

## Appendix D.

# PNMS Science Plan Summary

The draft Palau National Marine Sanctuary (PNMS) Science Plan has been prepared by this Working Group as a foundation for assessing ecological, social, and economic outcomes of PNMS implementation. An overview of research and monitoring questions from the detailed Science Plan is below, aligning with the goals and subgoals of the PNMS legislation and addressing the most pressing knowledge gaps put forth by PNMS decision makers and stakeholders.

The full draft Science Plan can be downloaded at the link below and is a compilation of these research questions, associated methodological information, potential partners or collaborators already collecting data, and connections to the United Nations Sustainable Development Goals (SDGs). Advancing this preliminary draft to an actionable Science Plan will require local stakeholder review and ownership to ensure the content and granularity are appropriate for the needs and capacity of those conducting the monitoring. Recommendations for coordination amongst Palauan, regional, and international agencies and entities are included yet not exhaustive. Furthermore, these initial suggestions are likely to be adapted through national marine governance dialogues that include local stakeholders and decision-making processes.



Photo courtesy of Manu San Felix

This document is a component of the report titled *“Palau’s National Marine Sanctuary: Managing Ocean Change and Supporting Food Security; Report of an Expert Working Group Convened by PICRC and COS.”* For further information please see <http://picrc.org/picrcpage/palau-national-marine-sanctuary> and <https://oceansolutions.stanford.edu/pnms-report>

## 1. Healthy Ocean Populations and Ecosystems for Palau: Sustaining pelagic marine resources that benefit Palauan livelihoods and drive the Palauan economy

**Subgoal 1: Rekindle Palauan societal connection to and appreciation for Palau’s offshore environments and resources. Create the next generation of Palauan leadership to manage Palau’s open ocean resources.**

First Priority	What are the historical and current attitudes, perceptions, and connections of Palauans toward the pelagic environment and how do they change through time?
	What is the level of support for PNMS legislation among stakeholder groups and the public?
	What capacity do the institutions involved in managing the no-take and domestic fishing zones have and how is it likely to evolve?
	How are stakeholders engaged in dissemination of PNMS-related information and decision making?
Second Priority	What curricula exist at secondary and tertiary education levels to educate Palauans about the pelagic environment and the PNMS legislation? How can curricula be modified to include, and foster interest in, the pelagic environment?
	How does citizen science participation impact the attitudes and behaviors of the public?
	How is conflict about the management of, or access to, the no-take and domestic fishing zones addressed?

### **Data necessary for establishing a baseline:**

First Priority	Who are the key stakeholders?
	What are the public’s perceptions of current and future diversity of uses, interests, and values associated with Palau’s pelagic waters?

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**Subgoal 2: Protect pelagic populations and preserve marine biodiversity in Palau’s waters.**

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First Priority      How does primary production change through time (including species composition)?

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What is the current biodiversity within Palau’s open ocean and how does it change through time?

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How does bycatch amount and composition change through time?

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Determine distribution and abundance of different life states of mammals, reptiles, seabirds, and invertebrates within habitats over time to gain insight into how marine ecosystems function and the importance of different habitats and seasons for key species across their life cycles.

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Monitor sea temperature, salinity, and water quality.

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Second Priority    How do connectivity patterns change through time as well as home ranges for reef and open ocean species?

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What is the distribution, abundance, life stage, fertility state, and size and weight of pelagic fish through time?

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What does population connectivity look like for species of interest?

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What are the statuses of culturally important species? What are the perceptions of species’ population health by stakeholders and the public? What are the levels of stakeholder knowledge of natural history in Palau’s pelagic waters?

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What are compliance levels with no-take and domestic fishing zone regulations?

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How do pelagic fishes that are caught on FADs and those caught in the open ocean use reef food sources? Are there differences?

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**Data necessary for establishing a baseline:**

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First Priority      What are the baseline patterns of energy and trophic flows within the pelagic environment?

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What is the current size structure of target pelagic fish stocks?

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Second Priority    Map benthic environment and 3-D water column structure (e.g., eddies, currents, upwelling regions)?

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Where are the pelagic nursery habitats for species of interest (i.e.: calving grounds or spawning aggregations) within Palau’s EEZ?

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What are the connectivity patterns and oceanographic mechanisms for connectivity between reefs and the open ocean environment?

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**Subgoal 3: Support sustainable fisheries by replenishing Palau’s fishing zones and adjacent areas.**

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First Priority	What are the demographics of pelagic fish populations of commercial interest?
	How do catch volumes, rates, and composition change through time?
	How do imports and exports of seafood, including fish not landed in Palau, change through time?
	What proportion of fishing trips for both the purse seine and longline fleets have observers on board?
	How is fishing effort for all sectors changing through time?
	How have spatial and temporal fishing patterns changed in Palau’s waters? For example, have exemptions been granted and to whom? How does this affect catch, revenue, and fish stocks?
	How are FADs being used over time? What are the factors affecting use?
Second Priority	How is the PNMS legislation affecting bilateral and multilateral agreements?
	What is the ratio of catch from each fishing zone through time?

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## 2. Food Security for Palau: Ensuring sustained, nutritious, and safe supply of food for Palauan residents

### Subgoal 1: Increase the availability of and access to domestic pelagic fish according to standard guidelines for health and nutrition for all Palauan residents.

First Priority	What are the nutrient levels of reef and pelagic fish? <hr/> Availability: What volume and species composition are residents consuming now and how does this change through time? What are the geographic and demographic profiles of residential consumers? <hr/> Access: How does catch, price, and source of fish at markets change through time? What is the source of fish (e.g., pelagic offshore, pelagic nearshore, reef)? <hr/> What is the mercury level of pelagic fishes available in local markets? <hr/> What is the amount of (both pelagic and reef) fish leaving Palau as part of the (informal) cooler trade now? How does this change through time?
Second Priority	How does agricultural production change through time, particularly with regard to climate change? Are there shifts in agriculture production that correspond with changes in fish landings?

### Subgoal 2: Reduce fishing pressure on reef fish for the sustained cultural and socioeconomic benefit to Palauans.

First Priority	How do reef fish populations change through time? <hr/> What are the size of coolers exported and the species, number, and size composition of seafood inside each cooler? <hr/> What is reef fish catch per unit effort (CPUE) and how does it change through time? <hr/> What is the volume and species composition of reef fishes consumed at restaurants? What is the volume and species composition of pelagic fishes consumed at restaurants? <hr/> What are the historical and current cultural uses of reef fishes, and to what extent would individuals be willing or consider it culturally appropriate, to substitute these for pelagic fishes?
Second Priority	What is the abundance, size, and number of fishes caught for cultural use? How do these factors impact those species' long-term sustainability?

### 3. Sustainable Development for Palau: Developing a domestic pelagic fishing industry and supporting existing sustainable tourism initiatives

#### Subgoal 1: Enhance the contribution of the Domestic Fishing Zone to economic development, food security and the conservation of the coral reef fish and invertebrate populations.

First Priority	<p>How effective are Fish Aggregating Devices (FADs) at increasing fishing efficiency?</p> <hr/> <p>What type of FADs are currently in place, what is their condition, and are other FAD materials or configurations likely to be more effective?</p> <hr/> <p>Who funds the FADs? Who deploys and maintains them? Where are they located?</p> <hr/> <p>How many fishers use the FADs? How frequently are FADs visited?</p> <hr/> <p>What is the cost of operating on a FAD (e.g., fuel cost) versus benefit of operating on a FAD (e.g., efficiency of catch compared to non-FADs, price of catch).</p> <hr/> <p>How many fishers are engaged in the DPF?</p> <hr/> <p>How does income change through time for pole and line fishers? What are their operating costs and how much do they sell their catch for?</p> <hr/> <p>What are the most viable business plans for developing a DPF? What infrastructure investments (e.g., fleet, processing, marketplace) for pelagic fisheries development are being considered?</p> <hr/> <p>What training opportunities are being provided to fishers for engaging in the DPF? What is the investment in safety training and equipment for those fishers?</p>
Second Priority	<p>Where does pelagic catch enter the marketplace and how is it distributed?</p> <hr/> <p>What is the proportion of fisheries products imported from overseas (e.g., canned tuna), compared to locally sourced seafood?</p>

#### Subgoal 2: Support Palau’s brand as a high-value ecotourism destination.

First Priority	<p>How is the PPEF distributed throughout the economy?</p> <hr/> <p>How does the “Pristine Paradise” branding influence Palau’s appeal to tourists with regard to the open ocean environment? What proportion of tourists said that they visited Palau as a result of the establishment of the PNMS?</p> <hr/> <p>Where do tourists spend money?</p>
Second Priority	<p>How is the PNMS messaging being used to promote tourism?</p>

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**Subgoal 3: Support long-term health and well-being for Palauan residents.**

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First Priority      What does wellbeing mean to Palauan residents?

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What are the cultural effects of PNMS implementation on Palauans?

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Second Priority      What is the proportion of Palauan residents that present non-communicable diseases and how does it change through time?

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What are the community effects of the no-take and domestic fishing zones on Palauan residents?

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**Subgoal 4: Support long-term economic sustainability in Palau.**

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First Priority      How do jobs and employment distribution (e.g., gender, age) in ecotourism change through time?

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How do jobs and employment distribution (e.g., gender, age) in fisheries and fishing-related operations change through time?

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How does the PNMS legislation support Palauans beyond fishing and tourism (e.g., new jobs in monitoring, research, administration, etc.)?

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