-teams (biophysical and socio-economic) as they implement their monitoring design, data collection, analysis and analysis. For them also to lead and support the collaborative work among the sub-teams in keeping with the project objectives. Decide on appropriate levels of interaction (based on Table 15) and facilitate cross-communication among sub-teams throughout the project. Make sure data are cross-analyzed to understand SES interactions and changes. Capture lessons and address issues.

For the ESD socio-economic and human dimension team lead and facilitating coordinators to meet periodically with PIFSC leadership and PIRO to discuss lessons learned and monitoring adjustments.

For the ESD socio-economic and human dimension team lead and facilitating coordinators to communication results and processes of the project with internal and external audiences, including relevant communities, management agencies and programs.

For the ESD socio-economic and human dimension team lead and facilitating coordinators to develop future plans to roll-out lessons from the project to other regional ecosystem-based initiatives.

Concluding remarks

Most existing socio-economic data are considered important and respondents are generally well-aware of their existence. These include data related to demographic and economic indicators, particularly in the fisheries sector. The biophysical data that has attracted the greatest awareness and is considered most important is data about fish and about such wider factors as coral habitat and oceanographic and climate conditions. The various data types about which people are generally aware and which they consider important must, however, be much more comprehensively linked. Much of the existing socio-economic data were collected for specific purposes, most often without any plan for being integrated with data collected for other purposes. As a result, there are inherent mismatches in scale and in comparability, making the integration of existing data sets or the "add-on" difficult, meaningless, or impossible. Integrated monitoring is a long-term activity that, to be successful, requires strategic thinking from the beginning, collaborative implementation throughout, and effective communication among team members and data users. We emphasized that the purposes of integrated monitoring need to be clearly articulated and that appropriate strategies must be developed to help materialize it. It is critical to have commitment for long-term support from the leadership, as well as from those who collect data to collaborate, to achieve more holistic understandings of changes in social-ecological systems and their interactions. Without these, data gaps and mismatched data scales will remain unresolved.

There are several areas where integrated monitoring would serve well. For example, the socio-economic and biophysical data gaps that respondents identified in the survey. The most significant socio-economic data gaps are community resilience and well-being, particularly in relation to the cultural aspects thereof. Yet, to understand community resilience, biophysical conditions and changes have to be understood. At the same time, the most commonly noted biophysical data gaps focused on land-based sources of pollution and inputs. To understand land-based sources, social data of human activities and development are critical. Without social data, land-based sources are perhaps among the most difficult to pin down by biophysical monitoring alone. At the same time, they are among the most challenging management to pinpoint. In another example, one of the socio-economic data types about which most respondents were least aware — "Non-monetary/non-extractive value of marine and coastal species and resources by communities"—could serve as a productive focus for collaboration among managers, communities, and scientists. Non-extractive value can be informed by the ecological roles that those species or resources play in preserving healthy ecosystem functions. Scientists and community members alike would benefit from knowledge exchange on non-extractive value from their various perspectives. This, in turn, should be useful in formulating management actions that are both ecologically effective and supported by affected communities.

Scientific studies have produced an incredible amount of data. The next question would be how these data can be made accessible and brought together in a way that helps users better understand the interconnectedness among social and ecological systems, and to make use of this improved understanding of all the changes impacting both our natural resources and the well-being of our communities in developing management strategies and practices that are themselves adaptive and self-improving. In Hawaii, initiatives such as the Hawaii Monitoring and Research Collaborative (HIMARC) are helping to bring the different biophysical data together and make it accessible for data users. Similar efforts do not exist at present for socio-economic data. Such work requires an enormous amount of time and resources and can only be carried out successfully with appropriate funding and commitment.

While we were trying to figure how to better integrate biophysical and socio-economic monitoring, we became aware of the needs to expand socio-economic monitoring from focusing on fisheries economics to covering much broader areas, such as societal well-being and resilience to climate hazards—efforts that have started at place-based levels. A regional socio-economic monitoring plan for the Pacific Islands should consider standardization of data collected at various sites in relation to similar variables, while at the same time taking advantage of and continuing to collect data that are place-based and important for site management, even when they are non-standardized. These latter types of data are those that are identified as the most needed socio-economic data types, and the appropriate scale for their collection should be locally contextual. To move from the current way of data collection to one that is regional does not mean that everything should be the same. Instead, it means that the different purposes of each data type and the existence of varying needs and values must be taken into consideration. It also means that collaboration and partnerships within federal programs and with outsider partners are crucial to realizing the synergies needed to generate useful data at different scales and for different purposes.

Importantly, social sciences should play an equal role in the integrated monitoring of social-ecological systems, and communities should have a voice and decision-making power in place-based research. The importance of giving socio-economic factors equal consideration and the importance of taking community values, needs, and local knowledge seriously were pointed out multiple times in focus groups. Indicators, methods, and data must be co-created with affected communities if they are to be place-appropriate. Tools and methods introduced from the mainland US are often not applicable for the Pacific Island Region, and even within the region itself contexts vary significantly enough to warrant the continued inclusion of place-based and bottom-up approaches, such as biocultural methodologies, in designing and conducting research. These recommendations drive home the importance of teams composed of people with different social science disciplinary backgrounds and have significant staffing implications. For instance, in the same way that fish fecundity should by studied by a fish biologist and not a coral ecologist, studies of cultural heritage and its impacts should be conducted by anthropologists specializing in this field. Recognizing and addressing the need for the wider and stronger presence of social sciences in integrated monitoring, as well as the need for communities to have a big role in determining and participating in research, constitutes a significant paradigm shift. To complete this shift will require considerable commitment and support.

The original intention of this project was to look broadly at the prospects of integrated monitoring for the region as whole. However, at the end of the project, it seems more practical for integrated monitoring to start with a learning or pilot site project in the Pacific Island Region. The project will need to be fully supported by the leadership and the process integration will have to be strategically designed from the very beginning. The project will require qualified staff and resources to produce and/or bring different data types at the scales the project requires. The process should engage not only scientists from multiple disciplines, but also the communities. It should have adequate time to generate the data, to integrate the different data sets, to communicate the results, and discuss how to use them. Lessons from the learning site project can be used subsequently to conduct adaptive monitoring in other site projects and/or scaled up to the regional level.

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Appendix A: Survey Questionnaire

Integrated biophysical and social monitoring

Welcome!

Hi,

The Ecosystem Sciences Division (ESD) of the Pacific Islands Fisheries Science Center (PIFSC), with the funding from the NOAA Coral Reef Conservation Program, is conducting a survey to better understand long-term socioeconomic monitoring needs to improve fisheries, coastal and marine management that benefits human well-being. We are particularly interested in your awareness and use of socioeconomic and biophysical data that is currently collected, the links you see between them, and your thoughts on additional information that should be collected in the future. The results will help us understand the use of the data and the gaps and make recommendations on the types of data to be collected in the future monitoring.

You have been selected to participate in this survey as you are a possible user of the long-term monitoring data or as you are involved in the efforts of collecting the socioeconomic and biophysical data. Your participation is voluntary, and the information you provide will be kept strictly anonymous. No personally identifiable information (name, affiliation, email address) will be linked to your completed survey. Results will be aggregated, so that no responses can be attributable to individuals. This process will maintain the anonymity of the responses received. The information collected will be viewed only by the NOAA research team compiling the data, and will be destroyed at the end of the information collection process.

Thank you for taking the time to assist us with this effort.

Public reporting burden for this collection of information is estimated to average 30 minutes per response, including the time for reviewing instructions and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other suggestions for reducing this burden to Supin Wongbusarakum, ESD/PIFSC NOAA, 1845 Wasp Boulevard, Building 176, Honolulu, HI 96818, supin.wongbusarakum@noaa.gov.

Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number.

Privacy Act Statement
Authority: The collection of this information is authorized under the Coral Reef Conservation Act of 2000 (P.L. 106-562; 16 U.S.C. 6401 et seq.

Purpose: NOAA proposes to conduct a survey and focus groups. The information gathered will help inform partners in coastal and marine resource management and conservation about the types of data that are important for their monitoring programs, that can help fill data gaps, and that can

improve integrated monitoring.

NOAA Routine Uses: NOAA will use this information to generate information that will help ensure that monitoring programs are designed appropriately with useful indicators and are effectively implemented, and that will help bring about conditions that are optimized for users to apply data effectively in their work and to better integrate biophysical and socioeconomic monitoring in ecosystem approaches for fisheries, coastal and marine management. Disclosure of this information is permitted under the Privacy Act of 1974 (5 U.S.C. Section 552a) to be shared among NOAA staff for work-related purposes. Disclosure of this information is also subject to all of the published routine uses as identified in the Privacy Act System of Records Notice Commerce/NOAA-11, Contact Information for Members of the Public Requesting or Providing Information Related to NOAA's Mission.

Disclosure: Furnishing this information is voluntary; however, failure to participate in the survey will provide less information for use in this endeavor.

Integrated biophysical and social monitoring

Respondent profile

1. What are your title, program (division) and office (organization or agency)?

Your title: ____

Your program or division: ____

Your office, organization, or agency name: ____

2. What is your highest level of education completed?

- ○ High school
- ○ Community college
- ○ Undergraduate
- ○ Graduate (master)
- ○ Graduate (PhD)
- ○ Other (please specify)

____

3. What is your main type of overall work? Please check all that applies.

- ☐ Biophysical research or monitoring
- ☐ Field work/field station to collect biophysical research data
- ☐ Socioeconomic research or monitoring
- ☐ Field work/field station to collect socioeconomic research data
- ☐ Integration of biophysical and socioeconomic data
- ☐ Fisheries management
- ☐ Coastal/habitat management
- ☐ Making rules and regulations on resource use
- ☐ Endangered species
- ☐ Communications and outreach
- ☐ Administration
- ☐ Teaching and training
- ☐ Managing a student lab
- ☐ Engaging stakeholders
- ☐ Other (please specify)

4. What would you say are your top 2 areas of expertise and how many years have you worked in each of these 2 areas?

4.1 First area of expertise

For how many years?

4.2 Second area of expertise

For how many years?

5. What geographical areas does your work focus on? Please check all that applies

- ☐ Hawaiian islands
- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Marianas
- ☐ Federated States of Micronesia
- ☐ US Northeast
- ☐ US Southeast
- ☐ US Northwest, including Alaska
- ☐ US Southwest
- ☐ Caribbean
- ☐ Others (please specify)

Integrated biophysical and social monitoring

Importance of existing socioeconomic data for coastal and fisheries management

6. Below is a list of **socioeconomic and governance data** currently collected by long-term monitoring programs. Please rate how important each data type is for coastal management **AND** whether you are aware that such data exists. Please check your answers in both left and right columns.

	Importance of data	Awareness of data
1. Demographics, incl general communities, fishers, and vulnerable populations		
2. Community well-being, including health		
3. Types and proportions of community livelihoods, employment, and income		
4. Livelihood sustainability, (occupational) diversity and flexibility		
5. (Equitable) access to resources/assets		

	Importance of data	Awareness of data
6. Resource dependency for provisioning ecosystem services (including livelihoods, e.g. commercial and subsisting fisheries)		
7. Personal disruption due to unemployment, poverty level or interrupted education		
8. Housing (rent, number of rooms, with plumbing)		
9. Labor force		
10. Physical infrastructure and coastal development		
11. Resource governance, management, and institution		
12. Attitudes towards coastal and fisheries management		
13. Understanding of environmental regulations		
14. Attitudes towards coastal and fisheries enforcement and compliance		
15. Awareness of and attitude towards marine protected areas		
16. Community participation in resource stewardship		
17. Participation in recreational and tourism marine activities		
18. Ability of communities to decide and act in order to create change		
19. Economic/monetary value of marine and coastal species and resources		
20. Economic impact of dive/snorkel tourism		

	Importance of data	Awareness of data
21. Non-monetary/non-extractive value of marine and coastal species and resources by communities		
22. Perceived conditions of coastal and marine resources		
23. Awareness and knowledge of marine and coastal resources		
24. Perceived anthropogenic threats to natural resources		
25. Perceived climate threats and natural hazard risks to communities		
26. Learning and knowledge to adapt to climate change impacts		

7. Below is a list of **socioeconomic data** currently collected by long-term monitoring programs. Please rate how important each data type is for fisheries management **AND** whether you are aware that such data exists. Please check your answers in both left and right columns.

	Importance of data	Awareness of data
27. Participation in fishing activities, (including gear, effort and catch)		
28. Fisher classification based on purpose of fishing (e.g. commercial, recreational, subsistence, cultural, etc)		
29. Proportion of population being reliant on commercial and recreational fisheries		
30. Commercial fisheries economic data (cost/expenses and revenue) and impact assessment		
31. Recreational fisheries economic data and assessment		
32. Seafood industry economic trends and impacts, incl. fish trade (dealer, amount and value of fish sold)		
33. Participation in seafood markets (Catch disposition, sales, market utilization, perceptions of market conditions)		
34. Perceived fishing conditions		
35. Social and cultural uses of fishing		

Integrated biophysical and social monitoring

Importance of existing biophysical data for coastal and fisheries management

8. Below is a list of **biophysical data** currently collected by long-term monitoring programs. Please rate how important each data type is for coastal and fisheries management **AND** whether you are aware that such data exists. Please check your answers in both left and right columns.

Importance of data　　Awareness of data

	Importance of data	Awareness of data
36. Coral size structure		
37. Coral condition		
38. Benthic percent cover		
39. Coral growth		
40. Rugosity		
41. Fish abundance		
42. Fish size structure		
43. Occurrence of protected species		
44. Occurrence of macroinvertebrate key species		
45. Microbial biodiversity		
46. Cryptobiota diversity (i.e., small marine organisms that live predominantly within the complex reef structure)		
47. Sea level rise		
48. Water temperature		
49. Water chemistry (e.g., DIC, TA, DO, pH, dissolved inorganic nutrients, chlorophyll-a, salinity, fluorescence)		
50. Light (irradiance from remote sensing)		
51. Benthic accretion/bioerosion		
52. Meteorology (air temperature, wind speed, wind direction, humidity, etc)		
53. Large-scale climate forcing (El Niño/La Niña, Pacific Decadal Oscillation)		

	Importance of data	Awareness of data
54. Physical oceanography (e.g., ocean currents, wave metrics including height, period, power, and direction)		
55. Marine debris (sightings of man-made debris)		

Integrated biophysical and social monitoring

Data usage

9. If you said you use any of the socioeconomic and biophysical data on the previous pages, could you describe in a few words your top 3 most common uses?

1.

2.

3.

10. If there are data types you are aware of on the previous pages but never use, could you please list the 3 top reasons for not using them?

1.

2.

3.

Integrated biophysical and social monitoring

Potential sociocultural and economic data for management

11. The following list show types of **sociocultural and economic data** that are suggested by the literature and scientific experts as being potentially useful for management but to the best of our knowledge are not currently collected. Please rate how important you think each of these data types could be to inform management. Check "unable to assess” if you do not have any opinion.

	Not at all important	Slightly important	Moderately important	Very important	Unable to assess
1. Cultural heritage and connection to place	◯	◯	◯	◯	◯
2. Spiritual connection to nature and species	◯	◯	◯	◯	◯
3. Connection and sense of place and identity	◯	◯	◯	◯	◯
4. Social relations and network	◯	◯	◯	◯	◯
5. Existence value of resources (including nature as being a source of inspiration, creativity, and aesthetics)	◯	◯	◯	◯	◯
6. Gender issues (division of resource use, management, and gender equity)	◯	◯	◯	◯	◯
7. Willingness-to-pay for coral reef protection/conservation	◯	◯	◯	◯	◯
8. Community resilience to climate impacts and natural disasters	◯	◯	◯	◯	◯
9. Application and impact of aquaculture	◯	◯	◯	◯	◯
10. Access to information on coastal and marine resources	◯	◯	◯	◯	◯

Integrated biophysical and social monitoring

Potential biophysical data for management

12. The following list shows types of **biophysical data** that are suggested by the literature and scientific experts as being potentially useful for management but to the best of our knowledge are not currently collected. Pease rate how important you think each of these data types could be to inform management. Check "unable to assess" if you do not have any opinion.

	Not at all important	Slightly important	Moderately important	Very important	Unable to assess
11. Reproduction or fecundity of organisms	◯	◯	◯	◯	◯
12.Recruitment or connectivity of organisms	◯	◯	◯	◯	◯
13. Mortality rates of organisms	◯	◯	◯	◯	◯
14. Metabolic performance of organisms	◯	◯	◯	◯	◯
15. Land-based sources of pollution, water quality, sedimentation, nutrient inputs	◯	◯	◯	◯	◯
16. Other measures of habitat/structural complexity	◯	◯	◯	◯	◯
17. In situ measurements of light (e.g., irradiance of photosynthetically active radiation [PAR])	◯	◯	◯	◯	◯
18. Regulating ecosystem services (e.g carbon sequestration and storage, erosion prevention, moderation of extreme events)	◯	◯	◯	◯	◯

Integrated biophysical and social monitoring

* 13. Please select only one of the following areas that your overall work has been most relevant to. Your answer will direct you to the last survey section.

◯ Biophysical monitoring and research

◯ Sociocultural and/or economic monitoring and research

◯ Resource management, regulations, communications and outreach, administration, and all others

Integrated biophysical and social monitoring

Section for participants primarily involved in biophysical monitoring and research

14. What are your main roles in monitoring? Please check all that applies.

- ☐ Obtain funding, including proposal development
- ☐ Establish monitoring design
- ☐ Lead monitoring program
- ☐ Lead field data collection
- ☐ Collect data in the field
- ☐ Analyze data
- ☐ Report or communicate data to possible users
- ☐ Other (please specify)

15. What is the goal or purpose of your biophysical monitoring?

16. Please rate the following questions regarding the use of biophysical data in management.

	Not at all	little	Moderate	High	Very high	Don't know
How useful in general do you think the existing types of biophysical data collected by long-term monitoring programs are for informing management decisions?	○	○	○	○	○	○
To what extent do you think the existing data from long-term biophysical monitoring programs you are involved with have been used for management decisions?	○	○	○	○	○	○

17. Please rate the following questions regarding collaboration.

	Not at all	little	Moderate	High	Very high
How much is community engagement incorporated into your work?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **natural scientists** in different fields?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **social scientists**?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **resource managers**?	◯	◯	◯	◯	◯

18. What are the top 5 types of biophysical data that you think would be most useful for sociocultural and economic monitoring? Please list in order of importance.

1st

2nd

3rd

4th

5th

19. What are the top 5 types of sociocultural and economic data that you think would be most useful to complement your biophysical monitoring? Please list in order of importance.

1st

2nd

3rd

4th

5th

20. If there are comments you would like to make about integrating biophysical and social data to improve management, please share them below.

Integrated biophysical and social monitoring

Section for participants primarily involved in sociocultural and economic monitoring and research

21. What is your main role in monitoring? (check all that applies)

- ☐ Obtain funding, including proposal development
- ☐ Establish monitoring design
- ☐ Lead monitoring program
- ☐ Lead field data collection
- ☐ Collect data in the field
- ☐ Analyze data
- ☐ Report or communicate data to possible users
- ☐ Others, please specify ___________________________________

22. What is the goal or purpose of your sociocultural and/or economic monitoring?

23. Please rate the following questions regarding the use of sociocultural and economic data in management.

	Not at all	little	Moderate	High	Very high	Don't know
How useful in general do you think the existing types of sociocultural and economic data collected by long-term monitoring programs are for informing management decisions?	◯	◯	◯	◯	◯	◯
To what extent the existing data from long-term economic and/or sociocultural monitoring programs you are involved with have been used for management decisions?	◯	◯	◯	◯	◯	◯

24. Please rate the following questions regarding collaboration.

	Not at all	little	Moderate	High	Very high
How much is community engagement incorporated into your work?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **social scientists** in different djscjplines?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **natural scientists**?	◯	◯	◯	◯	◯
What is the extent to which your work is collaborative with **resource managers**?	◯	◯	◯	◯	◯

25. What are the top 5 types of sociocultural and economic data that you think would be most useful for sociocultural and economic monitoring? Please list in order of importance.

1st

2nd

3rd

4th

5th

26. What are the top 5 types of biophysical data that do you think would be most useful to complement your sociocultural and economic monitoring? Please list in order of importance.

1st

2nd

3rd

4th

5th

27. If there are comments you would like to make about integrating social and biophysical data for better management, please share them below.

Integrated biophysical and social monitoring

Section only for those choosing resource management and all other types of work

28. Please rate the following questions regarding the use of biophysical data in management.

	Not at all	little	Moderate	High	Very high	Don't know
Are the types of biophysical data collected by long-term monitoring programs useful for informing management decisions?	○	○	○	○	○	○
How useful do you think the existing types of socioeconomic data collected by long-term monitoring programs are for informing management decisions?	○	○	○	○	○	○
What is the extent that you think biophysical data can be improved to better inform management decisions?	○	○	○	○	○	○
What is the extent that you think sociocultural and economic data can be better improved to inform management decisions?	○	○	○	○	○	○

29. Please rate the following questions regarding collaboration

	Not at all	little	Moderate	High	Very high
What is the extent you have worked directly with people who design or implement long-term biophysical monitoring?	○	○	○	○	○
What is the extent you have worked directly with people who design or implement long-term sociocultural and economic monitoring?	○	○	○	○	○
How much is community engagement incorporated into your work?	○	○	○	○	○
How important do you think it is for monitoring teams to work across social and natural scientific disciplines and collaborate with one another?	○	○	○	○	○
What is the level of your interest in working with the monitoring teams to make sure that the data produced meet your management needs?	○	○	○	○	○
What is the level of difficulty in combining biophysical and socioeconomic data in ways that are informative for management decisions?"	○	○	○	○	○

30. What are the existing or potential biophysical data types that you find most useful for your work?

1.

2.

3.

4.

5.

31. What are the existing and potential sociocultural and economic data types that you find most useful for your work?

1.

2.

3.

4.

5.

32. Are there any missing data that would be useful in better managing resources and addressing human well-being simultaneously. If yes, what would be the top 3 most important ones?

1.

2.

3.

33. If there are comments you would like to make about integrating social and biophysical data for better management, please share them below.

Integrated biophysical and social monitoring

34. Would you be willing to participate in a follow-up interview by phone?

- Yes
- No

35. If you know of anybody who would be suitable to participate in this survey, we would greatly appreciate if you could list their names and email addresses below so that we can contact them.

1.

2.

3.

4.

5.

This is the end of the survey. Thank you very much for your participation.

Appendix B: Focus Group Discussion Guide

Awareness and application of long-term monitoring data in the Pacific Islands
FOCUS GROUP DISCSSION GUIDE

Date ____________________________

Number of participants _____________

Introduction

Thank you for agreeing to participate in this focus group discussion. My name is ________________ and I am facilitating the discussion today. I am part of a team that is collecting data on behalf of a project to assess awareness and application of long-term socio-economic monitoring data in the Pacific Islands . You have been selected to participate in this group discussion as you have been involved in designing and implementing long-term monitoring data in the Pacific island region or you have been identified as a current or possible user of the data. Recently we have conducted a survey to examine awareness of available monitoring data and their uses. I will share with you a brief presentation of the key results before we begin the focus group discussions.

The purpose of the group discussion today is to learn more about your experiences with producing and/or using long-term monitoring data. We would like to obtain any suggestions you might have to optimize long-term monitoring, with an emphasis on socioeconomic data, for better ecosystem-based management of fisheries and coastal marine resources. The information you provide will help us make recommendations on the types of data collected in the future, how to better integrate biophysical and social monitoring efforts, and ways to make the data more useful for various types of users. We hope to outline a future socioeconomic monitoring plan in the Pacific island region as a result of this project.

This focus group discussion will last about 1.5 hours. Your participation is voluntary. You may be assured of complete anonymity. To protect your privacy, nothing you tell me will be personally attributed to you in any written documents that result from this session. At any time during the discussion, please feel free to let me know if you have any questions or if you would rather not be involved in the any part of the discussion. Please remember that we want to know what you think and feel, and to discuss with other participants. There are no right or wrong answers.

The public reporting burden for collecting this information is estimated to average 90 minutes to complete the group discussion. Send comments regarding this burden estimate or any other suggestions for reducing this burden to Supin Wongbusarakum, Ecosystem Sciences Division, Pacific Islands Fisheries Science Center, National Oceanic and Atmospheric Administration, 1845 Wasp Boulevard, Building 176, Honolulu, Hawaii 96818, supin.wongbusarakum@noaa.gov.

Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number

Is it OK if I record this discussion today? We are recording the session because we don't want to miss any of your comments. The recording and all raw data will be destroyed at the end of this project.

Thank you for taking the time to assist us with this effort. Do you have any questions before we begin?

Privacy Act Statement

Authority: The collection of this information is authorized under the Coral Reef Conservation Act of 2000 (P.L. 106-562; 16 U.S.C. 6401 et seq.

Purpose: NOAA proposes to conduct a survey and focus groups. The information gathered will help inform partners in coastal and marine resource management and conservation about the types of data that are important for their monitoring programs, that can help fill data gaps, and that can improve integrated monitoring.

NOAA Routine Uses: NOAA will use this information to generate information that will help ensure that monitoring programs are designed appropriately with useful indicators and are effectively implemented, and that will help bring about conditions that are optimized for users to apply data effectively in their work and to better integrate biophysical and socioeconomic monitoring in ecosystem approaches for fisheries, coastal and marine management. Disclosure of this information is permitted under the Privacy Act of 1974 (5 U.S.C. Section 552a**)** to be shared among NOAA staff for work-related purposes. Disclosure of this information is also subject to all of the published routine uses as identified in the Privacy Act System of Records Notice Commerce/NOAA-11, Contact Information for Members of the Public Requesting or Providing Information Related to NOAA's Mission.

Disclosure: Furnishing this information is voluntary; however, failure to participate in the survey or a focus group will provide less information for use in this endeavor.

Focus group semi-structured questions

1.) What is your vision for long-term monitoring?

2.) How has the long-term monitoring been in comparison to the vision?

3.) Are there challenges in terms of availability of data or accessing data you need? If so, what are they?

4.) (Following a brief presentation of the survey results), what do you think of the results? Do you have any thing you would like to comment on or add?

5.) Does management you are involved with have objectives related to benefiting human communities? If yes, what are they? If not, what do you think are the reasons?

6.) What would be indicators to evaluate effectiveness of alternative management scenarios?

7.) How has collaboration among resource managers and monitoring teams been?

8.) If you have worked across disciplines or collaborated with others from different disciplines, could you please elaborate on factors important for successes or failures?

9.) We are trying to integrate biophysical and social monitoring. What would you suggest to optimize such integration?

10.) What do you wish to see improved about monitoring design and process? [Facilitator may prompt with the following topics: collaboration between people who collect the data and managers for decision-making, sampling design, monitoring resources, types of available data, how to access data, how data are shared or communicated with those who may use them. Small group breakouts may be used to discuss factors to overcome obstacles participants have experienced.

11.) Is there any other area of improvement you would like to suggest? What would it be?

Thank you for your time!

Appendix C: Summary of Socio-economic Monitoring

Sources & Name of data collecting instrument	Indicator categories	Variables	Scale of data	Target sample	Who developed the survey	Who collects the data	Frequency	Jurisdiction
PIFSC/NMFS/HI DAR								
Federal Longline Logbooks	Longline fishing activities (including gear, effort, and catch)	Time and location of set/haul Gear configuration Effort (hooks, sets, trips) Catch by species	Regional	All longline trips	PIFSC	PIFSC	Each trip	Am Samoa, HI
Federal Longline Observer Program	Longline fishing activities (including gear, effort, catch, and expenses)	Time and location of set/haul Gear configuration Effort (hooks, sets, trips) Catch by species Trip costs by item (e.g. fuel, bait, etc.)	Regional	Observed longline trips	PIROP	PIROP	Each trip	Am Samoa, HI
State of Hawaii Fisher Reporting System	Fishing activities in the State (including gear, effort, and catch)	Day and location of fishing trip Gear configuration Effort (hours fished) Catch by species	Regional, island	Commercially-licensed fishers	DAR	DAR	5 days of ending a deep 7 bottomfish trip Monthly for others	HI
State of Hawaii Dealer Reporting System	Fish trade (dealer, amount and value of fish sold)	Fish seller license number Amount purchased (lbs, or fish) Amount paid	Regional, island	Seafood Dealers (purchase fish from fishers for sale)	DAR	DAR	Monthly	HI
WPacFIN creel surveys (shore and boat)	fishing activities in jurisdiction (AS, GU, Saipan)	gear, catch, disposition	Regional, island	Site	PIFSC	DAW, DMWR, DFW	On-going	Am Samoa, Guam, CNMI
MRIP/DAR Hawaii Recreational Creel survey	fishing activities in Hawaii	gear, catch, disposition, fisher classification, zip code, etc.	Regional, island	site	NMFS	DAR	On-going	HI

HI Weather and outdoor activity survey	Weather	Source of weather info, impact from severe weather event, frequency of advanced warning	Regional, island	household	NMFS	NMFS	Ongoing	HI
	Coast activities	Participation in nearshore, fresh or salt water fishing (shore and boat)						
	Telecommunication access							
	Demographics	Home ownership, length of residence, number of household members; sex, age, and race of up to 5 HH members						
	Recreational salt-water fishing	number of saltwater fishing days up to 5 HH members						
HMRFS / MRIP Intercept Survey Form	fishing activities in Hawaii	Location, gear, method, effort, type of catch and species, purpose	Regional, island	site				
Commercial Fishing Economic Assessment Index (CFEAI)	Fisheries Economic Data and Assessment	Fishing revenues*, Operating Costs**, Fixed Costs***, Quasi-Rent, Profit	Regional	n/a	NMFS	PIFSC	*Annual, **Every 3 years, ***Every 5 years	Am Samoa, HI, Guam, CNMI
Recreational Fishing Economic Assessment Index (RFEAI)	Fisheries Economic Data and Assessment	For-Hire revenue*, For-Hire Operating Cost**, For-Hire Fixed cost***, Trip expenditures#, Durable Expenditures#, Economic Impact Assessments#	Regional	n/a	NMFS	PIFSC	*Annual, **Every 3 years, ***Every 5 years, #Every 5-7 years	Am Samoa, HI, Guam, CNMI
Tier 1 Indicators	Fisheries Economic Assessment	trips, landings (annual, trip, day at sea), revenue (annual, trip, day at sea), gini coefficient	Regional	n/a	NMFS	PIFSC	annual	Am Samoa, HI

Fisheries Economics of the United States	Seafood Industry Economic Trends and Impacts	Economic Impacts (w/ and w/o imports), Landings/Revenues/Prices, Recreational Economic Impact, Seafood Sales/Processing/Support/Operations Economic Impact	Regional	n/a	NMFS	PIFSC	annual	HI
PIFSC Surveys	Participation in Seafood Markets	Catch disposition, sales, market utilization, perceptions of market conditions	Regional, island	?	?	?		Am Samoa, HI, Guam, CNMI
PIFSC Cost-Earnings Survey of Hawaii Longline Fishery	Ownership characteristics	Type of ownership, years, age, place of residence, education	Regional, island	Vessel owner/captain	PIFSC	PIFSC	ideally every 5-7 years (as funding allows)	HI
	Captain experience	Fishing and captain experiences of commercial fishing						
	Vessel and equipment information	Age, price, cost, type,						
	Costs	Costs of trips, labor, fish sale, expenses, and fixed costs						
	ITQ	Awareness and support						
PIFSC Cost-Earnings Survey of Hawaii Charter Fishery	Vessel characteristics		Regional, island	Vessel owner/captain	PIFSC	PIFSC	ideally every 5-7 years (as funding allows)	HI
	Trip characteristics							
	Types, amount, purpose of catch	Types, amount, purpose of catch						
	trip expenditures and revenues	Type and how much						

	Demographics and fisher classification	Ownership, business structure, age, native, years of resilience, race, income, types of client						
PIFSC Cost-Earnings Survey Hawaii Small Boat Fisheries (some gear/target distinctions)	Participation in fishing activities	Frequency of gear usage, location of use (state/fed waters, FADs), trips (boats and non-bats), landings (amounts in pounds), vessel types and operational considerations	Regional, island	fisher (1995, 2007/2008) Commercially-licensed fisher (2014, 2020)	PIFSC	PIFSC	ideally every 5-7 years (as funding allows)	HI
	Fishing trip costs	Different expenditures and how they are covered						
	Fisher classification/Market participation	Value of fish sold; purpose of fishing: commercial, recreational, subsistence, cultural, etc.						
	Demographics	Fisher demographics (sex, age, income, education, ethnicity, residence zip code, before tax household income)						
PIFSC Cost-Earnings Survey of American Samoa Longline Fishery	Ownership characteristics	Types, years, place of residence, location of fishing	Regional, island	Vessel owner/captain	PIFSC	PIFSC	ideally every 5-7 years (as funding allows)	Am Samoa
	Captain experience	Fishing and captain experiences of commercial fishing						
	Vessel and equipment information	Age, price, cost, type,						
	Costs	Costs of trips, labor, fish sale, and fixed costs						
PIFSC Cost-Earnings Survey of American Samoa Boat and Spear Fisheries (some	SEE HI COST EARNING SMALL BOAT	SEE HI COST EARNING SMALL BOAT	Island	fisher	PIFSC	contractor	ideally every 5-7 years (as funding	Am Samoa

gear/target distinctions)							allows)	
PIFSC Cost-Earnings Survey of Boat-Based Fishing (some gear/target distinctions) in the Mariana Archipelago (Guam and CNMI): 1985, 2011, 2018	Fishing experience	Trips, locations, catch amount	Regional, island				ideally every 5-7 years (as funding allows)	Guam, CNMI
	Perception on management							
	Fishing Purpose	Purposes and motivation						
	Market participation	Market, income, value of fish sold						
	Vessels and gear	size and type of boat						
	Expenditures	Fisheries and other related costs						
	Demographics							
Cost-Earnings Survey of MHI Bottomfish Fishery	Fishing experience	Trips, locations, catch amount	Regional, island	Bottom fish fisher	PIFSC	PIFSC	part of Hawaii small boat surveys (2014, 2020)	HI
	Perception on management	TAC, management effectiveness, catch share						
	Fishing Purpose	Purposes						
	Market participation	Market, income proportion by fishing and bottom fishing						
	Vessels and gear	size of boat, cost of crew, value of boat and gear						

	Expenditures	Fisheries and other related costs							
	Demographics								
	Management perception								
Hawaii Recreational Fishing Expenditure Survey (1st survey for shore and private boat, 2nd survey for Charter Patron)	Fishing characteristics		Regional	Non-commer-cial fisher	PIFSC	contractor	ideally every 5-7 years (as funding allows)	HI	
	Expenses	Types of expenses and personal spending							
	Demographics	Sex, age, race, HH income, education,							
NOAA Fisheries Hawaii Recreational Fishing Attitudes and Preferences Survey (boat and shore distinctions)							only one survey to date (2015)	HI	
PIFSC/LocalAgency(CNMI,GU,AS) Economic Trip Cost Data Collection Program							On-going since 2009	HI	
South Kohala/West Maui Knowledge, Attitude, Preference Surveys	Coastal activities	Purpose, frequency, activities, time of visit,	Local	individual (user on site)	PIFSC	contractor	only one survey to date (2012)	HI	
	Knowledge about site condition	Conditions of reef, fish, water, monk seal habitat, turtle nesting, watershed, sources of reef info							
	Conflicts of resource use								
	Public facilities	Awareness and satisfaction							

	Treats	Perception of different types of threats							
	Management	Support of CBSFA, MPA, enforcement, etc.							
	Benefits from reef	Ecosystem services							
	Demographics								
CNMI and Guam Resident Perceptions of Marianas Trench Monument	Perception and attitudes on the Monument	See left cell	Regional, island	household	PIFSC	contractor	only one survey to date (2012)	Guam, CNMI
	Perceived purposes of the monument	See left cell							
	Fishing activities in the monument	See left cell							
	Condition of resources in the monument	See left cell							
	Demographics	General demographics							
Guam DAWR off shore creel survey census	CPUE	Gear, hours, areas, number of people, weather	Island	site	PIFSC	DAWR	ongoing	Guam
Hi observer program longline trip expenditure form	Catch	Species, size, weight, price, sold/not sold	Island	Observed longline trips	PIFSC	PIROP	ongoing	
	Costs	fuel, ice, engine, bait, gear lost	Island	Observed longline trips	PIFSC	PIROP	ongoing	

Hawaii Recreational Fishing Attitudes and Preferences Survey (boat and shore distinctions)	Fishing activities	Trips, locations, types of fishing, change of fishing amount, purposes,	Regional, island	noncommercial fisher	PIFSC	contractor	only one survey to date (2015)	HI
	Perception of fisheries management	Conditions of fisheries; preference, importance, satisfaction of management strategies, threat					only one survey to date (2015)	
	Demographics							
CRCP/NCRMP 13 high level indicators								
NCRMP socioeconomic monitoring	Participation in reef activities	Frequency and location of use, access to activities; (new in 2020) of fishing for various species that are important to each jurisdiction	National, regional	House holds	CRCP, NOS	Contrac-tors	Once every 7 years	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Perceived reef condition	Perception of trends based on personal experience	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Attitudes towards management and enforcement	Perception of management activities and participation in management (MPA questions on Am Samoa, HI, Guam, CNMI awareness and agreement with functions)	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Awareness and knowledge of reefs	Source of information on reefs and awareness of threats, including climate	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Demographics/Human population change near reefs		National, regional	Secondary	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Economic impact of reef fishing to jurisdiction	Economic distribution (number of establishments, jobs, revenue, income)	National, regional	Secondary	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI

NCRMP socioeconomic monitoring	Economic impact of dive/snorkel tourism to jurisdiction	Economic distribution (number of establishments, jobs, revenue, income)	National, regional	Secondary	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Community well-being	Health, basic needs, economic security	National, regional	Secondary	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Cultural importance of reef	Cultural norms, cultural and spiritual practices at individual and community levels, importance of reefs to well-being and quality of life, multigenerational knowledge	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Participation in behaviors that may improve coral reef health	Participation in specific activities (new) such as beach cleanups, sustainable seafood choices, activities to reduce climate impacts, waster reduction, recycling, volunteering with environmental group	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Physical infrastructure	Development, energy infrastructure, physical access to coastal resources, EPA registered facilities, waste management, water supply	National, regional	Secondary	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Awareness of coral reef rules and regulations	Behaviors, norms, etiquette, customary rules	National, regional	House-holds	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	Governance	Current status of reef governance, e.g. local institution involved in reef conservation, management strategies enacted % of reef area under protection	National, regional	Marine Protected Area checklist survey	CRCP, NOS	Contrac-tors	Contrac-tors	Am Samoa, HI, Guam, CNMI
NCRMP socioeconomic monitoring	resident willingness-to-pay for coral reef conservation (Note: supplementary question, not one of the 13 high level		National, regional	House-holds				Am Samoa, HI, Guam,

	indicators).							CNMI
NCRMP socioeconomic monitoring	consumption of locally harvested coral reef seafood (Note: supplementary question, not one of the 13 high level indicators)		National, regional	House-holds				Am Samoa, HI, Guam, CNMI
PIMPAC-MC SEM-PASIFIKA[1]								
SEM-Pasifika monitoring	Demographics	General demographic variables	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	Palau, all islands in FSM, Guam, CNMI, RMI
SEM-Pasifika monitoring	Types and proportion of community livelihoods, employment and income	Household livelihood activities, income sources, livelihood sustainability, diversity and flexibility, level of access to livelihood resources, level of natural resource dependency for livelihoods	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	Palau, all islands in FSM, Guam, CNMI, RMI
SEM-Pasifika monitoring	Fishing activities	Fishing frequency, methods, types of catch, number and gender of household members who participate in	Local/site	House-holds	PIMPAC SEM advisor	Local agency or	When resources	Palau (cost and effort),

[1] The 19 assessments and sites are as follows. Assessment reports can be requested from Michael Lameier, PIMPAC coordinator in the PIRO office.
Yap: Ngulu, Tamil (2 assessments) and Weloy;
FSM:

Chuuk: Parem
Pohnpei: Metipw, Depehk Takaiou, and Nahtik
Korsrae: Walung (2 assessments)

CNMI: Laolao and Rota
Guam: Merizo
RMI: Jenrok
Palau: Jurisdiction-wide, Ngiwal, Habotobei, Ngarchelong, Rock islands

		fishing and harvest sea foods, fishing methods, purposes of fishing (including for household consumption, sale, cultural and social purposes), cost and effort, perceived changed in fishing conditions			with local team lead with community reps	conservation organization	are available	all islands in FSM, Guam, CNMI, RMI
SEM-Pasifika monitoring	Perceived conditions of coastal, marine and terrestrial resources	Perception of important species and habitat conditions (size, abundance, diversity)	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	FSM, Guam, Palau
SEM-Pasifika monitoring	Perceived value of marine and terrestrial resources	Level of importance of key locally relevant resources to household	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	FSM, Guam
SEM-Pasifika monitoring	Perceived threats to natural resources and communities	Perception on natural, anthropogenic, and climate threats to natural resources	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	
SEM-Pasifika monitoring	Marine Protected Area	Awareness of, support to, involvement in, and perceived benefits from protected and managed areas	Local/site	House-holds	PIMPAC SEM advisor with local team lead with community reps	Local agency or conservation organization	When resources are available	FSM, CNMI, Palau
SEM-Pasifika monitoring	Resource governance, management, and	Perception and attitudes towards formal and informal management of natural resources, understanding of	Local/site	House-holds	PIMPAC SEM advisor	Local agency or	When resources are	FSM, Guam, RMI

	institution	environmental regulations, attitudes towards enforcement and compliance, community participation in resource stewardship, awareness of and support for Micronesia Challenge			with local team lead with communit y reps	conserva tion organizat ion	available	
SEM-Pasifika monitoring	Community well-being	Household ownership of different types of basic necessities, connection to place, sociocultural heritage related to natural resources	Local/site	House-holds	PIMPAC SEM advisor with local team lead with communit y reps	Local agency or conserva tion organizat ion	When resources are available	FSM, Palau, Guam
SEM-Pasifika monitoring	Tourism and recreation	Perception on marine tourism activities, participation in recreation and marine activities, impact of tourism	Local/site	House-holds	PIMPAC SEM advisor with local team lead with communit y reps	Local agency or conserva tion organizat ion	When resources are available	Palau (tourism only), Guam
SEM-Pasifika monitoring	Climate change	Perceived climate threats and natural hazards risks to communities, perceived impacts of changing climate on natural resources and communities, learning and knowledge to adapt to changing climate and its impact, ability of community to decide and act in order to create change, access to climate information, perception on leadership ability to guide in hazards events, level of external assistance	Local/site	House-holds	PIMPAC SEM advisor with local team lead with communit y reps	Local agency or conserva tion organizat ion	When resources are available	FSM, Guam, Palau, RMI
SEM-Pasifika monitoring	Awareness and knowledge of marine and coastal resources	Level of understanding of marine and coastal resources, access to informational resources	Local/site	House-holds	PIMPAC SEM advisor with local team lead with communit y reps	Local agency or conserva tion organizat ion	When resources are available	FSM, GUAM

Appendix D: Photos of Focus Groups

Figure D 1. Focus group at Atlantis Workshop (May 22, 2019).

Figure D 2. Focus group at Atlantis Workshop (May 22, 2019)

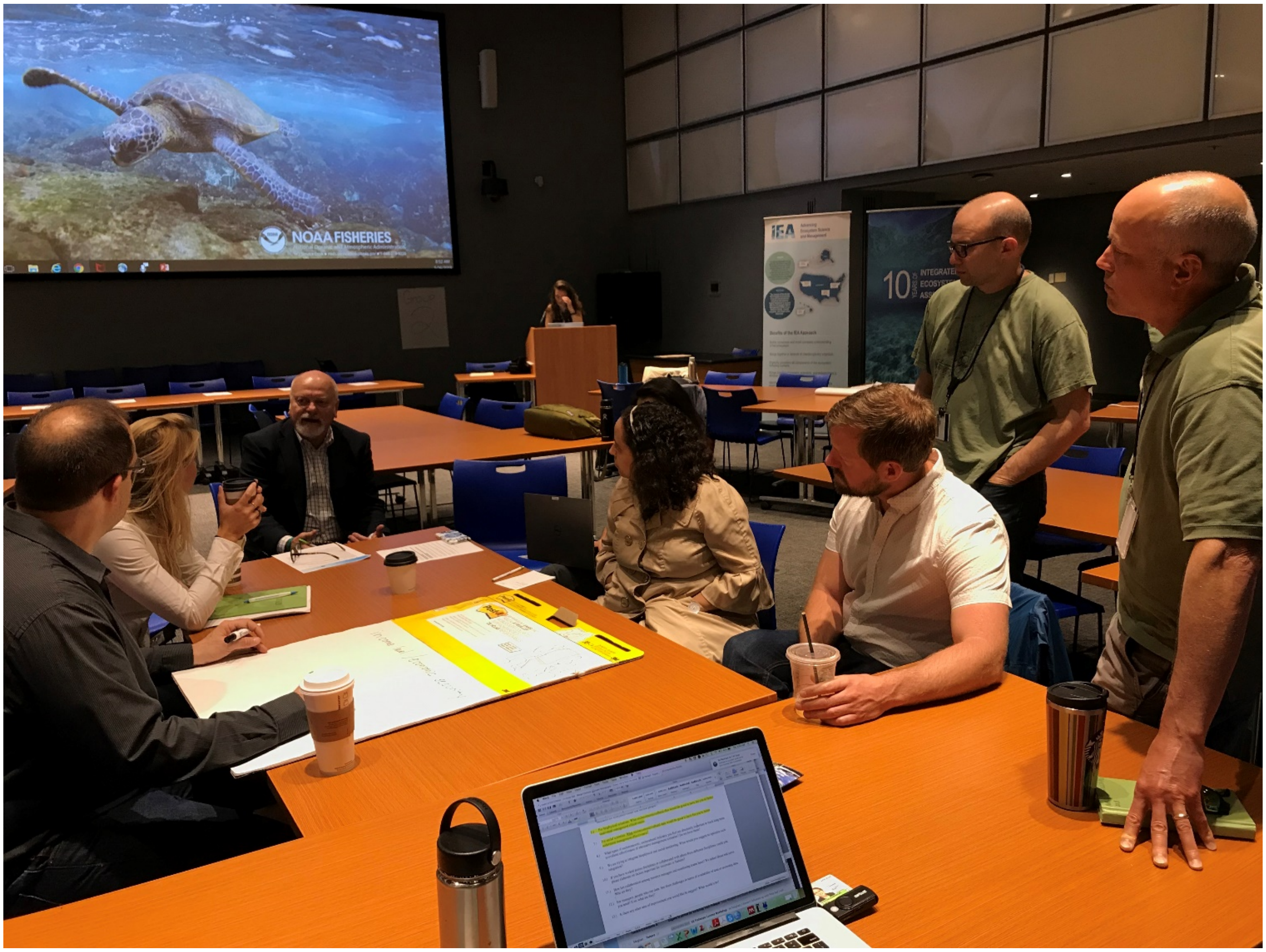

Figure D 3. Focus group at Integrated Ecosystem Assessment (May 16, 2019)

Figure D 4. Focus group at Integrated Ecosystem Assessment (May 16, 2019)

Social Indicators to Fill Data Gaps

Purpose and target readers

This document intends to provide indicators that help fill data gaps identified in the 2019 study "Assessing socio-economic data and indicators to determine connectivity with existing biophysical data and to improve their usefulness for resource management in the US Pacific islands". It also includes examples of data collecting instruments. The document does not intend to provide a comprehensive list of possible indicators, but rather a small set of examples of how related social data may be collected and used to improve reef and coastal resource management.

The intended main audiences for this document include those who are involved in social monitoring for coastal and fisheries resource management, coastal managers, governmental and non-governmental staff for coastal conservation and community development, researchers, and community facilitators or members who are interested in and able to conduct socioeconomic assessments.

Areas of identified data gaps

The most frequently mentioned data types that are considered crucially important but that are not yet collected are:

1. Community resilience to climate impacts and natural disasters (identified by multiple groups)
2. Cultural heritage (identified by multiple groups)
3. Connection and sense of place and identity (identified by multiple groups)

Access to information on coastal and marine resources (rated high for the respondents working in the Pacific island region, managers, and biophysical scientists)

4. Willingness to pay for coral reef protection/conservation (rated high by biophysical scientists)

Indicators examples

This section of the document provides examples for each of the data gaps listed above and recommends ways of collecting data, and suggests how the information thus generated might be used for coastal management. Many of the examples came from existing guidelines (including Nevitt and Wongbusarakum 2013, Wongbusarakum and Loper 2011, Wongbusarakum 2019) and from socioeconomic assessments conducted in the Pacific island region in recent years. The indicators below were designed with general Pacific island coastal communities in mind. Still, the relevancy of indicators for a particular study site should be determined through consultations with local stakeholders and people with relevant knowledge. The indicators, choices of answers, and data collecting methods should be modified and tailored to the management site so that they are fit for purpose in each specific context and in relation to useful scales of analysis. The following indicators may be applicable to sites in regions other than the Pacific island region.

1. Community resilience to climate impacts and natural disasters

Resilience refers to the capacity of a system to absorb shocks and disturbances and to catalyze renewal, adaptation, transformation, and innovation (Béné et al. 2013). As there could be a wide range of factors that foster resilience in a community, identifying and setting criteria are the first steps toward effectively understanding locally relevant factors to sustain environmental health and community well-being in the face of environmental, social, and economic change (Fazey et al. 2011; Folke et al. 2003). The following indicators provide some foundation for this process. These indicators are extracted from SocMon/SEM-Pasifika for Climate Vulnerability Assessment (Wongbusarakum 2019).

1.1 Perceived climate change impacts

This indicator helps coastal management understand household or fisher perceptions of the types and degree of impacts associated with the different climate-related events. While oceanographic and biophysical monitoring are tracking these changes, the perceptions of local communities can help in localizing the impacts when other data types do not provide the degree of resolution needed for effective local management. At the same time, perceived climate impacts—such as coral bleaching, sea level rise, storm surge, and ocean acidification—that are reported by communities or fishers as affecting their livelihoods, businesses, properties and environment, can be important enablers for aptly prioritizing management strategies and actions. This primary data collection could complement the Natural Hazards index for HI (Kleiber et al 2018) and help standardize hazard variables shared across the Pacific islands.

Example of a household survey question:

Please rate the degree of impact and coping capacity for the following climate hazards.

Climate hazards and impacts within the past 5 years	How would you rate the degree of negative impact on your household by this hazard? 3 = high, 2 = medium, 1= low 0 = No impact	How would you rate the difficulty of coping with this hazard, for your household? 3 = high, 2 = medium, 1 = low 88 = not applicable
Tropical storm/typhoon/storm surge		
Sea level rise		
Coastal/beach erosion		
Saltwater intrusion into gardens/fields/taro patches/wells/		
Changes in rainy and		

dry seasons, leading to changes in planting seasons, etc.		
Flood/land slide from heavy rain fall		
Drought		
Increased sea surface temperature		
Hotter air temperature		
Other: Specify ___________________		

Vulnerable groups to climate impacts and threats

Key informants can be interviewed to determine which segments of the population may be most at risk to different types of climate events, who and where they are, and how to reduce those risks. The informants might include community leaders, representatives from certain demographic groups (such as women, elders, and ethnic groups), representatives of occupational groups (fishers, tourism businesses), and those who serve the community in various capacities (such as health care workers, utility service providers, directors of emergency relief organizations, church leaders). The information helps identify groups that may be more vulnerable and generally less able to prepare, respond to, or adapt to climate hazards. The particular adaptive capacities of these groups should be taken into consideration. Often, the factors that keep people economically and socially marginal also make them vulnerable (Cinner et al 2018), so addressing root causes may support resilience building. These groups may include migrant families who may not understand the local language and lack local social support networks, people with economic hardships and limited access to resources, or certain ethnic groups. Existing demographic information, such as those from government census, may help bring an understanding of local levels of literacy, education, sex, and age into the process of developing more appropriate types of outreach and methods of informing respective groups about climate and risks. Information on occupations and education levels could be useful for developing programs that enhance adaptive capacity, such as alternative livelihood training. In other communities, high outmigration of young people could be an indicator of there being a limited number of acceptable or available livelihood options, which could in turn alert decision and policy makers to needs for developing programs suited to addressing this issue.

1.2 Dependence on coastal and marine resources

Dependence on coastal and marine resources is the extent to which households are dependent on coastal and marine resources for different goods and services. This information affords insight into the importance of different ecosystems and resources to the community in terms of food security and income, social and cultural practices, physical protection, and other services. In recent literature (e.g. Cinner et al., 2016), high dependency on coastal resources, in combination with a few other factors, has been shown to contribute to places where ecosystems are substantially better. Cross-referenced with information on resource conditions from biological monitoring, this information can also be used to identify threats and possible negative impacts to particular resources on which a community heavily depends. When cross-referenced with information on livelihood alternatives, it can help managers understand the range of possibilities and the limitations of a diversified economic structure at the site, and thus assist in developing realistic scenarios for mitigating problems related to food and income security. For example, if a household's sources of protein and cash income are primarily dependent on fishing and harvesting in reef areas, the impacts of mass coral bleaching or other forms of reef degradation are likely to threaten its food security and income. Alerted to this, managers may begin working toward adaptation strategies that support alternative livelihoods that are not reef-dependent.

Data collection methods that can help identify the types of resources and services vulnerable to climate change include:

- **Community mapping:** Community members are invited to create maps that show (1) the types and location of natural resources that they depend upon, (2) community infrastructure and services, (3) areas where key social and economic activities take place, and (4) areas impacted or threatened by climate hazards (see Rambaldi 2010).

- **Seasonal calendar:** Community members or representatives of occupational groups are invited to review annual seasons and climate events (e.g. rainy/dry season) and associated uses of natural resources and social activities (e.g. traditional ceremonies or local customs). This can provide an understanding of potential social and natural impacts from changes in seasonal events, and how to prepare to deal with them.

- Having identified the resources and services that are vulnerable to climate hazards, ask **key informants** to identify the major activities conducted by households in the area (i.e., fisheries, tourism, aquaculture, etc.). Then ask them to estimate the percentage of each good and service produced that is used for personal consumption or income generation. Also, ask key informants about the importance of ecosystems in terms of providing physical protection to the community (e.g., reefs and mangroves).

- A **household survey** can be used to list resources, related goods and services, and to generate percentages dependency in terms of both personal consumption and income generation. The importance of cultural values and the services and physical protection provided by the ecosystem can also be recorded.

Examples of household survey questions:

1. From the list below, please select the ones that you and other household members depend on for food or income and fill out how many adult males and females in your household depend on these activities to make a living.

Possible activities for income and livelihood	Check	Number males	Number females
Fishing			
Harvesting other seafood besides fish			
Farming, including livestock			
Salary from employment with governments			
Income from employment in tourism			
Income from other businesses/sources, please specify ___________________________________			
Private business owners – stores			
Remittances (money from relatives who live off island)			
Food exchange within community or family			
Public assistance for food or housing			
Pension/social security			
Others, please specify___________________			

2. Which are the 3 most important income sources for your <u>entire household</u> (not just yourself)?
   1st most important _________________________________
   2nd most important _________________________________
   3rd most important _________________________________

3. Is the number one most important livelihood activity above being negatively impacted by any big climate-related threat in the past 5 years?
   □ Yes □ No

4. If yes, what is the most important threat?__________________________

5. If you were not able to do your current job or livelihood, what would you do for food and income? ____

1.3 Perceived resource conditions

Perceived resource conditions refer to perceptions of the current status of the resources that are important to the communities economically, socially, or culturally. Where biological or physical monitoring data exist, the different data sets can be used to compare and complement each other and help identify both management actions and outreach and educational needs. It is important to keep in mind that many resources are impacted or threatened, not only by climate, but also by man-made causes such as pollution, sedimentation, overfishing, destructive fishing methods, and coastal development. In areas where such non-climate factors are present, cumulative impacts need to be taken into consideration as well.

Different data collecting methods may be use, including:

- **Secondary sources**: scientific reports on climate change, impacts and threats, and states of local resources such as coral reefs, beaches and coasts, crops, and forests.

- **Physical and biological assessments and monitoring:** This data can provide an understanding of physical resources, current biological conditions, and changes. It can also help identify climate-related problems and threats to physical areas, species, and ecosystems.

- **Key informants**, particularly those who have intimate relationships with coastal and marine resources, such as fishers and those who are involved in marine tourism activities.

- **Survey** for the household members or special groups who fish or harvest marine resources to rate their perception of different resources they use or have knowledge about.

Example of survey questions:

1 In your opinion, how is [each of the following natural resources] currently doing? You have choices of 1 very bad, 2 bad, 3 neither bad nor good, 4 good, 5 very good, or "Don't know".
2 How would you say the condition of [each of the following] has changed over the last 10 years? You have choices of 1 = a lot worse, 2 = slightly worse, 3 = no change, 4 = slightly better, 5 = a lot better, or "Don't know".

Resources	Q1 Current Condition (1-5) or "Don't know"	Q2 Change in condition over last 10 years (1-5) or "Don't know"
Ocean water quality (clean and clear)		
Coral reefs		
Upland forests		
Mangroves		
Seagrass		
Beaches/Shoreline		
Size of fish in general		
Amount of fish in general		
Groupers (Serranidae spp.)		

Resources	Q1 Current Condition (1-5) or "Don't know"	Q2 Change in condition over last 10 years (1-5) or "Don't know"
Humphead Wrasse (Cheilinus undulatus)		
Bumphead Parrotfish (Bolbometopon muricatum)		
Bluespine unicornfish (Naso unicornis)		
Jacks (e.g. caranx melampygus)		
Sharks		
Tunas		
Oysters		
Giant Clams		
Turtles		
Trochus		
Sea cucumbers		
Octopus		

1.4 Diversity and flexibility of occupations and livelihood activities

Occupational or livelihood diversity or multiplicity examines the number of types of occupations and livelihood activities a household engages in to support subsistence and generate income. *Livelihood* is "made up of the capabilities, activities and assets (including both material and social resources) that contribute to a means of living" (Carney 1998). This information provides an understanding of both household and community level vulnerability, and is useful for livelihood development and intervention to help build resilience. Households that rely on a single economic sector for their livelihood (e.g. tourism or fishery) may be more vulnerable to climate impacts than those that have a more diversified economy, especially if they are highly dependent on sensitive resources. Damaged or degraded resources could make it difficult to recover from an impact. Diverse income sources may also indicate higher willingness to change occupations in the face of hazards or other impacts. For example, research has shown that households with higher numbers of income sources are more likely to leave declining fisheries than those with fewer income sources (Cinner et al. 2009).

In the context of uncertainty related to changing climate and other major disturbances, alternative and supplementary livelihoods and their sustainability are becoming more important. *Alternative livelihoods* are activities that household members could engage in to support their families if they were no longer able to pursue their current livelihood. *Supplementary livelihoods* are activities that might add to existing livelihoods. A livelihood is considered sustainable when "it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Carney 1998). Sustainable livelihood frameworks cover social, natural, financial, human and physical capitals (IMM 2008; Benson and Twigg 2007). The less sustainable a household's current livelihood is due to climate impacts, the more important it is to develop alternative and supplementary livelihoods. Understanding households' perceived livelihood options can greatly inform adaptation strategies that make use of household's means, knowledge, and capabilities in creating enabling conditions and giving access to needed resources.

Research has shown that the availability of alternative livelihoods seems to lower perceived vulnerability and increase perceived resilience; households with alternative livelihoods do not rate their vulnerability to extreme events as highly as those without (Wongbusarakum 2010). An understanding of available alternative and supplementary livelihoods can also assist managers in designing new management and adaptation strategies so that new livelihoods can be developed and existing ones enhanced. The gathered information can also point to the types of training and capacity needed, which might be useful for designing a livelihood program that can help reduce pressures on impacted coastal resources by using more resilient or untapped resources. A community's more vulnerable demographic groups might be better supported to achieve alternative or supplemental livelihoods.

Livelihood diversification might be a critical adaptation strategy to climate change impacts. It focuses on the process of creating diverse livelihood strategies, and on related opportunities and challenges. Related factors might include level of attachment to one's profession, skill level, interest and willingness to change occupation or residence, available access to resources that would help create new livelihoods, economic opportunities (availability of demand, and access to market), and sociocultural norms (e.g. those related to gender and age groups) that may support or inhibit livelihood diversification, local customs related to resource access and tenures, and social relations.

Several data collection methods can be used as follows.

- **Household survey**. Before developing the survey, consult with local residents who are knowledgeable about the range of livelihoods in the area, and include these choices in the instrument. The respondent might be the head of household or another member who knows about the types of livelihood pursued by each household member. Conduct a household survey in which respondents are asked to identify possible alternative and supplementary livelihoods for their household, and (optionally) why each alternative livelihood was selected.

- Data collecting methods, such as **seasonal calendar** and **key informant interviewing,** can provide in-depth information about livelihood diversification strategy in the community. The information is useful for identifying changes in normal seasonal patterns that may be associated with climate change, and to consider the impacts of future climate scenarios on seasonal events. It can also provide insight into how resources can best be managed, and what type of adaptation should be planned with seasonal limitations and opportunities taken into consideration. Record any stories or anecdotes that illustrate why family members are or are not engaged in certain livelihood activities. Find out from key informants whether the livelihood options are seasonal, temporary, or potentially long-term. Also, ask key informants whether there might be potential livelihood options at the community level of which households are not yet aware (such as a sustainable aquaculture project under development, or a government project on aqua or mariculture). Summarize the requirements, opportunities, and constraints of each livelihood option and its potential sustainability.

For example, in a coastal or island community, it is not uncommon for some younger adults to be engaged in seasonal employment where else to earn cash income. A seasonal calendar can provide a visual timeline that gathers information about when certain weather patterns normally occur, and what seasonal events (fruiting season, tourism season, spawning aggregations) are associated with specific times of year. It can also provide information on such local practices as seasonal closures for certain species (see examples of participatory tools and methods on the LEAP tool (Gombos et al 2016)

Example from a household survey for fishing communities:

1. What is your level of agreement on the following? 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree

Diversity and flexibility	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
My household depends heavily on fishing						
My household is able to change fishing methods if necessary						
My household is able to move to different fishing sites if necessary						
In the last 5 years my household has developed new ways to use coastal and marine resources						
There are economic opportunities my household can take advantage of.						
My household is willing to learn and try different types of livelihood activities in response to climate impacts and hazards						
My household can access resources for a new type of livelihood						
Fishing is important for my household. It is a part of who we are.						

Migration is common in our community						

1.5 Learning and knowledge

Several indicators can be examined for learning and knowledge. For example, *knowledge and perception of climate hazards* assesses a household's awareness, understanding and perception of susceptibility to climate-related risks that have the potential to cause harm. This information can inform managers relevant actions. For example, if there is little awareness of climate threats, programs need to be developed to inform people and help them prepare to cope. Priority in adaptation planning should be given to those hazards that have severe impacts at the household level, with a special focus on households that have identified themselves as being unable to cope with them.

To compare awareness of household vulnerability and recorded climate hazard impacts, information can be gathered first about local climate hazards (types, character, frequency, and degree of community impact) from existing secondary sources such as meteorological services, newspaper articles, scientific research, climate reports, hazard mitigation plans, and emergency declarations. Interviews can also be conducted with people who have knowledge of climate events and the impacts over the past several decades, such as local residents, technical experts, climate scientists, and others who have been involved in working with the community to prepare for and recover from climate disasters (village leaders, community elders, government officials, disaster mitigation officers, long-term project staff, etc.).

Another indicator, *access to and use of climate-related knowledge,* measures household access to different sources of information related to climate change, climate variability and its impacts, and how this information is used. It also includes access to any type of early warning system and can include past experience, traditional or local knowledge of climate patterns and events, as well as other sources of education, media, and communications. The data provide an overview of a community's access to climate information. This tells managers how best to reach the community or particular households. It also helps identify gaps and problems. Greater access to, and use of, climate-related information should increase adaptive capacity by better preparing community members to cope with climate change.

To collect data, you may ask key informants to list all possible sources of climate information that are available locally or that can be accessed from a distance. This list is then used to create a related question in a household survey.

Examples from household survey questions:

1. From the following information sources, please check the one(s) from which you get your climate information and whether you use the information from the source(s) and how.

Sources of climate-related knowledge	Check if you ***get*** climate information from this source, and n/a if the source is not available for your household
Meteorological services	
Newspapers	
Radio	
TV	
Internet/social media	
School/teachers	
Visiting climate scientists/experts	
Community leaders	
From family and friends	
Government information	
Other (please specify) ________________	

2. Please tell us if there are any types of information that you need but cannot access, and what the barriers are to accessing the information.

____

What is your level of agreement on the following? 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree

Learning and knowledge	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
In my family, local and traditional knowledge for managing and sustaining fisheries are passed on from elders and parents to young people.						
My household is able to get information when we need to better cope with climate impacts on fisheries.						
Our community is aware of the causes and impacts of climate change.						
In the past, traditional knowledge and practices helped our community to successfully cope with climate events and impacts.						
Today, traditional knowledge and practices are adequate to help us now successfully cope with climate risks and impacts.						

Learning and knowledge	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
I know how changing climate may impact fisheries in the future.						

1.6 Leadership, governance and institutions

Leadership, governance and institutions is a broad indicator category that assesses a variety of characteristics that together indicate the processes by means of which decisions are made to serve the best interests of the community and stakeholders. *Leadership* assesses the presence of community leaders or government officials who can mobilize climate change responses and resources to support adaptation, and their effectiveness or credibility. This indicator is important because communities with strong, trustworthy, effective leaders will be more able to adapt. *Governance* and *institutions* are related to resource management and climate adaptation. Natural resource governance refers to "the norms, institutions and processes that determine how power and responsibilities over natural resources are exercised, how decisions are taken, and how citizens – women, men, indigenous peoples and local communities – participate in and benefit from the management of natural resources" (IUCN 2018).

Indicators in this category are best measured through both key informant interviews and household surveys. For example, for the indicator *effectiveness of community leaders in addressing climate hazards and adaptation planning,* ask key informants which community leaders are engaged in responding to climate change, including which sectors they represent (private sector, environment, technology, grassroots organizing, etc). Consider asking about these leaders' approaches and achievements in handling climate-related issues, depending on the sensitivity of this question in the local context. Then, in a household survey, ask a series of attitude questions to assess the degree to which household respondents are ready to affirm the existence of community leaders who can effectively guide and direct members to prepare, respond to, and adapt to climate hazards; to identify who these leaders are; and to assess how effective/ trustworthy they are perceived to be. Also ask about the level of stakeholder participation in management, and their satisfaction with the decision-making process. The way decisions are made has significant bearing on the outcome of those decisions. The effectiveness of leadership will impact how change is undertaken within a community. Trust of government will impact how receptive communities are to new adaptation strategies and livelihood initiatives. Meaningful participation of community members in the management process will improve the chances of success in any new climate-related initiatives, not only by enhancing buy-in, but by ensuring that all have a voice in decisions that could affect their lives.

Example of a survey question:

1. For each statement, please rate your level of agreement (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)

Leadership, governance and institutions	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
Our community leaders are interested in climate change issues and the impacts on our community.						
Our community has leaders who have knowledge and skills to effectively take charge of climate change adaptation.						
I trust our leaders to lead the community through climate change adaptation.						
Our community leaders/government officials inform us of national or regional climate change policy or initiatives that may impact our community.						
Our leaders can provide us with the resources we need to adapt to climate change						
There is a climate adaptation plan for our community.						
I have had the opportunity to participate in community-level decision-making						
Our coastal and marine resources are managed sustainably under formal or traditional rules and regulations or other forms of protection						

1.7 Availability and access to resources, assets, and capitals

Availability and access to resources, assets or capitals plays an important role in the social adaptive capacity of communities facing climate impacts. *Assets* include physical capital, such as materials for households and specific livelihoods, infrastructure, housing, tools and technology, energy and water supplies, markets, and natural capital or resources. It also covers non-material assets/capitals, such as human capital (e.g. knowledge, skills, experiences, good health), financial capital (wealth, money, source of credits), and social capital (ability to act collectively, social networks, connections, trust, social safety nets). Natural resources/capitals often serve as the foundation for products and ecosystem services. Levels of access to natural resources may vary from person to person within the same community due to traditional or legal rights, ownership and other types of institutional arrangements. Resources can also refer to benefits provided by government or community assistance programs (such as cash benefits, training in alternative livelihoods, information about climate change, and disaster relief packages).

This information can help predict the adaptive capacity of households and communities, and to identify particularly vulnerable households, which may need more attention in the event of a serious climate event. Data on access to resources among different socioeconomic groups can also be compared with perceptions of resource conditions or levels of climate knowledge; this may highlight key areas to target for adaptation strategies. This kind of feedback may also highlight groups that have better access than others to both resources and information about those resources. Not only can this help determine adaptation actions related to equity, it can also help identify who has the deepest understanding of the resource and is best able to help inform and develop adaptive strategies.

Example of a survey question:

For each statement, please rate your level of agreement (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)

Availability and access to resources, assets and capitals	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
My household has access to land and sea resources that we can use or sell.						
Access to the reefs and sea is fair and equitable for all community members, including women.						
My household has friends, relatives, and other community groups who support us through difficult times.						
Our community members work well with each other in times of natural disasters or difficulties.						
Our community is able to access support from outside agencies or organizations that can help us effectively cope with climate change impacts.						
There are sources of credits our household can access when needed.						
There are accessible markets for our products.						
Our household has the knowledge and experiences to deal with natural disasters.						

In relation to social capital, formal and informal networks are institutional and social networks that might contribute greatly to preparedness, response, and recovery. *Formal institutional networks* may include those that are formalized with clear structures and that are supported by governmental authorities or institutions, such as hazard mitigation networks, health service networks, or protected area networks. *Informal networks* are often formed through social connections in a group that shares common values, interests, engagement, or purpose. They may be large families, clans, church groups, women's groups, or occupational groups. In some communities, informal social networks might help them to be less vulnerable to hazards, as well as being their only source of disaster assistance. While such networks may have been in place for a long time, they might only recently have begun to be involved in addressing climate hazards. In other communities, such networks may have already dealt with climate-related hazards that regularly impact the community. In the Pacific, such as on Namdrik Atoll in the Marshall Islands, traditional leadership institutions are being reinforced as they are used to reconnect to ancestral practices that help the community deal with climate hazards (Ishoda 2011). In communities where religious affiliation is strong, religious services or meetings might be a means of reaching people, and support from religious leaders may be crucial for local participation and successful project implementation. Knowing the availability and quality of these networks could help gauge a community's adaptive capacity, as these networks will provide security during times of change (shelter during disasters, financial support, and basic social support during difficult times). If no networks are available, or if existing networks have challenges or problems, these are areas that could be addressed to improve a community's adaptive capacity.

Consider the totality of climate change issues facing the community. Is there a network or community group adequately addressing each issue? For example, if the community is facing sea level rise and coral bleaching, but there is only a network to watch for coral bleaching, there may be a need for a group that can monitor sea level rise.

To collect data, identify key informants and ask them to describe formal and informal networks, their supporting role in climate adaptation and hazard mitigation, their history and length of time of supporting/preparing for climate hazards, and their effectiveness. Key informants may include members or leaders of the networks, community leaders, and representatives from groups who have first-hand experience with climate impacts and adaptation. Information on processes, opportunities, problems, and challenges related to network roles should be recorded. In the case of formal networks, the purpose of which is hazard mitigation or climate adaptation, it is important to learn from both those who implement activities and those who are affected by and have first-hand perceptions of the quality and effectiveness of the program.

Examples of semi-structured questions for key informants:

1. Are there any groups of people or organizations that support climate change preparedness or help with the recovery after an event? If so, could you please describe who they are, how long have they exist, and what are their activities?

   Possible follow-up questions:

2 What is the percentage of the community participating in each of the groups/organizations?
3 Who participates?
4 How successful are these groups/organizations in helping the community?
5 Do you see any gaps in their work or the resources they would need? If so, could you describe?

1.8 Determining agency

Determining agency refers to ability of people to act on what is valued and to bring about change. In the context of social adaptive capacity, it may include the capacity or ability of a community to anticipate change and develop response strategies, as well as the capacity to learn, plan (or re-plan), re-organize and change in response to climate hazards. This indicator category is important since adaptive capacity is not only about having the necessary resources, but also about the willingness to act and the ability to mobilize resources for adaptive actions (Cinner et al 2018). Management may build agency for adaptive capacity by incorporating local knowledge in developing adaptation options, by empowering people through participatory processes in co-management and adaptation planning, or by removing barriers that may inhibit people's ability to exercise agency (Cinner et al 2018).

Ability of a community to reorganize is an example of an indicator under the *determining agency* category. It refers to the degree to which a community is able collectively to learn, plan, and make necessary changes to cope with climate-related impacts in such a way that its main functions are sustained. This may require restructuring organizations, changing plans, shifting priorities, adjusting roles, carrying out activities in different ways, or applying lessons from the past to better face a climate hazard. *Degree of community reorganization* is a function of factors including cooperation and collaboration among community members, planning for climate change, the level of collectivism in the culture, community leadership, shared goals and responsibilities, and access to and support from other sources in reorganization.

Data can be collected from key informants such as community members and leaders who are involved in collective activities, and they should be interviewed on issues related to the interest and ability of community members to work together to address external stresses. These might be related to climate or natural hazards. The key informants are asked to share their perspectives regarding how well the community is able to reorganize in working collectively to confront the consequences of climate hazards, how the community coordinates and collaborates, and the nature of shared goals and responsibilities among the leaders and members.

Survey questions can be included if a household survey is conducted to test whether community members share the same perspective as key informants. If the household survey reveals different perspectives than those of community leader informants, it could indicate a disconnect between the community and its leaders—an issue that perhaps should be explored, for example, by sharing the results of the household survey with community leaders/key informants.

Example of a household survey question:

On a scale of agreement from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree), please rate the following:

Determining agency	1 = strongly disagree	2 = disagree	3 = neither	4 = agree	5 = strongly agree	I don't know
My household is willing to learn and do things differently in response to climate impacts and hazards.						
I would like to do more to help sustain our fisheries.						
My household is able to reorganize to respond to a new situation.						
Our community is able to coordinate activities to respond quickly to the impacts of a natural event/hazard and a new situation.						
Our community has institutions that support us when we need to reorganize to cope with new situations or problems.						
Our leaders involve us in decision making that affects our community.						
Members of my household participate in management planning and decision making related to resource management.						

2. Cultural heritage

3. Connection and sense of place and identity

This section complements Table 16 in the main report by providing examples of indicators and survey questions for cultural heritage, and connection and sense of place and identity. Cultural heritage should be monitored using indicators chosen by local people to reflect the worldviews of their culture. Despite a lengthy process to derive such indicators, the results are locally owned and recognized. These areas require in-depth understanding and survey data should be complemented by qualitative data collecting methods appropriate for cultural studies (Pickering 2008).

The table below provides examples for indicators for heritage, and sense of place and identity of an on-going Integrated Ecosystem Assessment in West Hawaiʻi (Leong et al 2018).

Domains	Attributes	Potential indicators of cultural ecosystem services
Heritage	Multi-generational interactions/connections with natural resources	Transmission of knowledge or practices around deified ancestral guardians (e.g., *ʻaumakua*); use or transmission of stories

Domains	Attributes	Potential indicators of cultural ecosystem services
		and verbal histories (e.g., *moʻolelo*); birth place and family burial sites; ceremonial practices, practices of respect, and other practices related to connection with place and resources
Sense of Place & Identity	Sense of self, community, and/or home related to the coastal and marine environment	Activities on the landscape; heritage, social, and emotional connections to places
	Presence of historical place-based names which describe the past and present of the coastal and marine environment	Place names; landscape terms; species names; environmental process names (e.g., rain names, wind names); transmission of existing or creation of new cultural proverbs to describe these observations
	Engagement of families in coastal and marine resource based activities	Existence and availability of activities such as fishing or harvesting for livelihood or enjoyment
	Presence on and interaction with lands that will remain secure (formally or informally) for future generations	Presence by lease, physical access, ownership, and/or occupation; customary rights and tenure

Example of household survey questions (Community-based subsistence fishing practitioner survey 2017):

1. What is your relationship or connection to [Site Name]?
(INTERVIEWER: ALLOW RESPONDENTS TO RESPOND FIRST, AND CHECK ALL BOXES THEY SELF-IDENTIFY WITH, THEN ASK PROMPTING QUESTIONS FOR THE REMAINING OPTIONS AND CHECK ALL THAT APPLY)

☐ I was raised in and am familiar with the area since childhood

☐ My lineal ancestors are from[_Site Name]

☐ I am connected to [Site Name] as a practitioner of local traditional and customary fishing/ocean gathering.

☐ I regularly fish and gather from [Site Name]'s ocean waters.

☐ I am a resident of [Site Name]

☐ I work in [Community Name].

☐ I'm a regular visitor to [Site Name].

☐ I actively care for the ocean areas of [Site Name]

☐ Other **(PLEASE SPECIFY)** ________________________________

2. How many generations has your family been fishing or gathering ocean resources from the [Site Name] area?

(INTERVIEWER: ALLOW RESPONDENT TO ANSWER, AND CHECK BOX NEXT TO RESPONSE THAT BEST REFLECTS RESPONDENTS ANSWER. PROMPT AS NEEDED)

☐ Your generation is the first

☐ Since your parents' generation

☐ Since your grandparents generation

☐ Since your great grandparents generation

☐ Since beyond your great grandparents generation

3. How many years have you been fishing or ocean gathering in [Site Name]'s ocean waters? *(INTERVIEWER: REFER TO MAP)* ___________

4. What are the purpose of your fishing/seafood harvesting? (Check all that applies.)

☐ Share with other individuals and families (not special events)

☐ Provide food for special social events and gatherings (for birthdays, graduations, funerals etc.)

☐ Provide food for other Hawaiian cultural or religious ceremonial events (e.g. hula)

5. On a scale of agreement from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree), please rate the following:

Statements	1 = strongly disagree	2 = slightly disagree	3 = neither	4 = slightly agree	5 = strongly agree
In our community, young people learn from their parents and elders how to use and care for the land and sea of our place					
Both young and old people of our community participate in a traditional event or ceremony.					
At least one person in my family has appropriate knowledge to carry out a traditional cultural performance					
My household members have the knowledge and skills to use local land and sea resources to support our families.					
My household still uses traditional* skills in fishing & harvesting marine resources.					
Generally young people in our community are respectful of the elders					
Important cultural sites in our community are well-maintained					
It is common for people to use traditional place names or local language for the places					
My family believes we should take care of the land and the sea as they take care of us.					
Our customary rights for land and sea are practiced.					
The ways our generation is using the local natural resources will allow the next generations to meet their needs in the future.					

Statements	1 = strongly disagree	2 = slightly disagree	3 = neither	4 = slightly agree	5 = strongly agree
The reefs and the ocean are my life.					
The children in my family would like to live the same way of life we have had here in [Site Name]					
Our community come together when needed to work on a common cause					
Migration out is common in our community					
People who moved into our community respect the local rules					

4. Access to information on coastal and marine resources

The level of access to information on coastal and marine resources has been identified as a data gap and has recently also been identified in the socioeconomic NRCMP indicator review. This gap has already been addressed with a reef-focussed survey question being added for the next round of socioeconomic NRCMP data collection as follows. The sources of data and the focus of the topic may be adjusted, as needed, to ensure relevancy to specific study sites/jurisdictions and coastal management needs.

Example from a household survey (NCRMP 2019):

How often do you use each of the following sources of information to provide you accurate information on coral reefs and coral reef related topics in [jurisdiction]?

Sources	Never	Rarely	Sometimes	Frequently
Newspapers, other print publications				
Radio				
TV				
Online news sources/websites				
Social Media				
Friends and family				
Community leaders				
Government (jurisdictional)				
Federal government agencies (NOAA, EPA)				
Non-profit organizations				
Other, please specify				

5. Willingness to pay for coral reef protection/conservation

Similar to access to information, the data gaps on the willingness to pay for coral reef protection/conservation has been addressed by the socioeconomic NRCMP indicator review. Below are two examples from actual surveys.

Example from a household survey (NRCMP 2019):
[INTERVIEWER READS] Please carefully consider the following HYPOTHETICAL plan to protect coral reefs in [jurisdiction]:

There is a need to raise funds to improve management of coral reefs. IF the state government of [jurisdiction] was considering adding a "Reef Conservation Tax" to your existing local sales tax to raise these funds, the funds generated from the "Reef Conservation Tax" would go directly to agencies involved in the conservation of coral reefs. The funds would pay for some of the management actions described in previous questions in this survey. These management activities would improve the amount of reef fish, reduce pollution from the land, and restore damaged coral reefs.
Suppose, in order to implement the new policy, [jurisdiction] had to call a statewide referendum where all residents over age 18 were asked to vote on the amount of the tax increase. If the majority of persons vote for the increase, then the tax would be implemented.

Please note, there is currently NO actual tax under consideration.
If the proposed hypothetical tax were to cause your household expenses to increase by $XX per year, or in other words, $Y extra per month (Bid range: $10, $25, $50, $100, $250, $500), consider what decision you would make if you really had to spend the extra money, given your current budget.

(CHECK ONLY ONE ANSWER)
☐ YES ☐ NO

SKIP PATTERN-- If respondent answers "yes" to the question, skip to the next question:
What are the main reasons you oppose the "Reef Conservation Tax"? (CHECK ALL THAT APPLY)

a. This increased tax would be too expensive for me
b. I don't trust the government to give the money to the environmental agencies
c. I don't think the environmental agencies are effective
d. I prefer to donate directly to environmental organizations
e. I don't believe in raising taxes on principle
f. I think that current management is effective and doesn't require more economic resources
g. Other

Example from the a diver and snorkeler survey (Oldiais 2013):

Please rate your level of agreement on the following statements

Statements	Completely disagree	Disagree	Neither agree nor disagree	Agree	Completely agree

The $US 25.00 Rock Island permit fee for 10 days that I paid is reasonable.					
If you disagree that the Rock Island permit fee is reasonable, please suggest an amount $US______.					