Summary Report from the 4th Annual Collaborative Climate Science Workshop, 13–15 October 2020

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Background

In 2016, the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) enacted the NOAA Fisheries Climate Science Strategy (Link et al. 2015) as part of its proactive approach to better track, forecast, and incorporate information on changing climate conditions into living marine resource management. Drivers and impacts of climate change vary greatly by geographic location. Therefore, the strategy is being implemented through customized 5-year Regional Action Plans for climate science (RAPs). These RAPs detail regional climate science needs and specific action items to address them. By creating action plans at the regional level, NMFS is tailoring its response to meet specific climate challenges and forging critical partnerships at the local level.

The Pacific Islands Regional Action Plan for climate science (PIRAP; Polovina et al. 2016) is a 5-year action plan that runs from 2017 to 2021. The first step in implementing the PIRAP was twofold: (1) identifying the specific information needed by resource managers and (2) understanding the scientific research and data available or being developed. To facilitate this objective, PIRAP authors decided to convene an internal Annual Collaborative Climate Science Workshop as a forum where regional staff can keep abreast of changes on these fronts and integrate the active scientific endeavors with management needs. The first, second, and third workshops were held in September 2017, 2018, 2019, respectively (hereafter 1st, 2nd, and 3rd Workshop). The 4th Annual Collaborative Climate Science Workshop (hereafter 4th Workshop) was held on 13–15 October 2020. All workshops were attended by staff from the NMFS Pacific Islands Regional Office (PIRO) and Pacific Islands Fisheries Science Center (PIFSC), NOAA's National Environmental Satellite, Data, and Information Service, and the Western Pacific Regional Fishery Management Council (WPRFMC), as well as by several members of WPRFMC advisory bodies.

During the planning stages for the 2nd Workshop, the steering committee laid out a multi-year cycle of goals to unify the Annual Collaborative Climate Science Workshops. The 1st Workshop focused on broad information gathering and exchange. The 2nd Workshop narrowed the focus and identified regional priorities for moving forward. The 3rd Workshop focused on 15 specific projects aligned with those priorities. The steering committee envisioned the 4th and subsequent workshops focusing on progress within those projects as well as the broader regional priorities. Eventually, another information-gathering workshop will be held, and the cycle will repeat. Bringing a cyclical nature to the Annual Collaborative Climate Science Workshops will ensure that each year's workshop addresses contemporary concerns, that our regional climate science is continually moving forward, and that we are always working from a current set of management information needs and science products/endeavors.

The goals for the 4th Workshop followed the cycle described above and took into account that the following year (2021) would be the final year of the PIRAP. The workshop goals were to (1) review the successes and challenges of the focal projects discussed at last year's workshop, and (2) identify potential gaps in our region's climate-informed living marine resource management and conservation. The gap analysis was consistent with the 3rd Workshop report which stated that "with so much energy focused on the 15 [focal] projects… it will be important for regional scientists and managers to be cognizant of resulting gaps. The workshop steering committee and

PIRAP implementation leads will work to incorporate gap recognition into future planning" (Woodworth-Jefcoats et al. 2020).

Due to the ongoing COVID-19 pandemic, the 4th Workshop was held virtually. This was a stark departure from the workshop's traditional in-person format centered around multiple concurrent small group conversations. Rather, this year, all workshop sessions had a single group consisting of all participants.

The goal of reviewing the successes and challenges of the focal projects discussed at the 3rd Workshop was accomplished through the presentations delivered during the plenary opening session. Speakers provided updates on each of the 15 focal projects. A list of these projects can be found in Appendix A. All projects saw some degree of progress despite facing an extremely unexpected year. While many projects still leaned heavily towards the science side of the region's work, several included robust collaboration between scientists and managers. Most notable among these were efforts to document our current state of knowledge and identify information gaps surrounding mitigation work at French Frigate Shoals which grew out of the project examining monk seal responses to sea level rise, and the coral reef projects focused on vital rates and data downscaling. These projects were among those rated as having the closest alignment between current scientific work and management needs at the 3rd Workshop (Woodworth-Jefcoats et al. 2020).

Like previous workshops, the remaining sessions each focused on a specific ecological management component:

- Session 1: Protected species
- Session 2: Insular fisheries
- Session 3: Pelagic fisheries
- Session 4: Essential fish habitat and corals

All sessions followed the same format, though only relevant focal projects were discussed in each (see Appendix A for the list of projects discussed in each session). Sessions began with a brief exercise that took the place of traditional oral introductions. Participants listed their name, affiliation, climate-related area(s) of expertise, and any additional climate-related interests in a shared document. This information was aggregated across sessions and can be found in Appendix B. Following the introductory exercise, each relevant focal project was reviewed for potential gaps. Twenty minutes of facilitated discussion was devoted to each project. This was followed by a gap analysis of each of the four regional priorities identified at the 2nd Workshop:

- Understanding future shifts in species distributions underpinned with robust baselines
- Better understand species' physiological responses to climate change
- Continue to investigate food web responses to climate change
- Improved collaboration between scientists and managers

This analysis was focused on gaps that could be addressed within the remaining year of the PIRAP and areas on which to focus during the next iteration of the action plan, PIRAP2.0. Twenty minutes of facilitated discussion was devoted to each priority.

This year's workshop was preceded by a special session to document our current state of knowledge and identify information gaps related to mitigation work at French Frigate Shoals. This work grew out of the focal project examining monk seal response to sea level rise. NOAA's Pacific Region Executive Board (PREB) identified this project as a regional priority and is working through the Pacific Region Climate Council to bring together staff from across and outside NOAA in order to identify and mitigate the range of climate-related and anthropogenic threats that protected species are facing at French Frigate Shoals. French Frigate Shoals demonstrates, in a microcosm, the impacts anthropogenic forces (e.g., shoreline hardening and seawall construction) and climate change are having on protected species and ecology across the region. A separate report details the results of this special session (Marra et al. 2021).

Gaps and opportunities in the Pacific Islands region's implementation of climate-informed management and conservation

The gap analyses conducted during the 4th Workshop were done with the PIRAP timeline in mind. The workshop was held in 2020, year four of the 5-year action plan. Therefore, the steering committee was particularly interested in identifying gaps which should be addressed in the remaining year of the PIRAP. The steering committee also used the gap analyses to identify opportunities to be capitalized upon in the next phase of the action plan, PIRAP2.0. These gaps and opportunities are discussed below. Further avenues for scientist–manager collaboration are also discussed, as this was a common theme across this year's workshop and a priority identified during the 2nd Workshop (Woodworth-Jefcoats et al. 2019). We note that this report does not rank the priority order of these gaps, opportunities, or pathways to collaboration.

Climate-related gaps to address in the near term

Despite each focal project having specific, often unique, goals and each session having a different ecosystem and management focus, several common gaps emerged from the workshop discussions. These gaps comprised identifying clear priorities for allocating limited resources and capacity, establishing baseline information, conducting multi-faceted analyses, regional downscaling of global data, and enhancing engagement with social scientists. These issues are discussed below.

Priorities for allocating limited resources and capacity

There was much discussion on the need to establish clear priorities for allocating limited resources and capacity as well as acknowledging the challenges involved in determining these priorities. Discussions on the need for priorities generally fell into two categories: (1) a desire for clear regional priorities, which could be used to allocate staff capacity, or (2) the challenge inherent in balancing competing interests to set priorities. Of these two, the latter theme dominated.

When discussing the challenge of determining priorities, participants offered a range of approaches. One approach was to prioritize research and data processing based on management needs. This included both the needs of PIRO and WPRFMC as well as looking to other management agencies such as the U.S. Fish and Wildlife Service for examples where areas of responsibility intersect. Another suggested approach was prioritizing actions based on the immediacy of threats posed by specific stressors. This approach could be particularly relevant at French Frigate Shoals where long-term climate impacts on protected species are currently overshadowed by more immediate dangers from deteriorating infrastructure. A similar triage-like approach was also suggested when the coral reef vital rates project was discussed. This project tracks coral growth and mortality at sites across the region. One project member mentioned that "common and widespread taxa were selected" for analysis, thereby focusing attention where it is likely to have the greatest impact. Finally, participants also suggested using the degree of projected climate change impacts as a way to guide prioritization, with both extreme events and long-term trends offered as measures of change.

Fisheries management concerns were subject to a unique balance of competing priorities. Participants cited the tensions between the commercial value of fisheries and the number of

participants in a fishery. They also mentioned mismatches between the vulnerability of certain fisheries to climate change with the size of the fishery, creating a challenge for prioritization. Finally, the way in which fished species are managed (e.g., ecosystem components vs. management unit species or species complexes vs. single species) can create barriers to prioritizing research.

Conversations on prioritization also included possibilities for incorporating climate priorities into other existing priorities rather than considering climate priorities independently. This approach could allow regional climate work to capitalize on broader NOAA priorities such as genomics, artificial intelligence, and uncrewed observing platforms. The degree to which climate-related work can align with these agency priorities could be one way to prioritize regional climate science activities.

Baseline information

The necessity for baseline information was a component of the top priority that emerged from the 1st and 2nd Workshops: understanding future shifts in species distributions underpinned with robust baselines. This year's gap analysis reveals that not only does this need persist, but is more widespread than originally thought. It extends beyond species distributions to investigating food web responses to climate change as well as understanding physiological responses to climate change. Participants noted the need for baseline diet information, particularly for cetaceans and pelagic fish. They also noted a lack of baseline information regarding life history characteristics and demographics, especially for pelagic fish. The resource-intensive nature of establishing baseline information could be a contributing factor to the breadth of this gap.

Multiple participants noted the potential for tagging studies to address the challenge of establishing robust baselines of present species distributions. With work underway to establish international telemetry data sharing, this could be a particularly opportune time to leverage existing collaborations in order to strategically expand regional tagging efforts. Shared knowledge on tag deployments across the Pacific will allow for a more strategic and synoptic approach to future deployments. Cross-regional collaborations on using tag data, such as that at the heart of the telemetry focal project, will further inform decisions on future tagging operations. It is also expected that these types of cross-region collaborations can expedite the establishment of baseline species distributions.

Cross-region and international collaboration were noted as important components of establishing baseline life history and demographic information for pelagic fish. Such information is a key component of stock assessments. Both improved baseline information, as well as an understanding of how physiology and demographics may respond to climate change, will contribute to the development of climate-informed stock assessments. Participants noted that several collaborations are currently being developed in an effort to establish this baseline information for billfish and tunas.

Metabarcoding emerged as a particularly promising avenue for establishing baseline diet information. The one hindrance noted was the need to establish reference databases for mid-trophic and mesopelagic species. Once these databases are established, metabarcoding could be used across species and habitats. Furthermore, it is feasible that diet could be investigated on a nearly annual basis. Work is already underway at PIFSC to establish the reference databases.

Collaboration with academic partners and with NMFS scientists in other regions could help broaden the species included in the reference databases. Collaboration with taxonomists will also be an essential component of this work to ensure that genetic data are linked to the appropriate species.

Multi-faceted analyses

Across each workshop session, the need for multi-faceted analyses arose. These analyses included multi-stressor and multi-species approaches. For example, sea turtles will face not only rising nest temperatures, but also a loss of nesting beaches as a result of sea level rise. Coral reefs face not only increasing ocean acidification, but also increasing water temperatures. Dynamic pelagic habitat is shaped by temperature and oxygen concentration as well as prey distribution and other facets. Participants noted the need for future research to examine a more complete picture of climate-driven effects on living marine resources and habitats.

Multi-species analyses are another type of multi-faceted analyses that was discussed. Examples of these analyses include estimates of multi-species carrying capacity of terrestrial habitat at French Frigate Shoals. Aspects of pelagic fisheries also lend themselves to multi-species analyses, such as simultaneous investigation of targeted and protected species in order to understand climate effects on interactions.

Potential pitfalls of multi-faceted analyses were also discussed, primarily in regard to stock assessments. For example, to justify adding an environmental variable to a stock assessment, the relationship between that environmental covariate and the biological variable to which it connects must remain meaningful over time. Often this relationship eventually breaks down. Other challenges to multi-variate analyses involve determining which meaningful relationships should be included and recognizing when single variables may be more informative than a multivariate suite.

Regional downscaling

Discussions in several sessions addressed the need for regional downscaling of output from global climate and earth system models, both for scientific uses as well as management relevance. Downscaling encompasses a range of techniques for increasing the spatiotemporal resolution of these data which are typically available at a 1° horizontal resolution, monthly temporal resolution, and 10–15 m vertical resolution in the upper ocean. This need was raised in relation to coral reefs, insular fisheries such as bottomfish, and terrestrial habitat for protected species. The processes/variables mentioned as particularly needing downscaled data were sea level rise, currents, and temperature. Further communicating how higher-resolution data would be useful to scientists and inform management decisions would help the modeling community focus on specific outcomes and justify devoting resources to downscaling efforts.

Multiple downscaling methods were discussed. These included statistical downscaling, dynamic downscaling, and the use of neural networks. Participants stated that different approaches may be more appropriate than others in certain situations. For example, strong mechanistic relationships may be able to be captured through statistical downscaling; however, more nuanced and dynamic variables such as near-shore currents may require dynamic downscaling. Given regional

scientific expertise, this is a gap that will likely have to be filled through partnering with academia or other regions and line offices.

Engagement with social scientists

The steering committee observed that there were several data gaps that could be addressed through engagement with social scientists. Many conversations during the insular fisheries session included participants sharing comments from fishers about how fishing grounds and catch have changed over time. The pelagic fisheries session included questions about how vessel captains make choices about fishing practices such as fishing time and location. Questions about the effects of foreign fleets were also raised. These included concerns about the potential for Illegal, Unreported, and Unregulated (IUU) fishing as well as questions about the competitive threat posed by foreign vessels. While there are real challenges associated with collecting this type of information, one social scientist attending the workshop expressed optimism about the prospect of moving towards routine collection of social data as primary data.

Greater engagement with social scientists could also help natural scientists better quantify the costs of climate effects on regional living marine resources, such as the socioeconomic impacts of changing target species distributions. Furthermore, increased collaboration between natural and social scientists and managers could lead to a better understanding of the costs of various options for climate mitigation. Often in responding to climate change, action is less expensive the earlier it is taken which introduces an element of urgency to this engagement.

Cross-cutting opportunities for bolstering regional climate-informed management

The discussions at this year's workshop also yielded several cross-cutting opportunities upon which the region could capitalize to advance climate-informed management and conservation. These opportunities included recognizing management-driven inroads for climate science, capitalizing on the United Nations Ocean Decade, conducting scenario planning, and supporting ecosystem-based fisheries management (EBFM). These opportunities are outlined below.

Management-driven inroads for climate science

Workshop discussions highlighted some counter-intuitive areas where management intersects with climate science. The most frequently mentioned example was bycatch being a direct management link to pelagic fisheries. Of primary concern is how climate-driven changes in longline fishing grounds could affect protected species interactions. Thus, the most straightforward way to incorporate climate science into pelagic fisheries management may actually be through the lens of mitigating fishing impacts on protected species. Management boundaries were another example, with fishing effort moving into regional Monuments during certain phases of the El Niño–Southern Oscillation. Monuments were also mentioned as potentially home to bigeye spawning areas. Here, the path to including climate science in Monument management may be through climate-driven effects on transient, commercially valuable species rather than through habitats or species unique to the Monument.

Better awareness of these management inroads could create new opportunities to integrate climate science into regional management. One way to foster these connections would be to increase cross-topic collaboration, for example, between protected species and insular and pelagic fisheries or between social and natural scientists. Researchers' deeper understanding of

the management process could also raise awareness of these inroads. Focus sessions and discussions to this end are currently being planned by regional directorate staff. Finally, the structures of PIRO and PIFSC do not immediately suggest where one might go when reaching out across organizations. Having clear points of contact at both places, as well as at WPRFMC, would help alleviate this barrier.

Ocean Decade

The United Nations Decade of Ocean Science for Sustainable Development (UN Ocean Decade) begins in 2021. It is anticipated that the UN Ocean Decade will bring unprecedented attention to oceans and marine resources and how they will be affected by climate change. Such attention could bolster the visibility of regional climate work, leading to new opportunities for collaboration and data sharing.

Scenario planning

Scenario planning (Frens and Morrison 2020) was identified by workshop participants as a way to approach multi-faceted analyses and identify priorities for resource allocation. Scenario planning could be used to identify the range of potential futures, giving a sense of possible vs. likely climate effects. This approach could also help identify thresholds to incorporate into or trigger management actions.

Climate-driven changes to habitat can be extremely site-specific, and these location-specific elements of scenario planning must be well articulated and quantified in order to ensure the results are applied appropriately. Participants noted that it will be important to capture dependencies and assumptions built into scenarios. These include, but are not limited to, species-specific responses, assumptions regarding the order of chains of events, and dependencies between physiological rates.

Ecosystem-based fisheries management

The EBFM Roadmap highlights the importance of continuing to observe regional climate-related variables and incorporating the effects of climate change into EBFM. This overlap between NMFS priorities potentially provides opportunities to leverage resources. For example, EBFM-oriented initiatives could be avenues for pursuing the multi-species analysis mentioned above. They could also provide managers with projections of climate effects on protected and managed species. As one workshop participant stated, “The goal of EBFM is to get to a place to do predictive types of modeling,” to assist in effective management. Recently expanded staff capacity for Management Strategy Evaluations could also be brought to bear in merging EBFM and climate-related work.

The close alignment between the region’s EBFM and climate goals also provides an avenue for prioritizing the allocation of resources and capacity by prioritizing work that simultaneously advances both NMFS foci. Aligning EBFM- and climate-oriented work could also maximize the reach of any funding directed specifically towards one of these initiatives (e.g., annual funds from the Office of Science and Technology to advance the implementation of RAPs).

Continued need for scientist–manager collaboration

The need for improved collaboration between scientists and managers was identified as a regional priority during the 2nd Workshop (Woodworth-Jefcoats et al. 2019). This year's workshop highlighted several successful collaborations. These included the efforts to document our current state of knowledge and identify information gaps related to mitigation work at French Frigate Shoals, data downscaling around coral reefs, coral reef community vital rates, and climate-informed stock assessments. Despite these successes, the clear need for continued attention to this priority emerged during the workshop. The steering committee offers the following possible avenues for continuing to improve scientist–manager collaboration in the Pacific Islands region: leadership-led socialization of priorities, spotlighting successful collaborations, and data sharing. These avenues are discussed below.

Leadership-led socialization of priorities

The opening plenary session included remarks from the directors of the Science Center and the Regional Office, both of whom emphasized the role these workshops play in setting and advancing regional priorities. In this vein, the steering committee reiterates the importance of continued emphasis of the priority leadership places on scientist–manager collaboration and for collaborative leadership in establishing shared priorities. Furthermore, this emphasis needs to be communicated down the supervisory chain with pathways for engagement provided by the appropriate leadership, as well as encouragement to engage early in and frequently throughout collaborations. Leadership could also share their vision of the types of collaborative results they are seeking and define what is considered a successful collaboration between managers and scientists.

Spotlighting successful collaborations

Another way to continue improving regional scientist–manager collaboration is to draw attention to successful collaborations. Doing so would provide a road map that others could follow. Means for highlighting successful collaborations include the IRC Seminar Series, mentions in all-hands messages from regional leadership, and discussions in program and division meetings. These discussions should include information on how the collaborations were forged and maintained, the specific management and scientific results of the collaborations, and identification of the particular value added by collaboration.

Data sharing

Awareness of existing data emerged as a specific area where scientist–manager (and scientist–scientist) collaboration can be improved. There were a number of workshop discussions in which one participant mentioned the need for specific data, and another participant responded that they had said data. The Pacific Islands region maintains myriad time series and datasets that range from multi-decadal time series of biophysical variables from coral reefs to visual and acoustic cetacean surveys to logbook and observer records. Asking staff to keep track of this full suite of data is impractical. Thus, more efficient means of publicizing and exploring regional data are needed. The steering committee is crafting an undergraduate internship project that will focus on facilitating regional data sharing. Internal publicity for fieldwork, receipt of grant deliverables, staff publications, and specific information needs related to management actions could also

bolster data sharing. We note that a coordinated approach as well as a central repository to reference (e.g., intranet) is required to avoid overwhelming staff with information.

Data sharing has the potential to yield novel approaches to existing data applications. Improved within-region data sharing is also likely to improve data sharing across regions and with external partners. Such benefits are expected to increase the return on investments in data collection. Going forward, data collection efforts should take into account existing data and strive to augment these data sets to the fullest extent possible.

We note that data sharing does include challenges. For example, there may be mismatches between the resolution at which data are collected and that which might be needed for a certain application. Improved early cross-project collaboration should help address this particular concern. Data confidentiality is also a challenge inherent in the sharing of fishery-dependent data. At the practical level, data storage and transmission can also be significant hurdles, particularly during the current period of extended mandatory telework. Understanding how to work with various types of data also poses a real, though not insurmountable, obstacle. Challenges such as these should be anticipated when making plans to expand regional data sharing.

Summary and next steps

The goals of the 4th Annual Collaborative Climate Science Workshop were to review successes and challenges of the focal projects discussed at last year's workshop and to identify potential gaps in our region's climate-informed living marine resource management and conservation. To achieve these goals, the 4th Workshop included a plenary session devoted to reviewing the focal projects and four theme sessions devoted to gap analyses. These yielded cross-cutting gaps as well as opportunities. Workshop discussions also highlighted the ongoing need to bolster collaboration between managers and scientists.

The gaps identified during the workshop can be grouped into five categories. One: participants consistently noted the need to identify clear priorities for allocating limited resources and capacity. It was felt that priorities should be management-driven and based on the degree to which living marine resources may be affected by climate change. Two: baseline information is necessary to assess the degree of change projected and occurring. Species distributions, diet composition, physiology, and demographics all require more thorough baseline information. Three: multi-faceted analyses were raised as a potentially valuable tool. Examples of such analyses include multi-stressor and multi-species projections. Four: regional downscaling of global earth system model output is needed. This is particularly true for coral reef environments and projections for Hawai'i's bottomfish fishery. Five: managers and natural scientists need to pursue greater engagement with social scientists and vice versa. Applications for such engagement range from assessing the socioeconomic impacts of potential mitigation measures to gaining historical insight from longtime fishery participants to projecting how coastal communities may be affected by climate-driven changes to the marine resources upon which they rely.

Opportunities that emerged from this year's workshop included recognizing management-driven inroads for climate science, capitalizing on the UN Ocean Decade, conducting scenario planning, and supporting ecosystem-based fisheries management (EBFM). A better understanding of the intersection between regional management concerns and climate science could create new opportunities for advancing climate-informed living marine resource management and conservation. The UN Ocean Decade is expected to create opportunities for ocean observation and global data sharing. Scenario planning was highlighted as a way to synthesize climate impacts across ecosystems in order to prioritize management actions. There is considerable overlap between NMFS's climate and EBFM goals, creating a natural nexus for collaboration on mutual interests.

The continued goal of improving collaboration between scientists and managers was evident throughout this year's workshop. Leadership-led socialization of this priority, spotlighting successful collaborations, and data sharing are all avenues for advancing these partnerships. While several focal projects advanced regional scientist–manager collaboration, the majority are still struggling to find the best techniques to achieve collaborative success. Leadership-led, top-down emphasis placed on this priority could help regional staff identify resources and pathways for collaboration and provide staff with examples for modeling future initiatives. Data sharing offers a fruitful path through which regional managers and scientists can engage with one another.

This year's Annual Collaborative Climate Science Workshop drew the largest audience to date. While there were undoubtedly a number of contributing factors, its virtual nature was likely chief among them. Going forward, the steering committee hopes to retain the flexibility the virtual format afforded, where participants could step in or out as their interests aligned with the topics at hand and their schedules allowed, while also hopefully bringing back at least some of the in-person elements of previous workshops.

Next year's workshop will be held during the transition between the current and next phases of the PIRAP. Its alignment with the fifth and final year of the first phase of the PIRAP makes the venue ideal for reviewing PIRAP actions. Additionally, PIRAP2.0 will be drafted prior to convening the 5th Workshop, raising the possibility that the workshop could be used to launch it. This could initiate better integration of its action items into regional planning.

See you next year!

The 5th Annual Collaborative Climate Science Workshop will be held in September 2021. If you would like to help plan the workshop or provide feedback on this year's workshop, please contact a member of the workshop steering committee:

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Pacific Region Climate Council: John.Marra@noaa.gov

We are also looking for staff who are interested in contributing to PIRAP2.0, the next phase of our region's action plan for climate-informed living marine resource management. If you would like to be among those drafting this plan, please contact Phoebe.Woodworth-Jefcoats@noaa.gov or Ariel.Jacobs@noaa.gov.

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Appendix A: Agenda

Special Session in Mitigation Work at French Frigate Shoals: Tues, 13 Oct, 9am–12pm

9am	Opening and session overview	John Marra
9:30am	Small group discussions of elements/services and sensitivities/stressors	
11am	Small group report out and discussions	
11:45am	Next steps and adjourn	John Marra

Plenary Opening Session: Tues, 13 Oct, 1–4pm

	Opening remarks on regional climate-related priorities	
1:00pm	Welcome and opening remarks	Phoebe Woodworth-Jefcoats
1:10pm	Remarks from PIFSC Director	Michael Seki
1:15pm	Remarks from PIRO Director	Michael Tosatto
	Updates on Protected Species focal projects	
1:20pm	Climate mitigation work at French Frigate Shoals	John Marra
1:30pm	Sea turtle response to rising nest temperatures	Summer Martin
1:40pm	Cetacean distribution mapping	Erin Oleson
	Updates on Insular Fisheries focal projects	
1:50pm	BFISH: The Bottomfish Fishery-Independent Survey in Hawai‘i	Benjamin Richards
2:00pm	Identifying relationships with climate or the environment in the Mariana Archipelago through fish otoliths	Erin Reed
2:10pm	Environmental variables included in the bottomfish stock assessment	John Syslo
2:20pm	Social indicators for fishing communities	Danika Kleiber
	Updates in Pelagic Fisheries focal projects	
2:30pm	Progress and challenges in climate-informed stock assessments	Michelle Sculley
2:40pm	Using telemetry data to define pelagic habitat	Melanie Hutchinson
2:50pm	Projected movement of Hawai‘i’s bigeye fishery	Johanna Wren
3:00pm	Longline trip cost modeling	Hing Ling Chan
	Updates on Essential Fish Habitat & Corals focal projects	
3:10pm	Assessing coral reef community vital rates	Tom Oliver
3:20pm	Data downscaling around coral reefs	Malia Chow
3:30pm	The role of herbivorous reef fish in Pacific Island Region reef persistence	Tye Kindinger
3:40pm	Dynamic pelagic habitat	Johanna Wren

	Closing remarks and next steps	
3:50pm	Concluding remarks and workshop preview	Phoebe Woodworth-Jefcoats

Protected Species: Wed, 14 Oct, 9am–12pm

9am	Welcome and opening remarks	Phoebe Woodworth-Jefcoats
9:10am	Introductory exercise	
9:15am	Discussion of gaps and priority needs related to climate mitigation work at French Frigate Shoals	
9:35am	Discussion of gaps and priority needs related to sea turtle response to rising nest temperatures	
9:55am	Discussion of gaps and priority needs related to cetacean distribution mapping	
10:15am	Discussion of gaps within priority to build an understanding of future shifts in species distributions underpinned with robust baselines	
10:35am	Discussion of gaps within priority to better understand species' physiological responses to climate change	
10:55am	Discussion of gaps within priority to continue to investigate food web responses to climate change	
11:15am	Discussion of gaps within priority to improve collaboration between scientists and managers	
11:35am	Concluding remarks	Phoebe Woodworth-Jefcoats

Insular Fisheries: Wed, 14 Oct, 1–4pm

1pm	Welcome and opening remarks	Phoebe Woodworth-Jefcoats
1:10pm	Introductory exercise	
1:15pm	Discussion of gaps and priority needs related to BFISH: The Bottomfish Fishery-Independent Survey in Hawai‘i	
1:35pm	Discussion of gaps and priority needs related to identifying relationships with climate or the environment in the Mariana Archipelago through fish otoliths	
1:55pm	Discussion of gaps and priority needs related to environmental variables included in the bottomfish stock assessment	
2:15pm	Discussion of gaps and priority needs related to social indicators for fishing communities	

2:35pm	Discussion of gaps within priority to build an understanding of future shifts in species distributions underpinned with robust baselines	
2:55pm	Discussion of gaps within priority to better understand species' physiological responses to climate change	
3:15pm	Discussion of gaps within priority to continue to investigate food web responses to climate change	
3:35pm	Discussion of gaps within priority to improve collaboration between scientists and managers	
3:55pm	Concluding remarks	Phoebe Woodworth-Jefcoats

Pelagic Fisheries: Thurs, 15 Oct, 9am–12pm

9am	Welcome and opening remarks	Phoebe Woodworth-Jefcoats
9:10am	Introductory exercise	
9:15am	Discussion of gaps and priority needs related to progress and challenges in climate-informed stock assessments	
9:35am	Discussion of gaps and priority needs related to using telemetry to define pelagic habitat	
9:55am	Discussion of gaps and priority needs related to projected movement of Hawai‘i's bigeye fishery	
10:15am	Discussion of gaps and priority needs related to longline trip cost modeling	
10:35am	Discussion of gaps within priority to build an understanding of future shifts in species distributions underpinned with robust baselines	
10:55am	Discussion of gaps within priority to better understand species' physiological responses to climate change	
11:15am	Discussion of gaps within priority to continue to investigate food web responses to climate change	
11:35am	Discussion of gaps within priority to improve collaboration between scientists and managers	
11:55am	Concluding remarks	Phoebe Woodworth-Jefcoats

Essential Fish Habitat and Corals: Thurs, 15 Oct, 1–4pm

1pm	Welcome and opening remarks	Phoebe Woodworth-Jefcoats

1:10pm	Introductory exercise	
1:15pm	Discussion of gaps and priority needs related to assessing coral reef community vital rates	
1:35pm	Discussion of gaps and priority needs related to data downscaling around coral reefs	
1:55pm	Discussion of gaps and priority needs related to the role of herbivorous fish in Pacific Islands Region reef persistence	
2:15pm	Discussion of gaps and priority needs related to dynamic pelagic habitat	
2:35pm	Discussion of gaps within priority to build an understanding of future shifts in species distributions underpinned with robust baselines	
2:55pm	Discussion of gaps within priority to better understand species' physiological responses to climate change	
3:15pm	Discussion of gaps within priority to continue to investigate food web responses to climate change	
3:35pm	Discussion of gaps within priority to improve collaboration between scientists and managers	
3:55pm	Concluding remarks	Phoebe Woodworth-Jefcoats

Appendix B: List of Participants with Affiliations

Area(s) of climate-related expertise and interests are listed for participants who provided the information. For full affiliations and other acronyms see Appendix C.

Camryn Allen	PIFSC – PSD *Expertise:* Sea turtles *Interests:* Increased temperature effects on sex ratios
Robert Ahrens	PIFC – FRMD *Expertise:* Incorporating climate variable into population models, population and ecosystem modeling *Interests:* General population and ecosystem modeling, management strategy evaluation
Angela Amlin	PIRO – PRD
Jacob Asher	PIFSC – ESD *Expertise:* Essential fish habitat, coral reef ecology, MCEs
Megan Asher	PIFSC – ESD *Expertise:* Ecosystem-based fisheries management (EBFM), large marine ecosystems *Interests:* Involved in PIRO-HCD – ESD coordination and EBFM, so helpful to be aware of current and future activities/needs
Adam Ayers	PIFSC – ESD
Jason Baker	PIFSC – PSD
Michelle Barbieri	PIFSC – PSD *Expertise:* Hawaiian monk seals; health
Hannah Barkley	PIFSC – ESD *Expertise:* Climate impacts to coral reefs, ocean acidification, coral reef oceanography/climate
Brenda Becker	PIFSC – PSD *Expertise:* Hawaiian monk seals
Ingrid Biedron	PIFSC – DO
Jessica Bohlander	PIFSC – PSD *Expertise:* Hawaiian monk seals and PSD operations
Layne Bolen	PIRO – PRD

	Expertise: Coastal/estuarine/marine systems; graduate coursework sea level rise and climate change; ESA species reviews, listings, critical habitat, sea turtles *Interests:* Endangered ecosystems; critical habitat; specific cause/effect of climate to species condition; unmanned aerial systems (UASs/drones) habitat survey methods and image processing
Tia Brown	PIFSC – DO
Hing Ling Chan	PIFSC – ESD *Expertise:* Trying to model how climate change affects the economic performance of the Hawaii longline fleet *Interests:* What specific topics are of interest related to climate change impacts on the economic performance of the Hawaii longline fleet?
Malia Chow	PIRO – HCD *Expertise:* EBFM, EFH, habitat, monuments *Interests:* Climate impacts to habitats in the Pacific, ecosystem indicators to monitor climate impacts and of trends over time, climate impacts on essential fish habitat, incorporating climate impacts in EFH consultations and EFH designations
Anne Chung	PIRO – HCD *Expertise:* EFH consultations in the MHI, coral reef management *Interests:* Science to support EFH considerations
Christina Coppenrath	PIFSC – PSD *Expertise:* Sea turtles
Brett Cooper	PIFSC – FRMD
Courtney Couch	PIFSC – ESD *Expertise:* Coral reef ecology
Shelby Creager	PIRO – PRD *Expertise:* ESA species, elasmobranchs
Emily Crigler	PIRO – IFD *Expertise:* Climate change point of contact for IFD *Interests:* General climate considerations for fisheries management, including understanding shifting species productivity and distributions and any associated fleet responses or economic impacts associated with those shifts

Joshua DeMello	WPRFMC *Expertise:* Island fisheries coordinator *Interests:* Climate considerations in fishery management
Réka Domokos-Boyer	PIFSC – ESD *Expertise:* oceanography, biogeophysical processes, large and mesoscale pelagic oceans, active acoustics *Interests:* This is my first time participating, interested in learning about climate-related work and possibly collaborating
Sarah Ellgen	PIRO – SFD, Workshop Steering Committee Member
Mark Fitchett	WPRFMC *Expertise:* Pelagic fisheries scientist *Interests:* Climate considerations in fishery management, addressing uncertainty in pelagic fishery production and assessment, adaptive fishery management to address emerging bycatch issues
Atsuko Fukunaga	ONMS – PMNM
Alexander Gaos	PIFSC – PSD *Expertise:* Marine turtles *Interests:* Collective ideas to mitigate climate impacts on marine turtle nesting and forage habitat
Leon Geschwind	Inouye Regional Center (IRC) *Expertise:* IRC education and outreach specialist *Interests:* Looking for those interested in climate change education and outreach opportunities
Rini Ghosh	PIRO – IFD *Expertise:* NEPA point of contact for IFD, incorporate climate change analysis in NEPA documents *Interests:* How to utilize climate change information for fisheries management and incorporate such information into analytical documents that support management options
Alexa Gonzalez	PIFSC – SOD
Cherry Griffith	PIRO – OMI
Phyllis Ha	PIRO – SFD *Interests:* Climate considerations in proposed fishery management for environmental impact analysis and baselines; Monitoring changes needed to accurately

	determine changes in stock status and distribution for various management unit species
Richard Hall	PIRO – HCD *Expertise:* Climate change impacts on monuments, commercial fishing in the region, and ecosystem-based fishery management *Interests:* Interested in trends in modelling climate change on fisheries and in research related to climate change impacts, synergies and coordination on climate-related research
Ariel Halperin	PIFSC
Celeste Hanley	PIRO – OMI
Jeff Hare	PIFSC
Marie Hill	PIFSC – PSD
Heidi Hirsh	PIRO – HCD *Expertise:* Monuments, ecosystems, habitats *Interests:* Ecosystem indicators of climate change, ecosystem trends and health indicators
Justin Hospital	PIFSC – ESD *Expertise:* Economics, fishing communities, seafood markets
Brittany Huntington	PIFSC – ESD *Expertise:* Coral reef ecology
Melanie Hutchinson	PIFSC – FRMD *Expertise:* Elasmobranchs and bycatch
Kurt Ingeman	PIFSC – ESD *Expertise:* Climate and trophic interactions; coral reef fish ecology; ecosystem recovery
Asuka Ishizaki	WPRFMC *Expertise:* Protected species coordinator *Interests:* Climate considerations in fishery management
Mia Iwane	PIFSC – ESD *Interests:* Fishing communities' adaptive capacity
Ariel Jacobs	PIRO – DIR, Workshop Steering Committee Member *Expertise:* PIRO climate change POC

	Interests: Looking for those who are interested in contributing to PIRAP2.0
Danielle Jayewardene	PIRO – PRD *Expertise:* ESA coral recovering planning, Section 7 *Interests:* Incorporating climate change science and mitigation
Thea Johanos-Kam	PIFSC – PSD *Expertise:* Hawaiian monk seals
Irene Kelly	PIRO – PRD *Expertise:* Sea turtles *Interests:* Understanding climate impacts on sea turtle biology, ecology, and habitats
Tye Kindinger	PIFSC – ESD *Expertise:* Postdoc work on effects of ocean acidification and warming on trophic interactions
Michael Kinney	PIFSC – FRMD *Expertise:* Including climate/environment into animal movement and life history investigations *Interests:* Currently working to develop a Bayesian approach to modeling growth; interested if any has experience/ideas or code that would help to include environmental covariates to such a model
Danika Kleiber	PIFSC – ESD *Expertise:* Social indicators *Interests:* Collaboration
Donald Kobayashi	PIFSC – ESD *Expertise:* Pelagic ecology, fishery oceanography, coastal pelagic ecosystems, connectivity, climate impacts, plankton, nearshore oceanography *Interests:* Ideas and collaborators for current and future projects
Randall Kosaki	NOS – ONMS – PMNM *Expertise:* Coral reef fish ecology
Diana Kramer	PIRO – PRD *Expertise:* MMPA policy issues *Interests:* Learning more about climate impacts relevant to marine mammal conservation policy
Daniel Kubota	PIFSC – ITS

Adam Kurtz	PIRO – PRD *Expertise:* Protected species harassment/threats, outreach and education *Interests:* Facilitator
Mike Lameier	PIRO – HCD *Interests:* Continue to work with Tye and make connections with DAR managers about herbivory
Joshua Lee	PIRO – SFD *Expertise:* Hawaii deep-set and shallow-set fisheries, MSA, ESA *Interests:* Incorporating climate change science into rulemaking
Kirsten Leong	PIFSC – ESD *Expertise:* Human dimensions, especially human-wildlife interactions; social-ecological systems *Interests:* How might climate change affect interactions (range shifts, phenology, etc.)? Effects on community involvement/interactions with resources; adaptations to changes in fishery distribution, etc.; change in interactions between people and marine resources
Charles Littnan	PIFSC – PSD
Keolohilani Lopes	ONMS – PMNM
Beth Lumsden	PIFSC – FRMD, on detail to NESDIS, Workshop Steering Committee Member Expertise: Climate steering committee Interests: Regional collaboration opportunities, understanding cross-line office climate activities
John Marra	NESDIS, Workshop Steering Committee Member
Summer Martin	PIFSC – PSD *Expertise:* Sea turtles *Interests:* Collective ideas to mitigate climate impacts on sea turtle nesting habitat
Floyd Masga	WPRFMC
Laura McCue	PIFSC – PSD
Michelle McGregor	PIRO – SFD
Steven McKagan	PIRO – HCD

	Expertise: Resilience studies and restoration *Interests:* Have CRCP funding for 2022/23 resilience work on Rota and Tinian (looking to integrate the latest science)
Ann Mooney	PIRO – DIR, Workshop Steering Committee Member *Expertise:* Climate change workshop committee *Interests:* PIFSC/PIRO collaboration opportunities
Paul Murakawa	State of Hawai‘i Division of Aquatic Resources
Shawn Murakawa	PIFSC – PSD *Expertise:* Sea turtles *Interests:* Collective ideas to mitigate impacts on sea turtle nesting habitat, hatchling success, sex ratios
Erin Oleson	PIFSC – PSD *Expertise:* cetaceans
Thomas Oliver	PIFSC – ESD *Expertise:* Corals, environmental driver modeling *Interests:* Looking to focus newly developed tools to pair monitoring data to needed answers to management questions
Risa Oram	PIFSC – SOD
Michael Parke	PIFSC – ESD *Expertise:* EBFM and habitat; EFH coordinator and EBFM lead *Interests:* Climate impacts to habitat and EBFM, ecosystem indicators and dynamic pelagic habitats
Frank Parrish	PIFSC – ESD
Noah Pomeroy	PIFSC – ESD
Hoku Ka‘aekuahiwi Pousima	PIRO – HCD
Lynn Rassel	PIRO – SFD *Expertise:* Hawaii deep-set and shallow-set fisheries, MSA, ESA
Erin Reed	PIFSC – FRMD *Expertise:* Insular fisheries, climate variability effects on life history, fish life history *Interests:* Climate and environmental data, collaboration opportunities, ideas for management connections to climate and fish life history

Benjamin Richards	PIFSC – SOD *Expertise*: Deep 7 bottomfish, BFISH survey, survey design *Interests*: need resources for mapping seawater temperature at depth (75–400 m). SST is common, but what about temperature at depth?
Joshua Rudolph	PIRO – PRD *Expertise:* ESA species, Section 7; fisheries *Interests:* Information relevant to ESA consultations; considerations for ESA consultations; increase collaboration efforts
Ryan Rykaczewski	PIFSC – ESD *Expertise:* Global climate and biogeochemical models; plankton ecology; small pelagic fish *Interests:* Pathways to better include climate information in management decisions
Marlowe Sabater	WPRFMC, Workshop Steering Committee Member *Expertise:* Islands fisheries scientist *Interests:* Climate considerations in fishery management
Jennifer Samson	PIFSC – ESD *Expertise:* Nearshore habitats/coral reefs *Interests:* Drivers of reef resilience and recovery of coral reefs, understanding the biophysical links between nearshore and insular/pelagic fisheries
Brett Schumacher	PIRO – SFD, on detail with PIFSC – FRMD *Expertise:* Coral reef ecology; reef resilience *Interests:* Climate change effects on species distribution; life history characteristics; stock productivity; how to incorporate into management
Molly Scott	PIFSC – FRMD
Michelle Sculley	PIFSC – FRMD *Expertise:* Including climate/environment into stock assessments
Michael Seki	PIFSC – DO *Expertise:* Oceanography, climate impacts on living marine resources and ecosystems, observation systems *Interests:* Hearing management needs, current activities, and science priorities
Craig Severance	WPRFMC – SSC, Retired

	Expertise: SSC, retired; fishery social science *Interests:* Fisheries SIA, communities
Noriko Shoji	PIFSC – SOD
Joy Smith	PIFSC – ESD *Expertise:* Ocean acidification, warming, bleaching, oceanography, coral reef ecology, oceanography
Lance Smith	PIRO – PRD *Expertise:* Corals & coral reefs; incorporation of climate change into Endangered Species Act work on corals and coral reefs
Kristin Sojka	PIFSC – SOD *Expertise:* Marine and scientific support operations
Taylor Souza	PIFSC – ESD *Expertise:* Large marine ecosystems *Interests:* Climate impacts to ecosystem-based fisheries management
Tori Spence	PIRO – SFD *Expertise:* Environmental effects of aquaculture industries globally *Interests:* Nexus of climate issues with potential aquaculture management program
Jennifer Stahl	PIFSC – FRMD
Jan Willem Staman	PIFSC – PSD *Expertise:* Sea turtles *Interests:* Collective ideas to mitigate climate impacts of sea turtle nesting habitat (sex ratios, habitat loss)
Marylou Staman	PIFSC – PSD *Expertise:* Sea turtles *Interests:* Collective ideas to mitigate climate impacts of sea turtle nesting habitat (sex ratios, habitat loss)
Jonathan Sweeney	PIFSC – ESD *Expertise:* Decision making and risk analysis/economic impact analysis for protected species, climate impacts on U.S. fisheries, foreign fisheries interactions *Interests:* Developing new types of protected species regulations that are incentive compatible, collaborations with oceanographers, biologists, and other social scientists

Yonat Swimmer	PIFSC – FRMD
John Syslo	PIFSC – FRMD *Expertise:* Deep 7 bottomfish, stock assessment *Interests:* Climate data available to improve stock assessments
Molly Timmers	PIFSC – ESD *Expertise:* Coral reef ecology and biodiversity, specialize in metabarcoding and DNA barcoding techniques
Michael Tosatto	PIRO
Rebecca Weible	PIFSC – ESD *Expertise:* Coral reef ecology
Mariska Weijerman	PIFSC – ESD *Expertise:* Incorporating climate model output in ecosystem models in the insular realm; coupling biophysical and end-to-end models with socio-economic systems; integrated ecosystem modeling focused on insular systems *Interests:* Need for sensitivity estimates of marine organisms (especially fishes) to climate change, any updated data
Jonathan Whitney	PIFSC – ESD *Expertise:* Larval fish ecology, population genetics, pelagic habitats and food webs, fisheries oceanography, reef ecosystem biodiversity, eDNA of coral reef biota, metabarcoding, nearshore larval fish habitat, pelagic-reef connections *Interests:* Climate effects on larval ecology and recruitment (pelagic and shorefishes), trends in climate effects on pelagic fisheries, building collaborations, using eDNA metabarcoding to assess and monitory coral reef ecosystem changes through time
Morgan Winston	PIFSC – ESD *Expertise:* Coral reef ecology
Phoebe Woodworth-Jefcoats	PIFSC – ESD, Workshop Steering Committee Member *Expertise:* Climate model output and ecosystem models in the pelagic realm *Interests:* Looking for those who are interesting in contributing to PIRAP2.0
Johanna Wren	PIFSC – ESD

Expertise: Pelagic ecology, oceanography, particle/larval dispersal, biological oceanography
Interests: Looking for additional data and collaborations, especially pelagic *in situ* data (from CTD casts, etc.), and if you work on anything bigeye-related I'd love to talk to you!

Appendix C: List of Acronyms

BFISH	The Bottomfish Fishery-Independent Survey in Hawai‘i
CRCP	Coral Reef Conservation Program
CTD	Conductivity-Temperature-Depth cast
DIR	Directorate (Pacific Islands Regional Office)
DO	Director’s Office
EBFM	Ecosystem-Based Fisheries
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESD	Ecosystem Sciences Division
FRMD	Fisheries Research and Monitoring Division
HCD	Habitat Conservation Division
IFD	International Fisheries Division
MHI	Main Hawaiian Islands
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Act
NEPA	National Environmental Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NOS	National Ocean Service
OMI	Operations, Management, and Information
ONMS	Office of National Marine Sanctuaries
PIFSC	Pacific Islands Fisheries Science Center
PIRAP	Pacific Islands Regional Action Plan for climate science
PIRO	Pacific Islands Regional Office
PMNM	Papahānaumokuākea Marine National Monument

PRD	Protected Resources Division
PSD	Protected Species Division
SFD	Sustainable Fisheries Division
SIA	Social Impact Assessment
SOD	Science Operations Division
SSC	Scientific and Statistical Committee
SST	Sea Surface Temperature
UN	United Nations
WPRFMC	Western Pacific Regional Fishery Management Council