Ecosystem Services Valuation of U.S. Coral Reefs

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Table of Contents

Executive Summary ES-1
Methods ES-2
Findings ES-3
Monetary Values ES-3
Non-Monetary Values ES-7
Limitations ES-10
Lessons Learned and Recommendations ES-10
I. Background and Purpose 1
II. Methods 2
Approach 2
Monetary Valuation Methods 5
Performed Literature Review for Monetary Valuation 6
Determined Defensibility and Transferability 7
Implemented Benefit Transfer Methods 8
Non-Monetary Valuation Methods 10
Evolution of Non-Monetary Approach 10
Performed Literature Review for Cultural Ecosystem Service Valuation 11
Conducted Interviews 14
Developed the Non-Monetary Ecosystem Service Value Indicators Database 18
Workshops 20
Jurisdictional Workshops 20
TWG Workshops 26
III. Results 29
Using These Results 29
Summary of Monetized Results 31
National-Scale Estimates 31
Summary of Non-Monetized Results 38
Interview and Token Exercise Results 38
Non-Monetary Ecosystem Service Indicators Database Results 40
Results by Jurisdiction 45
Guam 45
South Florida 51
Hawai‘i 59
Puerto Rico 67

Pacific Remote Island Areas 74
American Samoa 76
U.S. Virgin Islands 82
Commonwealth of the Northern Mariana Islands 88
Flower Garden Banks National Marine Sanctuary 93
IV. Limitations 99
V. Recommendations 101
Potential Policy Applications for Non-Monetary Values 101
Threshold Analysis 101
Habitat and Resource Equivalency Analysis 101
Scenario: Disease-Driven Reef Degradation and Cultural Equivalency 102
Future Valuation Efforts 103
Lessons Learned 103
Building on This Work 104
References 108
Data Availability 117
Appendix A. Non-Monetary Database Methods A-1

List of Tables

Table 1. Project Timeline 1
Table 2. Interview Completion Rates 16
Table 3. IPBES Value Typology Concepts 19
Table 4. IPBES Valuation Method 20
Table 5. Jurisdictional Workshop Details and Outcomes 21
Table 6. Socioeconomic Experts Workshop Details and Outcomes 27
Table 7. National-Scale Economic Benefit Estimates for Coastal Protection (in 2025 USD) 32
Table 8. National-Scale Annual Economic Benefit Estimates for Aesthetic/Amenity Value and Biodiversity (in 2025 USD) 32
Table 9. National-Scale Annual Economic Benefit Estimates for Recreation (in 2025 USD) 33
Table 10. National-Scale Economic Impact Estimates for Coastal Protection 33
Table 11. National-Scale Annual Economic Impact Estimates for Research and Education (in 2025 USD) 34
Table 12. National-Scale Annual Economic Impact Estimates for Recreation and Tourism (in 2025 USD) 35
Table 13. Summary of Monetized Ecosystem Service Annual Benefits per Acre (in 2025 USD) 36

Table 14. Summary of Monetized Ecosystem Service Annual Economic Impacts per Acre (in 2025 USD) 37
Table 15. Quantitative data types included in the database. 40
Table 16. Quantitative and Qualitative Non-Monetary indicator counts per ecosystem service and Jurisdiction. 42
Table 17. Summary of Annual Economic Benefits from Guam (in 2025 USD) 46
Table 18. Summary of Annual Economic Impacts for Guam (in 2025 USD) 48
Table 19. Selected Non-Monetary Indicators for Guam 50
Table 20. Summary of Annual South Florida Economic Benefits (in 2025 USD) 53
Table 21. Summary of Annual Economic Impacts for South Florida (in 2025 USD) 56
Table 22. Selected Non-Monetary Indicators for South Florida 58
Table 23. Summary of Annual Hawai‘i Economic Benefits (in 2025 USD) 61
Table 24. Summary of Annual Economic Impacts for Hawai‘i (in 2025 USD) 64
Table 25. Selected Non-Monetary Indicators for Hawai‘i 67
Table 26. Summary of Annual Puerto Rico Economic Benefit Estimates (in 2025 USD) 69
Table 27. Summary of Annual Puerto Rico Economic Impact Estimates (in 2025 USD) 71
Table 28. Selected Non-Monetary Indicators for Puerto Rico 73
Table 29. Selected Non-Monetary Indicators for PRIA 75
Table 30. Summary of Annual American Samoa Economic Benefits (in 2025 USD) 77
Table 31. Summary of Annual Economic Impacts for American Samoa (in 2025 USD) 79
Table 32. Selected Non-Monetary Indicators for American Samoa 81
Table 33. Summary of Annual USVI Economic Benefits (in 2025 USD) 83
Table 34. Summary of Annual Economic Impacts for USVI (in 2025 USD) 85
Table 35. Selected Non-Monetary Indicators for the USVI 87
Table 36. Summary of Annual CNMI Economic Benefit Estimates (in 2024 USD) 89
Table 37. Summary of Annual CNMI Impact Estimates (in 2024 USD) 91
Table 38. Selected Non-Monetary Indicators for CNMI 93
Table 39. Summary of Annual FGBNMS Economic Benefit Estimates (in 2025 USD) 94
Table 40. Summary of Annual FGBNMS Economic Impact Estimates (in 2025 USD) 96
Table 41. Selected Non-Monetary Indicators for FGBNMS 97

List of Figures

Figure 1. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) values typology. 3
Figure 2. Feasibility of developing quantitative estimates. 4

Figure 3. Studies by ecosystem type following the conclusion of the initial non-monetary ecosystem service literature review in project year 3 12
Figure 4. Top five non-monetary cultural ecosystem services and methods for all ecosystem types 13
Figure 5. Top five non-monetary cultural ecosystem services and methods for coral reef ecosystems ... 14
Figure 6. The template for the non-monetary token exercise. 17
Figure 7. Total token counts for both regions. 38
Figure 8. Averaged ecosystem service token counts per interviewee in both regions. 39
Figure 9. Total token counts for both inhabited and uninhabited jurisdictions. 39
Figure 10. Averaged ecosystem service token counts per interviewee in inhabited and uninhabited jurisdictions 40
Figure 11. Treemap detailing the distribution of qualitative and quantitative indicators across jurisdictions 44
Figure 12. Non-monetary token exercise outcomes for Guam. 51
Figure 13. Non-monetary token exercise outcomes for South Florida 59
Figure 14. Non-monetary token exercise outcomes for Puerto Rico. 74
Figure 15. Non-monetary token exercise outcomes for PRIA. 76
Figure 16. Non-monetary token exercise outcomes for the USVI. 88
Figure 17. Non-monetary token exercise outcomes for FGBNMS. 98

Key Terms

The following terms are used widely throughout this report.

Term	Definition
ecosystem service	The benefits people obtain from ecosystems.
value	The worth, importance, or significance of a good, service, or outcome to individuals or society, expressed in monetary or non-monetary terms.
use value	The benefits people derive from directly or indirectly interacting with an ecosystem or its services — such as fishing, recreation, or the role a coral reef plays in protecting coastlines.
non-use value	Also called passive use value is the value people assign to an ecosystem's existence independent of any material use — including existence value (knowing it exists), option value (preserving the possibility of future use), and bequest value (leaving it for future generations).
monetary valuation	The estimation of value in dollar terms using market data or nonmarket methods (e.g., willingness to pay).
non-monetary valuation	The characterization of ecosystem service value using qualitative descriptors or quantitative metrics as indicators.
economic benefit	Values that society derives from ecosystem services, but that are not examples of money exchanged in the economy. Social welfare.
economic impact	The economic activities (spending, taxes, jobs) that result from the use of the ecosystem services in the study area.
plural valuation	An approach to assessing ecosystem service value that recognizes and integrates multiple value types—monetary and non-monetary, including ecological, social, and cultural—rather than relying on a single metric.
benefit transfer	Estimating the ecosystem service value for a “policy site” using existing information from one or more different “study sites.”

Executive Summary

The National Oceanic and Atmospheric Administration's (NOAA's) Coral Reef Conservation Program (CRCP) uses a multidisciplinary approach to manage and conserve coral reef ecosystems, which are among the most productive ecosystems in the world. As part of this work, CRCP studies the benefits that humans derive from coral reef ecosystems—commonly referred to as ecosystem services. In 2021, NOAA's Office for Coastal Management (OCM) contracted with Ocean Associates, Inc. (OAI), and its subcontractor Eastern Research Group, Inc. (ERG), to conduct a comprehensive valuation of coral reef ecosystem services in nine U.S. coral reef jurisdictions. These include the seven U.S. states and territories that contain coral reefs, as well as two uninhabited coral reef areas (see box).

U.S. Coral Reef Areas Included in the Study

- American Samoa
- Commonwealth of the Northern Mariana Islands (CNMI)
- South Florida
- Guam
- Hawai'i
- Puerto Rico
- U.S. Virgin Islands (USVI)
- Flower Garden Banks National Marine Sanctuary (FGBNMS)
- Pacific Remote Island Areas (PRIA)

Over the five-year period from April 2021 to May 2026, the OAI/ERG team conducted valuation studies in all nine jurisdictions, documenting the study methods and results in a series of annual reports that describe the work done over the course of each project year. The purpose of this report is to summarize the results from the full project.

The measurement and categorization of ecosystem services is an evolving field. Conventional valuation approaches focus on producing monetized estimates for services such as commercial fishing and recreation. However, more recent thinking highlights the importance of ecosystem services that are difficult, if not impossible, to represent in dollar values, such as coral reefs' contributions to cultural heritage and sacredness.

This report emphasizes the importance of both monetary and non-monetary approaches in characterizing the ecosystem services provided by U.S. coral reefs. In the early stages of the study, the project team received guidance from local stakeholders in multiple jurisdictions that monetary valuation paints an incomplete picture of coral reef value. In response, the project team drew on recent scholarly advances in plural valuation, an approach that employs multiple representations of value (most notably, plural valuation expands beyond monetary indicators of value to include non-monetary indicators as well). This report offers advances in decision-relevant plural valuation, though it should be noted that the joint inclusion of monetary and non-monetary valuation was found to pose multiple challenges. One challenge relates to disparate beliefs about whether and how these two approaches can work together to inform decision-making. Another challenge relates to the different stages of development of monetary and non-monetary valuation methods: over a half-century of research and practice informs monetary valuation methods, whereas research and practice related to non-monetary valuation methods are much newer (with most growth in the past decade) and still evolving.

Despite these challenges, this report incorporates both monetary and non-monetary valuation results. The non-monetary results are exploratory, but their inclusion in a report of this nature represents an advance, and many valuable lessons were learned in the process. Overall, this report provides important contributions: it includes a baseline compilation of resources for monetary and non-monetary valuation of coral reefs, and it also is one of the first efforts to explicitly attempt to elevate a broader view of non-monetary valuation into coral reef ecosystem services across U.S. coral reef jurisdictions. A summary of the methods, results, limitations, and recommendations presented in this report is provided below.

Methods

The project began with a scoping year, during which the project team developed a roadmap for conducting studies in the nine jurisdictions over the following four years. Scoping year activities included:

- Conducting a comprehensive review of the literature on coral reef ecosystem services.
- Extracting source and valuation data as well as other metadata for analysis.
- Performing a gap analysis that highlighted areas and services for future consideration.
- Engaging with local stakeholders and socioeconomic experts (including cultural and anthropological experts) in a series of workshops.

Synthesizing Results

This project attempted to develop the relationship between monetary and non-monetary ecosystem service values. The project team grappled with how best to position these two approaches. At times, the team treated them as parallel frameworks, acknowledging that there was no clear basis for comparison between the two; at other times, the team explored ways to synthesize and elevate both approaches. Feedback from stakeholders has varied regarding the appropriateness of these different efforts. The project team recognizes and respects the diversity of perspectives across U.S. coral reef jurisdictions on both forms of ecosystem service valuation.

The project was initially intended to focus on monetary estimates for coral reef ecosystem services. However, during the scoping year workshops, local stakeholders across multiple jurisdictions emphasized the importance of including non-monetary valuation in the assessment, stating that dollar values would be insufficient to represent why coral reefs matter to them. Based on this feedback, the project team expanded its focus to include non-monetary valuations. The following paragraphs summarize the general approach used for each type of valuation:

- **Monetary valuations.** Because the project was not scoped to include primary economic research, the project team used a benefit-transfer approach to produce monetary valuations of coral reef ecosystem services. Benefit transfer involves taking an economic value estimated from a study conducted at one site and applying that estimate, with adjustment, to a different site or period. Use of benefit transfer allowed the project team to produce value estimates for numerous ecosystem services in a cost-effective and efficient manner. However, a key limitation is that benefit transfer can only be used to value those ecosystem services that are already estimated in similar regions by valid and defensible studies.

- **Non-monetary valuations.** Coral reefs provide certain kinds of ecosystem services (e.g., those related to heritage, spirituality, and identity) that are difficult, infeasible, or considered potentially unethical to effectively evaluate using a monetary approach. To include these ecosystem services, the project team worked with stakeholders and researchers in each jurisdiction to identify non-monetary indicators of the value of coral reef ecosystems. These indicators are quantitative measures and qualitative descriptors that reflect why coral reefs matter. To develop indicators for each jurisdiction, the project team conducted literature reviews, expert interviews, and a review of materials created by reef-related nonprofits. Many of the values represented through non-monetary indicators relate to cultural ecosystem services—the non-material benefits of nature—as well as relational values grounded in meaningful human–nature relationships.

After the scoping year, the project team conducted valuations for ecosystem services in two to three jurisdictions per year, using the approaches described above. For each project year following the scoping year, the project team:

- Conducted additional literature searches for each jurisdiction to capture any new studies across both monetary and non-monetary dimensions.
- Developed place-based approaches for gathering non-monetary sources to maximize the number of studies, reports, and other indicators of coral reef value.
- Engaged with local stakeholders via virtual workshops.
- Engaged with academics and researchers through Technical Working Group meetings.

Findings

Monetary Values

Table ES-1 and Table ES-2 provide a summary of monetary ecosystem service values by jurisdiction.[1] These results represent the most up-to-date estimates available. Data used for this assessment have undergone a rigorous evaluation for defensibility, and the results have been reviewed and vetted by valuation experts. This project assessed two kinds of economic indicators: economic benefits and economic impacts. **Economic benefits are the values that society derives from ecosystem services (e.g., protection from storm surge, or the value of biodiversity within coral reefs for fisheries). Economic impacts are the economic activities (e.g., spending, taxes, jobs) that result from the use of the ecosystem services in the study area.** These distinct monetized indicators provide two ways to estimate the value of coral reefs.

As noted in the Methods section above, the monetary values reported here were estimated using a benefit-transfer approach. These results, therefore, are based on the best estimates for ecosystem service benefits and impacts as found in the peer-reviewed academic literature and government reports. The benefit-transfer process entailed updating ecosystem service values within a jurisdiction-specific study from the U.S. dollar (USD) value at the time of publication to 2025 USD. In some cases, more generalizable studies from international and national-scale studies were used to fill gaps in other locations. In the tables below, value estimates are not provided for some ecosystem services in each jurisdiction. These gaps reflect data limitations; they should not be interpreted as an indication that certain ecosystem services are not available in individual jurisdictions.

Aside from the specific aggregated results outlined within this report, summing values across ecosystem services or jurisdictions is not recommended. The diverse methodologies of the source literature make aggregation unreliable rather than merely approximate. Since these results rely on a variety of studies, at times there is overlap in benefits measured. Therefore, double counting is possible when adding values across ecosystem services. See the Limitations section for more information on data limitations.

[1] Monetary values for the Pacific Remote Island Areas are not included in the tables because the project team was unable to find sufficient data to perform benefit transfer for that jurisdiction.

Table ES-1. Summary of Monetized Annual Ecosystem Service Benefits by Jurisdiction (in millions of 2025 USD [a])

Ecosystem Service	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS
Amenity	**N/A**	$3.87	$318.49	$54.90–$78.23	$16.62	$9.91	$7.73–$56.66	$4.38–$4.64	-
Biodiversity	**N/A**	$10.67–$75.48	$6,207.82–$49,499.21	$34,425.42–$67,936.19	$115.14–$323.93	$193.10	$58.25–$150.62	$90.36	$6,473.47–$19,790.33
Coastal protection	**N/A**	$10.98	$569.27	$510.02	$83.05	$38.17	$33.40	$6.13	-
Fishing	**Recreational fishing**	-	$146.35–$163.40	-	-	-	$3.76	-	-
	Subsistence fishing	-	-	-	-	$0.12	-	-	-
	Traditional fishing	$2.12–$14.76	-	-	-	-	-	$0.24–$1.34	-
Non-use/passive use	**Bequest value to future generations**	-	-	-	$126.78	-	-	-	-
	Existence value to current generations	-	-	$14,401.27	$184.03	-	-	-	-
	Option value to current generations	-	-	-	$116.30	-	-	-	-
	Non-use value (unspecified)	-	-	-	-	$17.99			-
Recreation/ tourism	**Recreation—all types combined**	$111.58	$384.95	$55.41	$479.66	$0.25	$106.05	$4.59	-
	Recreation—swimming/fishing	-	-	-	-	-	-	-	-
	Recreation and tourism—diving and snorkeling	-	$1,147.49	$260.75	-	$0.09	-	-	-
	Recreation—artificial reefs	-	$31.17	-	-	-	-	-	$0.01–$0.09
	Recreation—natural reefs	-	$42.91	-	-	-	-	-	$0.02–

Ecosystem Service	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS
									$0.21

Note: Blank cells reflect data limitations and gaps; they do not indicate that particular ecosystem services are not available in certain jurisdictions. See Results by Jurisdiction for additional study details.
[a] CNMI values are represented in millions of 2024 USD. An updated local Consumer Price Index (CPI) with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined using the national-level CPI from the Bureau of Labor Statistics (BLS).

Table ES-2. Summary of Monetized Annual Ecosystem Service Economic Impacts by Jurisdiction (in millions of 2025 USD [a])

Ecosystem Service	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS
Coastal protection	**N/A**	$16.30	$510.24	$731.08	$147.71	$10.73	$38.51	$8.85	-
Fishing	**Commercial fishing**	$0.01–$0.13	$94.23–$126.02	$1.10–$4.49	$2.09–$2.62	$0.02–$0.15	$1.22–$2.20	$0.05–$0.09	$2.00
	Recreational fishing	-	$533.11	-	-	-	-	-	$22.19
	Subsistence fishing	-	-	$9.50–$17.08	-	$0.97	-	-	-
	Artisanal fishing	-	-	-	-	$0.19	-	-	-
Recreation/ tourism	**Recreation—all types combined**	$233.11–$487.23	$1,732.65	$824.03–$1,691.40	$773.51–$2,328.28	$2.52	$370.02	$34.32–$63.12	-
	Recreation and tourism—trip-related expenses and durable goods (from trips)	-	-	-	-	-	-	-	-
	Recreation and tourism—diving and snorkeling	-	$1,253.69	$334.14	-	$0.04	-	$1.48–$6.18	-
	Recreation and tourism—fishing (artificial reefs)	-	$3,855.57	-	-	-	-	-	-
	Recreation and tourism—diving (artificial reefs)	-	$1,897.62	-	-	-	-	-	-

Ecosystem Service	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS
Research	**N/A**	$0.78	$64.26	$11.08–$20.43	$3.35	$2.00	$1.56	$0.94	$2.81–$2.92

Note: Blank cells reflect data limitations and gaps; they do not indicate that particular ecosystem services are not available in those jurisdictions. See Results by Jurisdiction for additional study details.
[a] CNMI values are represented in millions of 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Non-Monetary Values

As described in the Methods section, the project team developed various approaches to collect non-monetary indicators of the value of coral reef ecosystems for each jurisdiction. This is the first time non-monetary values have received extensive treatment in an ecosystem service valuation assessment for NOAA CRCP. Non-monetary indicators provide critical insight into dimensions of coral reef importance that monetary metrics cannot fully capture and thus are necessary to fully understand the value of coral reefs in the United States. Non-monetary valuation is particularly indispensable as a method for representing sources of importance related to meaningful and fulfilling lives (e.g., sacredness, identity, and social ties).

A limited number of established approaches exist to collect, organize, report, and apply non-monetary ecosystem service values. Non-monetary valuation represents an evolving field where various worldviews inform the approaches used, and few examples of large-scale efforts have been documented in the literature. The work in this field is ongoing, and as such, the results presented here are only a partial expression of non-monetary values across U.S. coral reef jurisdictions. These are provisional results, and the expectation is that future efforts will expand on them as the field continues to develop, incorporating new ecosystem services, approaches, and reporting best practices.

Table ES-3 presents a summary of ecosystem services that were valued in this study primarily through the use of non-monetary indicators. For each ecosystem service, the table provides examples of non-monetary indicators developed for different jurisdictions. In the table, as throughout the report, *quant* signifies an indicator that is a quantitative measure, while *qual* signifies an indicator that is a qualitative descriptor. Although some non-monetary values entail multiple ecosystem services, the table does not highlight these overlaps and instead focuses on specific ecosystem service examples. Additionally, some ecosystem services lack one or the other indicator type.

Table ES-3. Ecosystem Services Represented Primarily by Non-Monetary Indicators, with Examples of Indicators

Ecosystem Service	Indicator Example
Amenity/ aesthetics	"If you want to sell the view, you have to protect the coral reefs, because coral reefs are going to keep the waters clean, the coral reefs are going to provide the ways to enjoy the blue waters that we enjoy here… So, one idea we threw to some of these people is that you have to consider coral reefs as part of your working capital. If you don't have coral reefs, if you don't invest in them, you won't have beaches to sell." [Puerto Rico, *Qual*]
Cultural heritage	33% of artisanal fish catch from Kīholo Bay is shared (~10,000 meals per year). In addition, 21.4% is used for pāʻina (cultural functions) (~6,400 meals per year). [Hawaiʻi, *Quant*] "As part of Pacific Island culture, the Western Pacific territories support conservation measures that sustainably use and conserve natural resources. We depend on these resources for food, recreation, our economy, and to practice indigenous Chamorro and Refaluwasch cultures." [PRIA, *Qual*]
Ecological knowledge	In CNMI, 57.9% of NOAA survey respondents (2024) considered coral reefs important for local language. [CNMI, *Quant*] "It's called Kumulipo, a Hawaiian creation chant, and it was passed down throughout the lineage. It tells how organisms and people first came. It starts with Kumulipo and Po'ele, the two humans. From there, the first thing that was brought forth was the coral polyp. Not

Ecosystem Service	Indicator Example
	something on land. It was the coral polyp. And from there, the coral colony. The reason this occurred is they realized how important the coral was to the base of the whole ocean and the land because the fish use it for shelter. Invertebrates use it. They use it for food. I mean, it's just so important and integral in the Hawaiian culture that that was the first key organism that was produced. And so, I think we have to, here in Hawai'i, understand that today as well that this is not something we can do without. And we need to make the changes to make sure it stays." [Hawai'i, *Qual*]
Existence	"People from Santa Barbara to Omaha, Nebraska, really appreciate just knowing that there is a spot out there where sea turtles are breeding, where sharks at densities are doing their thing the way they have been doing that for hundreds of years. That adds some richness to their sense of what American national heritage and biodiversity and wilderness—again, some of those terms are a little problematic—... adds some richness to folks' perspective about what biodiversity is part of our national jurisdiction." [PRIA, *Qual*]
Identity	"As a student, getting to participate in research and join [researchers] for work is a catalyst for them. It serves as a benchmark for future job interviews, success in their career, new endeavors and opportunities. It has the potential to become an incredibly important piece of their identity." [FGBNMS, *Qual*]
Intergenerational relationships	In Guam, 66.8% of recently (2023) surveyed residents believed coral reefs were extremely important for establishing and maintaining cultural and familial ties. [Guam, *Quant*] "It's a generational thing, you know… I'm thinking about the legacy of the Frenchie fishermen, and for generations, you know, grandfather, great grandfather, and their children today, going out and fishing certain areas. You know, if they're not, if that dies off and they're not able to do that, you're losing, well, it's also loss of wealth and loss of a living. If they don't have that available to pass down." [USVI, *Qual*]
Knowledge systems	"The Carolinians named various places on the reef in the Carolinian language. The big rocks out there are called Faay Likkáp. It means 'Big Rock,' or Acho' Dánkolo in Chamorro. Faay means the rock, which is actually coral. In the old days we used pole to push our boat. These are all paddling type boat, and once we crossed this big rock out there, we're supposed to throw rocks, and ask for forgiveness: 'Excuse me, I'm passing by.'" [CNMI, *Qual*]
Learning/ education	In 2018, 664 individuals attended a screening of the film *Chasing Coral*, hosted by Flower Garden Banks National Marine Sanctuary. [FGBNMS, *Quant*] "And so we're really in the ideal environment for learning both about the marine environment, about the ecosystem. But even with developing skills, so like…from the archaeologist's perspective, I have pushed to have a lot of different field schools occurring down here, because if you can learn to dive and work in this type of environment, then you can, you know—that's a good place to kind of build your skills. It's also a good place for experimentation in terms of trying different things to protect resources." [South Florida, *Qual*]
Non-commercial fishing	In a 2011 survey, 85.1% of surveyed fishers (n=139) consider reef fish an important source of food for their families. [Guam, *Quant*] "There's a lot of catching fish near reefs that never even makes it to the economic ledger, it just gets given away in reciprocity networks and that value gets lost a lot." [Puerto Rico, *Qual*]

Ecosystem Service	Indicator Example
Recreation [a]	Coral-reef-related tourism sustains 3,787 jobs. [South Florida, *Quant*] "You feel like you're no longer on St. Thomas when swimming at these reefs. It helps with your mental health. For many of the kids, it gives them an escape, a getaway from whatever might be troubling them at that time." [USVI, *Qual*]
Security	Number of children protected by coral reefs from flooding, by island: Tutuila: 383; Ofu and Olosega: 2; Ta'ū: 6; Total: 391 [American Samoa, *Quant*] "I think the governor just recently signed into law that coral reefs are considered an infrastructure, and if we have a disaster declaration by the federal government, we can get funding to assist with the restoration of coral reefs." [USVI, *Qual*]
Sense of place/belonging	"We have one highway that comes through the Keys. You can see the lighthouses, you know, as you're coming down the Keys, and so I think it's, you know, something that everyone is aware of. You know that these things are marking reefs." [South Florida, *Qual*]
Social capital/social cohesion	"When I was at a younger age, we had more fish, an abundance of fish. We'd get a couple 300, 400 pounds of fish, easy, and that's half a day, and we always share it. We share our fish. We sell some of the fish to make up for some of our expenses, obviously, like gas or whatever, but most of it is kept, and most of it is shared amongst family." [Guam, *Qual*]
Social responsibility	Sharing fishing catch within the community is a perpetuation of traditional culture that strengthens social bonds. In one 2016 survey, 78% of recently surveyed fishers reported that they always or often shared their catch. [Hawai'i, *Quant*] Fishing is often not strictly for subsistence, but for fa'alavelave (sharing at a family function or ceremony), for feasoasoani (general help), for to'onai (Sunday meal), or for tautua (service gifts for village chief or clergy). [American Samoa, *Qual*]
Spiritual	In CNMI, 63.6% of respondents to a recent (2024) NOAA survey considered coral reefs important for ancestral connections. [CNMI, *Quant*] "So much of our culture and history is about traversing the ocean, writ large, so that the ocean itself and that within it is sacred… The spirituality elements of the ocean, and PRIA, recognizing that there is an opportunity for all these different Pacific Island communities to reconnect with the sacredness that is in that spot, and in some ways to create new sacredness with the corals, and the islands, and those locations." [PRIA, *Qual*]
Stewardship	Volunteers spent 7,733 hours cleaning up Virgin Islands National Park, including reefs and beaches, in 2023 alone. [USVI, *Quant*] "I think overall the people in Hawai'i are very passionate about their natural environment. I think growing up here, we're all kind of raised with a sense of responsibility for our natural resources, and so I do think that people are very conscious of the issues that are happening. A lot of people who have grown up here, they're well aware of what's happening and, you know, the risks that we're facing, the threats that we're facing in terms of our reefs and also, like, our upland environments, because people have seen the changes just like I have, they've seen what can happen to their backyard." [Hawai'i, *Qual*]
Subsistence	Nearly 70% of residents consumed seafood from local coral reefs at some point during the year. [Guam, *Quant*]

Ecosystem Service	Indicator Example
	"The coral reefs provide, especially for the coastal poor people, a source of food that is not available in other ways." [Puerto Rico, *Qual*]

[a] Recreation and tourism are heavily represented in monetary indicators, but their value can also be represented non-monetarily.

Limitations

Some studies used for monetary valuations overlapped in the benefits that they measured. As a result, double counting is possible when adding up values across ecosystem services. For example, if one study estimates the value of diving and snorkeling in Hawai'i and another estimates the total recreation value of coral reefs for Hawai'i (but does not specify activity-by-activity estimates), the project team assumed there is the potential for overlap between the two values, because diving and snorkeling may be included in the broader study. Nevertheless, this report provides ranges of total economic impact values where possible based on summing over subsets of values where the project team determined that double counting is least likely.

Readers should also note that the non-monetary values included in this assessment likely reflect a small subset of the relevant ecosystem service values. There is a severe lack of data related to non-monetary value. Additionally, non-monetary valuation data lack standardization.

Lessons Learned and Recommendations

Monetary values cannot fully capture the worth of coral reefs. While monetary ecosystem service valuation can estimate certain reef impacts and benefits—such as tourism revenue or avoided storm damages—many dimensions of coral reef value cannot be understood using the monetary toolkit. Cultural identity, intergenerational knowledge, and spiritual connections to places are often central to how communities understand coral reefs' importance, yet these values cannot be adequately expressed in dollar terms. Relying solely on monetary metrics can therefore underrepresent the full contribution of coral reefs to human well-being.

> *Recommendation: Including non-monetary valuation can enrich ecosystem service valuation. Non-monetary valuation should be viewed as an approach capable of making distinct contributions toward describing coral reef ecosystem service values.*

There cannot be a one-size-fits-all approach to coral reef ecosystem service values for U.S. jurisdictions. Coral reef ecosystems support communities in fundamentally different ways across U.S. jurisdictions, reflecting variation in geography, culture, and economic reliance on reef-related activities.

> *Recommendation: To avoid obscuring local differences and to produce results that best align with local decision-making needs, employ valuation approaches tailored to each jurisdiction.*

Incorporating non-monetary valuation requires considerations and steps that are new to valuation projects. Non-monetary approaches, such as conducting interviews or using quantitative but non-monetized indicators, offer a way to systematically account for values that cannot be monetized. However, these methods require time, expertise, and sustained engagement with local communities, and may not be appropriate or feasible for every ecosystem service valuation effort.

Recommendations: Select valuation approaches that align with available resources, capacity, and decision timelines. Seek guidance from social scientists and local experts about how to engage with stakeholders, co-design projects, and collect appropriate data.

Engaging with stakeholders in a place-based and on-the-ground manner can improve trust and help identify and characterize culturally relevant ecosystem service values. Meaningful stakeholder engagement grounded in local contexts can strengthen the legitimacy and relevance of ecosystem service assessments. Direct interaction with community members, practitioners, and cultural leaders helps highlight local values and narratives that are often missed in remote analyses. Such engagement not only improves trust in the valuation process, but also generates richer, more actionable examples of how coral reefs matter to people in place.

Recommendation: Conduct outreach with local partners and stakeholders to align with local priorities early in the project scoping phase and frequently throughout the duration of the project.

Across the NOAA jurisdictions, there is a lack of standardized data (trips, visitors, etc.) related to reef use for ecosystem services such as recreation, fishing, and diving. Better standardization is needed to help ensure that future valuation efforts will have a robust and up-to-date set of data to work with.

Recommendation: Encourage local governments, tourism agencies, and federal partners to standardize the non-monetary metrics that support the efficient application of benefit transfer.

Many gaps remain in ecosystem services research across the jurisdictions. New research directions can be influenced by the gaps identified in this effort.

Recommendation: Encourage partners (organizations, researchers, and governments) to undertake more primary data collection efforts to fill data gaps and update older studies.

Non-monetary values for ecosystem services can be incorporated into current decision-making frameworks without forcing them into uncertain or non-credible monetary estimates. Threshold analysis and Habitat and Resource Equivalency Analysis are two approaches that can be used to incorporate non-monetary benefits into decision-making without estimating the benefits' dollar value.

Recommendation: Tailor valuation efforts toward application of the results in relevant decision-making and policy contexts.

The precise approach to valuation that will be most effective and productive will vary based on the intended use of the results. Clearly articulating who will use the results and in what ways can help a project team provide useful characterizations of value.

Recommendation: When planning future ecosystem service valuations, emphasize the intended use of the results in the statement of purpose and project objectives.

I. Background and Purpose

The National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management's (OCM's) Coral Reef Conservation Program (CRCP) aims to increase the resilience of U.S. coral reef ecosystems to sustain valuable ecosystem services for current and future generations. In fulfilling this mission, CRCP funds and equips conservation activities by NOAA and its partners in the seven U.S. states and territories containing coral reefs, as well as in remote uninhabited areas. From 2021 to 2026, NOAA OCM/CRCP contracted with Ocean Associates, Inc. (OAI), and Eastern Research Group, Inc. (ERG), to:

- Provide updated estimates of the ecosystem service values of the seven U.S. coral reef jurisdictions.
- Estimate the ecosystem service values of the Flower Garden Banks National Marine Sanctuary (FGBNMS) and the Pacific Remote Island Areas (PRIA).

This work builds on a previous effort led by CRCP, which conducted seven valuation studies in each of the U.S. coral reef jurisdictions over a 10-year period (2001–2011): American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), South Florida, Guam, Hawai'i, Puerto Rico, and the U.S. Virgin Islands (USVI). These valuation studies quantified the benefits society garners from coral reefs in each jurisdiction. The studies did not quantify ecosystem goods and services provided in the two uninhabited coral reef areas, FGBNMS and PRIA, nor did previous studies explore non-monetary valuation.

This updated valuation study was conducted over five years (2021–2026), with an initial scoping year followed by four years to perform the valuation work. In the latter four years of the contract, NOAA directed OAI/ERG to focus on two to three coral reef jurisdictions in each year (Table 1). This project was initially scoped to focus on monetary estimates for coral reefs. However, during the scoping year workshops, local stakeholders across multiple jurisdictions emphasized the importance of including non-monetary values in the assessment. The project team expanded the approach to include non-monetary valuation in Project Year 1 and continued to collect and expand the use of non-monetary data in subsequent years. As the non-monetary approach evolved, jurisdictions were retroactively included in additional analyses.

Table 1. Project Timeline

Project Year	Jurisdictions
Scoping Year	Methodology was developed
Year 1	Guam, South Florida
Year 2	Hawai'i, Puerto Rico, PRIA
Year 3	American Samoa, USVI
Year 4	CNMI, FGBNMS

II. Methods

This valuation effort developed separate methods for estimating the monetary and non-monetary values. To help develop methods, promote the project, and review results, the project team conducted several virtual workshops each year with valuation experts and local stakeholders. These workshops covered both the monetary and non-monetary aspects of the project. The approach for each of these components is described below.

Approach

During the initial scoping year, the project team undertook the following activities to establish a roadmap for the subsequent four years:

- Conducted a comprehensive review of the coral reef ecosystem service literature in each jurisdiction.
- Performed a gap analysis highlighting areas and services for future consideration.
- Reviewed potential valuation methods.
- Engaged with local stakeholders and socioeconomic experts, including cultural and anthropological experts.

The scoping year resulted in a roadmap for conducting ecosystem service valuations for the remaining four project years. Given the amount of valuations needed across all nine coral reef areas, the project team determined that a benefit-transfer approach was most appropriate for estimating monetary values. Details about benefit transfer are in the next section.

After the scoping year, the project team conducted valuations for ecosystem services in two to three jurisdictions per year. For each project year following the scoping year, the project team:

- Conducted additional literature searches for each jurisdiction to capture any new studies across both monetary and non-monetary dimensions.
- Explored methods used to document non-monetary ecosystem service values.
- Developed place-based approaches for gathering non-monetary sources to maximize the number of studies, reports, and other indicators of coral reef value.
- Engaged with local stakeholders via virtual workshops.
- Engaged with academics and researchers through Technical Working Group (TWG) meetings.
- Reviewed monetary studies to ensure they are methodologically and contextually defensible and performed benefit transfer where applicable.

Stakeholders in both the jurisdictional workshops and the academic and researcher workshops repeatedly pointed to deeply important non-monetary values as missing within a purely monetary approach. Therefore, the project team sought to explore a broader array of value indicators beyond monetary value, adopting a plural valuation approach to incorporate non-monetary values. While monetized valuations of ecosystem services can be easily incorporated into current decision-making frameworks, they often do not fully capture the value of a service. Plural valuation involves using "a wide variety and combination of methods to elicit different types of values of nature and different approaches to dealing with issues of value comparability, compatibility, and representativeness" (IPBES, 2022, p. XXXI). This perspective requires acknowledging that monetary value is just one way to indicate

underlying value (see Figure 1), meaning indicators of value can take many forms, only one of which is dollars. Plural valuation is receiving increasing attention (in both scholarship and practice) due to widespread acknowledgment that monetary value systematically under-represents certain kinds of value (e.g., values related to heritage, spirituality, and identity).

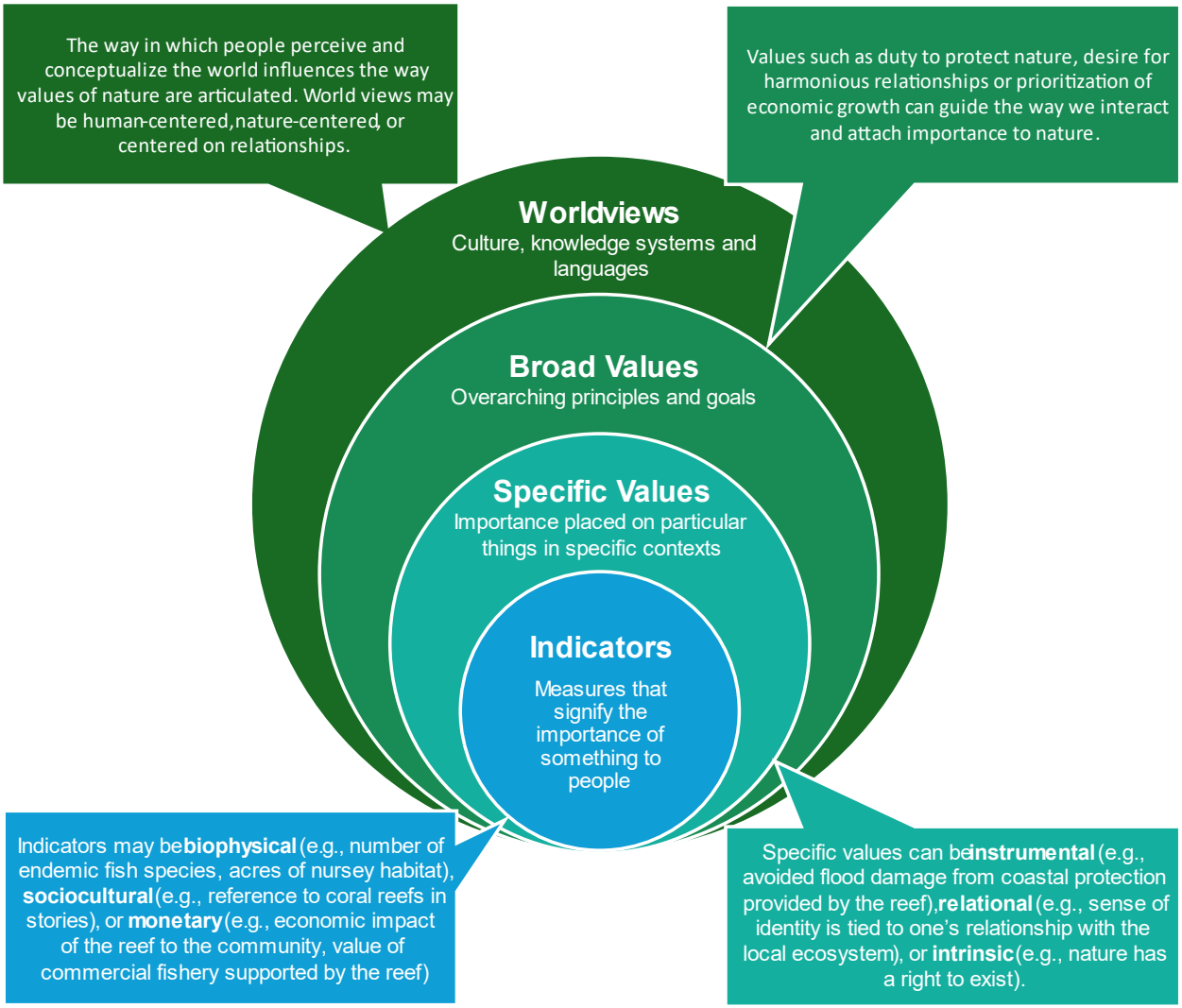

Figure 1. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) values typology. *This figure is adapted from the IPBES Values Assessment (p. 9). The typology presents four values concepts that are nested (Worldviews > Broad Values > Specific Values > Indicators). The idea is that indicators are the "visible" layer, supported by the underlying value types and worldviews.*

Our plural valuation combined monetary approaches with non-monetary approaches. The monetary approaches included a literature review followed by benefit transfer. The non-monetary approaches involved a separate literature review, interviews, token exercises, and a nonprofit search, culminating in a Non-Monetary Ecosystem Service Value Indicators Database; specific approaches are described in the Non-Monetary Valuation Methods section). Stakeholders in Hawai'i, American Samoa, and CNMI refrained from participating in both the interviews and the token exercises:

- For Hawai'i, stakeholders deemed the interviews and token exercises were inappropriate as currently envisioned.
- For American Samoa and CNMI, workshop participants and the NOAA liaison expressed doubts about the appropriateness of interviews.

These jurisdictions' apprehensions about the interview and token exercise point to foundational differences between the monetary and non-monetary ecosystem services literature. Different types of ecosystem service values hold varying meanings and levels of importance across communities, and their usefulness depends on the specific context in which they are applied. However, these two approaches can complement each other. Monetary valuations often require quantitative non-monetary values such as the number of dives or visitors at a coral reef, which are stand-alone indicators of ecosystem service value. Qualitative indicators of value often describe the importance of ecosystem services for specific communities or places in ways a quantitative measure, whether monetary or non-monetary, cannot.

We do not position the monetary and non-monetary approaches as parallel or as always complimentary, but rather as in dialogue, and acknowledge the varied preferences for different value types throughout the NOAA jurisdictions. While this project explored both approaches as deeply as possible given its scope, the project team also acknowledged that the attempt to incorporate non-monetary values was far from comprehensive and is only meant to be the start of such work in coral reef ecosystem service valuation. Lessons learned and recommendations to build on this work and bridge the two approaches are provided in the Recommendations section.

It is critical to note that this monetary and non-monetary valuation effort was limited to the ecosystem services that valid and defensible sources already estimate or provide (Figure 2). In areas that have less research this leads to fewer ecosystem services being represented.

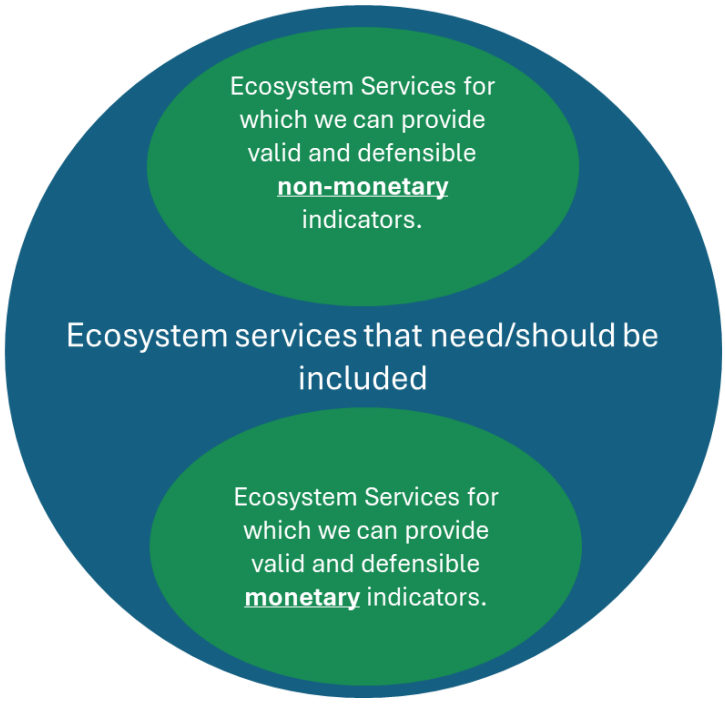

Figure 2. Feasibility of developing quantitative estimates

Monetary Valuation Methods

The project team developed monetary values through benefit transfer. While it would have been ideal to collect data for each coral reef jurisdiction to allow for up-to-date, site-specific values, the project team did not have the capacity to complete the required primary research. In such situations, benefit transfer is commonly used as a substitute. For the foundation of this approach, the project team conducted a comprehensive literature review of existing coral reef valuations and reviewed the results using a set of defensible and transferable criteria (described below) to identify which sources could be used for benefit transfer. This study provides monetary values in terms of both benefits and economic impacts.

The monetary valuation component of this project was initially designed to update and build upon the ecosystem service estimates reported in CRCP's jurisdiction-specific reports. Monetary valuation involves calculating dollar values for the benefits people receive from natural resources, such as coral reef ecosystems. For example, coral reef–associated commercial fisheries generate measurable economic benefits through net revenue (i.e., revenue minus costs) earned by fishers and others involved in the industry. At the same time, fishing often holds deep cultural significance, such that U.S. residents may be willing to pay to keep fisheries well management even if the commercial value is considered low. Economic valuation can take different shapes depending on the research question asked and the methods used to elicit values. Therefore, the project team sought to compile a variety of monetary value estimates across jurisdictions to create a transparent "ledger" of coral reef values—one that decision-makers, stakeholders, and the public can readily understand and use when considering the role of coral reefs in policy and management decisions. The key distinctions between two ecosystem services value types are described below.

Monetary estimates can be divided between economic ***benefits*** and economic ***impacts*****. Economic benefits are the values that society derives from ecosystem services.** Economists often measure this value using willingness to pay (WTP) through simulated markets or referendum surveys. Economists also use other approaches, including calculating avoided damages or replacement costs. Economic benefits are designed to include the value of goods and services that are not traded in markets, such as aesthetic or existence values. These methods attempt to measure what the ecosystem services are worth to society. Monetary economic benefit estimates are meant to reflect a public benefit to society; for example, if people value some specific ecosystem service at $100 million annually and that service disappears due to the degradation of its associated habitat, then society is worse off by $100 million annually.

In addition to economic benefits, this study includes economic *impact* estimates reported from prior studies. **Economic impacts are the economic activity (e.g., spending, taxes, jobs) in the study area that are related to ecosystem services.** Economic impact estimates will often start with direct impacts, defined as the initial spending associated with something (e.g., coral reef–related recreation). Economists then use multipliers to determine how that spending ripples through a regional economy to generate additional economic activity, including jobs. These include indirect impacts, which are generated when reef-dependent businesses (e.g., fishing businesses) purchase goods and services from other local businesses/suppliers, as well as induced impacts, which occur when the people employed in the direct and indirect layers spend their wages in the local economy.

This project was not designed to include performing primary traditional economic impact analysis as described above. Thus, indirect and induced impacts are not reported. Unless otherwise specified in the reference materials, economic impact estimates are limited to measures of direct expenditures (e.g., reported commercial fisheries revenue, tourism revenues) reported in the academic literature, fisheries databases, and government reports.

Note that impacts typically represent a redistribution of spending from one sector or group to another. For example, assume an area has $300 million in spending related to a specific ecosystem service (e.g., recreational fishing); that spending is then used to calculate impact values using multipliers derived from an input-output model. Those multipliers will provide estimates of the additional economic activity generated from the spending and its associated income and jobs. If the ecosystem service disappears, that $300 million in spending is not assumed to completely disappear. It may end up being spent on other things (e.g., other watersports, shopping, entertainment) or be spent elsewhere (e.g., in another region that has recreational fishing).

Since economic impacts are generally considered a transfer from one group to another, economists and other federal agencies such as the U.S. Environmental Protection Agency use benefits as the measure of the value society places on ecosystem services. Nevertheless, economic impact estimates are also important for understanding how coral reefs can contribute to the local economy of an area. Thus, in this analysis, the project team tabulates both economic benefits and direct economic impacts as separate categories. Generally, economists and agencies do not add together the economic benefits and economic impacts, even though both are measured in dollars, because in each case the dollars measure different economic concepts.

Performed Literature Review for Monetary Valuation

The project team conducted a literature review to identify studies to use in benefit transfer. The review was initially conducted during the scoping year for U.S. states and territories. This work involved extracting source and valuation data, as well as other metadata, for analysis; performing a gap analysis highlighting areas and services for future consideration; and engaging with local stakeholders and socioeconomic experts, including cultural and anthropological experts, to guide the project in Year 2 and beyond. Following the scoping year, the project team expanded the literature review to include a wider array of international sources and to fill gaps in non-monetary values. The literature review was updated annually to capture newly published studies.

Literature was gathered through a search of coral reef and ecosystem service databases, Google Scholar, incorporated studies provided by NOAA, and TWGs, totaling 197 publications by Project Year 5 from both the academic and gray literature. At the beginning of the scoping year, NOAA supplied 19 peer-reviewed studies and gray literature reports from past coral reef ecosystem service valuation projects. The search included specialized databases including:

- Blue Value Database, an online, searchable ecosystem service tool (Harte Research Institute, n.d.).
- Ecosystem Service Valuation Database, an expanded database from the United Nations' The Economics of Ecosystems and Biodiversity initiative that is managed by the Ecosystem Services Partnership (Brander et al., 2025).
- Mapping Ocean Wealth Research Library, a list of sources used for The Nature Conservancy's Mapping Ocean Wealth project (Spalding et al., 2016).

The project team also used Google Scholar to further expand the search, excluding studies from before 2000. Participants from jurisdictional workshops also provided several sources for the literature review. As a final step in the scoping year, the project team extracted the references cited within sources considered meta-analyses or systematic reviews and reviewed the references for additional valuations.

To increase the number of potential studies to fill remaining gaps related to the number and quality of valuations, starting in May 2022 (Project Year 1), the project team searched the original literature review databases and expanded the search to include a set of international locations. After selecting studies in the identified countries/regions, removing valuations from sources already included in the literature review, and removing duplicate sources, a total of 471 valuations and 96 sources remained.[2] The project team chose these expanded search locations based on their biogeophysical, socioeconomic, and cultural similarities to NOAA jurisdictions. From this expanded review, the project team found:

- Many jurisdictions and services were eligible for benefit transfer (described below) based on primary valuations extracted during both phases of the literature review. However, considering the sociocultural and biogeophysical aspects of the policy and study sites is critical and may limit the transferability of some valuations to certain jurisdictions.
- At this juncture, critical gaps remained for key services across several jurisdictions, due to a lack of studies or a lack of quality research.

To address remaining gaps in subsequent project years, the project team added sources through updated literature reviews and recommendations from stakeholders and socioeconomic experts.

Determined Defensibility and Transferability

The project team analyzed studies and valuations for two purposes: general defensibility and transferability. Establishing defensibility simply meant ensuring that the study was of sufficient quality. Transferability related to context compatibility for the study-site-to-policy-site benefit transfer process (see the Implemented Benefit Transfer Methods below for more detail). The project team assessed transferability for valuations that would have required transferring an estimate from one location to another.

While reviewing and extracting data from studies included in the literature review, the project team relied on a basic defensibility scoring system to assess valuations using the following criteria, with higher scores indicating a need for increased scrutiny:

- **Valuation methods.** The project team flagged methods that were poorly explained, uncommon or novel for the service being valued, or otherwise questionable in quality and approach. A valuation methods flag counted as one point toward the defensibility score. For example, if the methods presented for a fishing valuation do not distinguish between reef and pelagic species, the project team would flag the value due to this issue.
- **Threat events since publication.** While imperfect, this criterion sought to incorporate the biogeophysical threat events to corals for each jurisdiction—including coral bleaching, disease introduction, invasive species, storms—assuming such events can negatively impact the level of services reefs provide. This scoring involved counting the number of threat events since the valuation publication year; it does not account for recovery, restoration, or compounding damage to reefs. For example, if a jurisdiction experienced two bleaching events and a major ship grounding since the publication of the valuation in question, that valuation would receive a total of three points for this criterion.

[2] Counts of studies are different from counts of valuations. Each study may provide one or more valuations. For example, studies involving estimates of reef diving benefits may provide separate values for natural versus artificial reefs. Both would have been included as separate values in this project.

- **Valuation defensibility score.** The final score is a sum of the two categories above. The scores ranged from zero to five for studies included in the review.

These criteria are not weighted in any particular way due to the variety of potential method issues, and impacts from threat events. For example, the methods flag could have entailed a novel method that has no precedent in the literature, or a very poor description of a commonly used approach such as contingent valuation. Likewise, impact events such as storms or disease are important to note, but the degree of impact and recovery from each event in every jurisdiction is not known. For these reasons, these two criteria were meant to alert the project team to the existence of potential issues, not to act as a basis for disqualification.

All valuations for each jurisdiction were reviewed in-depth for a second time to reassess defensibility, and to also explore the transferability of studies from one jurisdiction or location to another where necessary. The defensibility scoring system described above provided a heuristic for judging the quality of valuations during the second review. Ultimately, valuations were given a ranking of high, medium, or low defensibility. High defensibility entails primary valuations for which no major concerns were found. Medium defensibility entails valuations where the methods and end result were sufficient, but where further expert review and project team deliberation is needed to determine usability. Low defensibility entails valuations that are unlikely to be usable due to poorly explained or non-existent explanations of methods, or limited valuation applicability (e.g., a commercial fisheries valuation that includes pelagic species along with reef species without separating the value for each catch).

Two gap analyses informed the transferability assessment. The project team added The Economics of Ecosystems and Biodiversity[3] (2010) and the Common International Classification of Ecosystem Services[4] (Haines-Young & Potschin-Young, 2018) classifications retroactively for valuations from the initial monetary literature review. These classification systems allowed for viewing gaps across the jurisdictions. The project team used both gap analyses to identify which services were missing and which jurisdictions might have compatible studies. The team ranked studies using on the same scale as above based on their transferability. This ranking included international studies, but ultimately, the project team did not use studies from international locations to fill gaps in U.S. coral reef jurisdictions.

Implemented Benefit Transfer Methods

Using studies identified in the literature review, the project team used benefit transfer to estimate the monetary values of coral reef ecosystem services. Benefit transfer approaches involve taking estimates from previously performed studies and applying those estimates to another situation. Despite the name, benefit transfer can be applied to both economic benefit *and* economic impact estimates. In its simplest form, benefit transfer will involve taking an economic value estimated from a study conducted at one specific site (i.e., the study site) and applying that estimate, with adjustment, to the site of interest (i.e., the policy site). Benefit transfer approaches do not require collecting primary data for valuation studies, which is often prohibitively expensive and time-consuming. However, benefit transfer involves some inherent challenges. Errors from primary valuations of study sites can include biased econometric estimators, while ecological and social discrepancies between the study sites and policy sites can

[3] The Economics of Ecosystems and Biodiversity is a global initiative that highlights the economic value of ecosystem services to inform policy and decision-making, emphasizing the costs of biodiversity loss and the benefits of conservation.

[4] Common International Classification of Ecosystem Services is a standardized framework for classifying ecosystem services—provisioning, regulating, and cultural—to support consistent environmental accounting, assessment, and policy analysis.

complicate the transfer process (Johnston et al., 2021). For this assessment, the project team prioritized using studies with primary valuation methods.

Benefit transfer generally has three approaches:

- **Point value transfer.** An estimate from one or more study sites is applied to a policy site after some adjustment to reflect conditions at the policy site (e.g., averaging overestimated values, adjusting for regional price differences).
- **Function transfer.** A valuation function from a study site is applied to a policy site using data from the policy site to generate an estimate.
- **Meta-analysis.** Results from multiple study sites are analyzed to identify trends over a set of explanatory variables related to the study sites and methods to develop a predictive equation that can be applied to a policy site.

In general, meta-analytic approaches tend to be superior to value transfers and function transfers since they rely on larger numbers of primary studies to identify relationships between estimated economic values and factors that influence those values. The project team was unable to perform a meta-analysis for this study. Additionally, given differences across policy and study sites, the project team was also unable to identify suitable studies for function transfers.[5] Therefore, analysis for this study relied on a value transfer approach known as point value transfer.

Point value transfer is the simplest benefit transfer method. It can be an effective way to estimate values when information on the values is limited. To implement a point value transfer, the project team:

1. Identified relevant studies for each jurisdiction and/or ecosystem service that met defensibility criteria. Identifying studies could involve using more than one study to form a range for the estimate. When using multiple values, the project team needed to ensure the values were consistent with one another, and that any differences between them could be reasonably explained. The team mostly used single-point estimates based on a review of the available studies.
2. Determined whether the studies have a similar scale (e.g., size of ecosystem service change, area) to the jurisdiction or service under consideration.[6]
3. Adjusted for inflation and possibly jurisdictional price levels.

To apply point value transfer, the project team developed an initial list of studies to consider using in the valuation and assessed those studies for defensibility. Once these studies were identified, the team estimated the value of ecosystem services using the studies and other available information. This process led the project team to consider additional studies to fill gaps and, in some cases, alternative studies that were better suited to the purposes of the work. The final set of studies used in this assessment reflects the literature review, the defensibility assessment, and the project team's best professional judgment on the most suitable studies and approaches to address the ecosystem services. Using benefit transfer in this project allowed for a cost-effective and efficient valuation of multiple ecosystem services. As noted above, benefit transfer always has some level of error based on the differences between the study site and the policy site.

[5] To effectively perform a function transfer, the function estimated at the study site would need to be applied at the policy site with updates to the data. For the most part, the estimated functions from study sites for this assessment used data not readily available at the policy site (e.g., collected through a survey).

[6] Transferring values between studies with different scales can be accomplished with some adjustments, but this should be done with caution since the underlying monetary values may depend on the scale itself.

Non-Monetary Valuation Methods

The project team explored several avenues for identifying and presenting non-monetary values for each jurisdiction. A core aim of this exercise was to create *indicators of value* that move beyond dollar amounts. **Indicators of value are "quantitative measures and qualitative descriptors that reflect nature's importance to people. Indicators are generally grouped as biophysical, monetary and sociocultural"** (IPBES, 2022, p. XXIV). The project team also conducted a literature review, led interviews, and reviewed publicly available tax information from reef-related nonprofits to gather qualitative and quantitative values for each jurisdiction.

Many values represented with non-monetary indicators are associated with cultural ecosystem services (MA, 2005). Many are also associated with relational values—that is, values associated with relationships between people and natural resources, and often with meaningful, fulfilling lives (Chan et al., 2018). This project's understanding of non-monetary ecosystem service values evolved from an initial orientation toward the definition of cultural ecosystem services provided by the Millennium Ecosystem Assessment (MEA), to a broader definition of ecosystem services rooted in the IPBES indicators definition above. Non-monetary values, as conceptualized in this project, include indicators of sociocultural ecosystem service values; collecting and analyzing biophysical data was beyond the scope and capacity of this project.

Evolution of Non-Monetary Approach

This project's orientation to non-monetary valuation evolved based on conversations with and feedback from stakeholders and researchers. This deliberative strategy allowed stakeholders to direct the project team toward effective and appropriate means of expressing non-monetary values. Although not as straightforward or established as monetary estimation, the various approaches described below provide crucial information on how coral reefs are important in a way that monetary values cannot fully represent. The project team contends that, while this assessment could be highly valuable for ecosystem service valuations, its approaches are only an initial look into this complex topic.

Although they can communicate ecosystem service values where monetization falls short, non-monetary valuations do not always align with the needs of decision-makers. Aligning non-monetary valuation with decision-maker needs—and modifying decision-making to better accommodate diverse values—is an active area of research. This report draws on the most current approaches and recommendations available and also acknowledges that the work herein, and reactions to it, constitute part of a distributed international effort to improve the representation of non-monetized values in decision-making. Research on non-monetary valuation of ecosystem services relies heavily on concepts of cultural ecosystem services and relational values; these two concepts are deeply intertwined with research on diverse topics pertinent to human–nature relationships, such as Indigenous and Local Ecological Knowledge and sense of place.

Several key limitations of the non-monetary approach require explanation. First, many non-monetary values are explicitly place-based or even time-bound, which is both a strength and weakness. The non-transferability of many cultural and non-monetary values highlights the importance of specific coral reef contexts. Second, the applicability of non-monetary value data to decision-making contexts is not as simple or as common when compared to monetary estimates. Qualitative descriptors and quantitative indicators of non-monetary value (e.g., the number of resource users) can be more ambiguous to diverse audiences than dollar values. These limitations are only relevant when making comparisons between monetary and non-monetary data, but they do not diminish the value of this approach for accurately representing the importance of coral reefs for stakeholders in NOAA jurisdictions. Rather, it requires

creative application approaches to communicate what the core values of coral reefs are to communities who interact and rely on these resources.

Performed Literature Review for Cultural Ecosystem Service Valuation

The project team conducted an extensive literature review of cultural ecosystem service valuation sources to discern the most common methods for determining cultural ecosystem services and to find trends in the field. The review informed recommendations for cultural ecosystem service valuation approaches for the project. The review included coral reef studies, but also other biomes and contexts. This method allowed the project team to determine the primary methods being used across the cultural ecosystem service field, in different geographical contexts, and in different ecosystems. This effort emphasized cultural ecosystem services as conceptualized by the MEA (MA, 2005),[7] which framed the initial organization of services in the scoping year. Several jurisdictions found that ecosystem service categorization and accounting schemes, and the MEA in particular, were reductionist approaches to assessing resources that held significantly more complex values to stakeholders. The project has since evolved to adopt the plural valuation approach, detailed at the beginning of the Methods section, meaning non-monetary values are not strictly cultural but can include expressions of any ecosystem service in a non-monetary way.

The project team collected sources from four existing reviews and meta-analyses of cultural ecosystem service. Additionally, the team used an online academic search engine, Web of Science, to ensure any recent studies were included. Then, the team reorganized these studies into a singular matrix to analyze information about each study and the methods and services it discussed. The primary sources and search terms are available in Appendix B.

After reviewing studies in the Web of Science search and adding studies over the course of the project, the non-monetary cultural ecosystem services literature review resulted in a sample of 879 studies across all ecosystem types that used non-monetary valuation of ecosystem services. Most of the studies pertained to terrestrial ecosystems, which the project team briefly analyzed to categorize their methods and services (Figure 3). This effort provided a foundation from which non-monetary service values could be explored for other jurisdictions in subsequent years.

[7] The MEA was a global scientific effort that evaluated the condition of the world's ecosystems and the services they provide to human well-being. It organized ecosystem services into four categories—provisioning, regulating, cultural, and supporting.

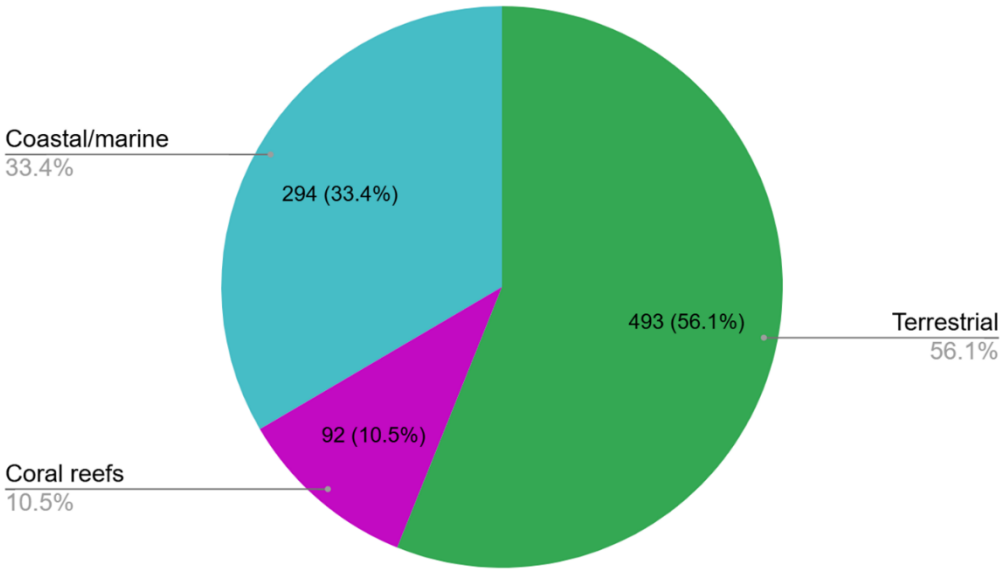

Figure 3. Studies by ecosystem type following the conclusion of the initial non-monetary ecosystem service literature review in project year 3

Conceptualized Defensibility for Non-Monetary Values

The project team established defensibility criteria for the monetary valuation sources—either peer-reviewed sources or government reports—that assumed the authors were held to high research standards while still verifying the methods and results. While the non-monetary valuation sources also included peer-reviewed sources and government reports, the sources were more varied in general. Therefore, holding non-monetary sources to the same level of scrutiny regarding their methods and results was in some cases impossible. Unlike monetary valuation, which strictly uses dollar values, non-monetary values come in more than one shape and size. Quotes from interviews detailing personal stories (i.e., a narrative indicator) or a nonprofit reporting its annual volunteer involvement (i.e., a count indicator) are fundamentally different kinds of information. Assessing the validity of each documented value is far more complex than checking the math, or trusting that peer review or internal government review processes will ensure validity. The project team did not have the capacity or, in most cases, the data to facilitate any kind of ground truthing.

The project team used the subset of papers focused on coral reefs as the backbone of each jurisdiction's non-monetary valuation, with different numbers of papers for each jurisdiction. Along with an analysis of the service values, this review also accounted for the methods used to value non-monetary services across a dataset representing ecosystem services research beyond just coral reefs and U.S. jurisdictions.

The results of the non-monetary cultural ecosystem services literature review provided insights into which methods to use in pursuing non-monetized expressions of coral reef values in U.S. jurisdictions. For all ecosystems included in the review, interviews were the top method used to capture non-monetary values (Figure 4). The same result can be seen in Figure 5 for coral-reef-based studies in particular. The results in these figures and from the stakeholder workshops influenced the next steps on the non-monetary side of the project. The project team included non-monetary services in this project through Interviews and continued literature review. Developing a survey instrument, GIS–based approach, setting up focus groups, and developing an observation-based approach were all beyond the

scope of the project and capacity of the project team. Ultimately, data collection for the methods-based database ceased after the fourth year of the project. At that point, interviews were well underway and the literature review shifted to an indicators-based approach that highlighted more characteristics about the values themselves and less about the particular methods used.

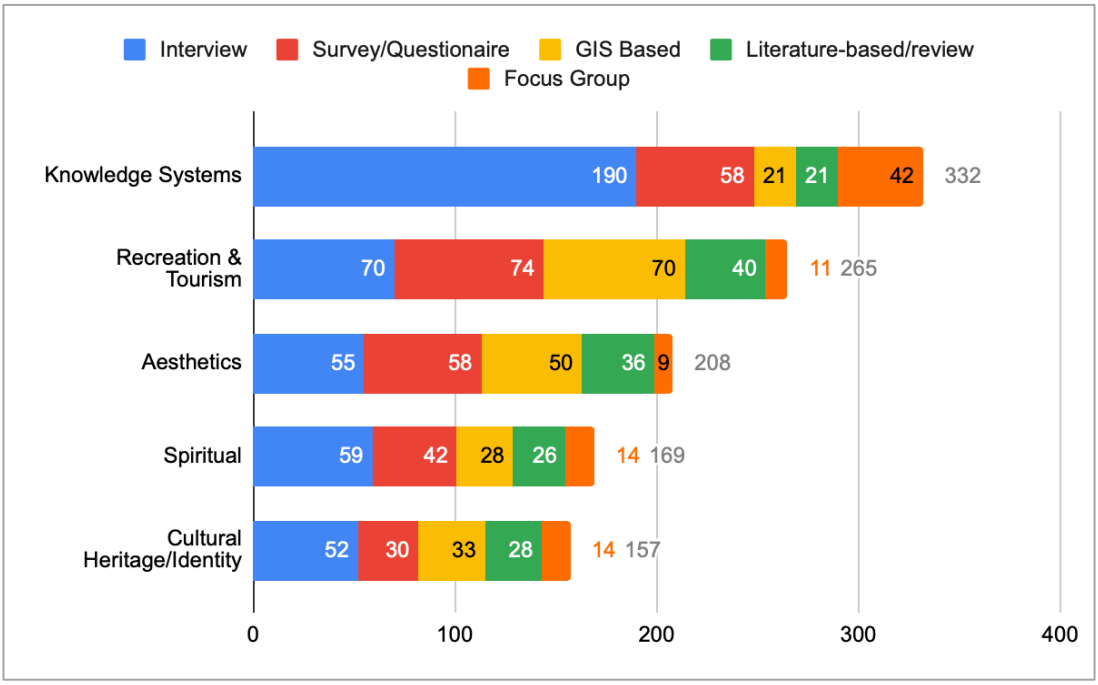

Figure 4. Top five non-monetary cultural ecosystem services and methods for all ecosystem types

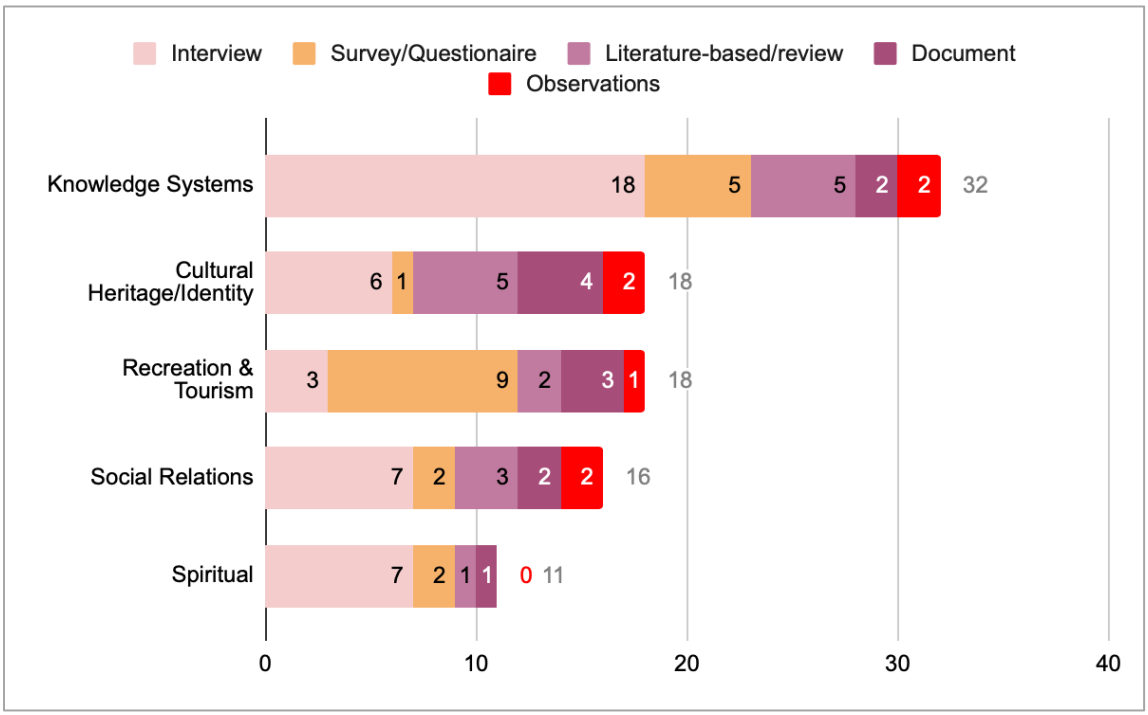

Figure 5. Top five non-monetary cultural ecosystem services and methods for coral reef ecosystems

Conducted Interviews

Starting in Project Year 2, the project team began incorporating interviews with local stakeholders into the non-monetary valuation approach. Three main developments spurred this decision. First, the literature review revealed relatively sparse literature about the cultural ecosystem services (and related values) specific to coral reefs, especially in NOAA jurisdictions. In most cases, the literature contained more work (or more clearly relevant work) on monetary valuation than non-monetary valuation. Second, stakeholders in workshops emphasized the crucial importance of values (e.g., spirituality, heritage) for which the project team could find no published information specific to coral reefs. Third, the methods exploration in the initial non-monetary cultural ecosystem services literature review pointed to interviews as a common method for recording non-monetary values across the cultural ecosystem services field, particularly for coral reef research.

Interviews in this project were not intended to comprehensively illustrate non-monetary values because the Paperwork Reduction Act limited the project team to no more than nine interviews per jurisdiction.[8] Instead, interviews were applied as a way to *explore* non-monetary values, *pilot* an ecosystem service ranking exercise, and *understand* the benefits and challenges of the approach for future NOAA ecosystem service evaluations. Three jurisdictions (Hawai'i, American Samoa, and CNMI) preferred to exclude the interview approach, partly because the limited number of interviews would not be able to represent the

[8] The Paperwork Reduction Act is a U.S. law that aims to minimize the paperwork burden the federal government places on individuals, businesses, and other entities, while ensuring the information collected has practical utility. The law requires federal agencies to justify information collection requests and obtain approval from the Office of Management and Budget before gathering data from the public. https://uscode.house.gov/view.xhtml?req=granuleid:USC-1999-title44-section3501&num=0&edition=1999

many perspectives the jurisdictions considered essential. Additionally, these stakeholders expressed that building relationships and trust was important to them before conducting any interviews, and this project did not have the resources to facilitate the travel and lodging necessary to build relationships and conduct interviews in person.

The project team used a purposive sampling approach common in research that collects qualitative data. This approach involves intentionally selecting a small number of categories of interviewee characteristics that people in the study area deem important and appropriately representative. Within each jurisdiction, the project team aimed to speak with one person representing each of five categories: (1) the recreation or tourism industry, (2) fishing communities, (3) Indigenous groups, (4) experts in cultural resources or cultural history (e.g., archaeological artifacts on reefs like shipwrecks), and (5) the scientific community. Occasionally, one interview respondent represented more than one category (Table 2).

Several challenges hampered the interviews. Communication via email outreach yielded a low response and interview completion rate (33%). Overall, recruiting for interviewees was challenging, with low engagement due to factors including hurricanes, typhoons, and low internet reliability, especially in Guam. As seen in Table 2, the project team did not complete more than four interviews in each jurisdiction where the NOAA liaisons and community members approved of the approach.

Table 2. Interview Completion Rates

Jurisdiction	Interview Goal	People Contacted	Interviews Completed	Interviewee Backgrounds	Notes
South Florida	5	7	4	Lacked an Indigenous group member interview.	Several attempts were made to connect with the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida.
Guam	5	9	3	All interviewees identified themselves as CHamoru, but none were representatives of the recreation and tourism community. One was involved in commercial fishing, one was a cultural expert/historian, and one was a coral reef scientist.	Typhoon Mawar hit Guam in May 2023, heavily impacting interview outreach. While attempts were made to conduct interviews post-disaster recovery, stakeholders did not respond until late 2024.
Hawai'i	0	N/A	N/A	N/A	Feedback from local stakeholders indicated interviews at this stage would be inappropriate.
Puerto Rico	5	26	4	Lacked an Indigenous group member interview.	The project team searched the internet for contact information for representatives of Taino and Jibaro groups, but did not find any contacts.
PRIA	5	12	4	Lacked a recreation/tourism group member interview.	Very few individuals recreate in PRIA, and there is no known tourism association for this region.
American Samoa	0	N/A	N/A	N/A	Feedback from local stakeholders indicated interviews at this stage would be inappropriate.
USVI	5	5	4	Lacked an Indigenous group member interview.	The project team searched the internet for contact information for representatives of Taino groups, but did not find any contacts.
CNMI	0	N/A	N/A	N/A	Feedback from local stakeholders indicated interviews would not be appropriate.
FGBNMS	5	10	4	Lacked an Indigenous group member interview.	As a recently discovered remote and submerged resource, the historical connections to Indigenous communities was assumed to be non-existent.
Total	**30**	**69**	**23**		

Token Exercise

The token exercise was meant to determine relative valuations for non-monetary services. Interviewees were asked to complete a token allocation exercise (Figure 6) at the end of each interview. Each interviewee was asked to allocate 100 tokens across the set of services and values the project team discussed with them during the course of the interview. Interviewees were also given the option to add categories. The project team included this option to explore its potential to represent non-monetary values in future work. Feedback on the token exercise from interviewees was mixed, with some interviewees finding the task very challenging, and others quickly working to assign tokens. Many interviewees expressed thoughts about the inadequacy of the exercise to represent coral reef values.

The token exercise was also piloted in workshops in Project Years 2 and 3 to gain insight into how stakeholders might perceive the approach and the results of a scaled-up exercise. In the workshops, participant reactions to the token exercise varied. Some participants were uncomfortable with the idea of assigning tokens and found it to be reductive. Several workshop participants across several jurisdictions noted that services may be defined differently by different user groups and it was difficult to assign tokens without more information about the beneficiaries or how the services were defined. Other stakeholders saw value in conducting this activity with a wider audience as long as it was clear how the information would be used. The data from the workshop token exercises were excluded from additional analysis and are not included in the results section.

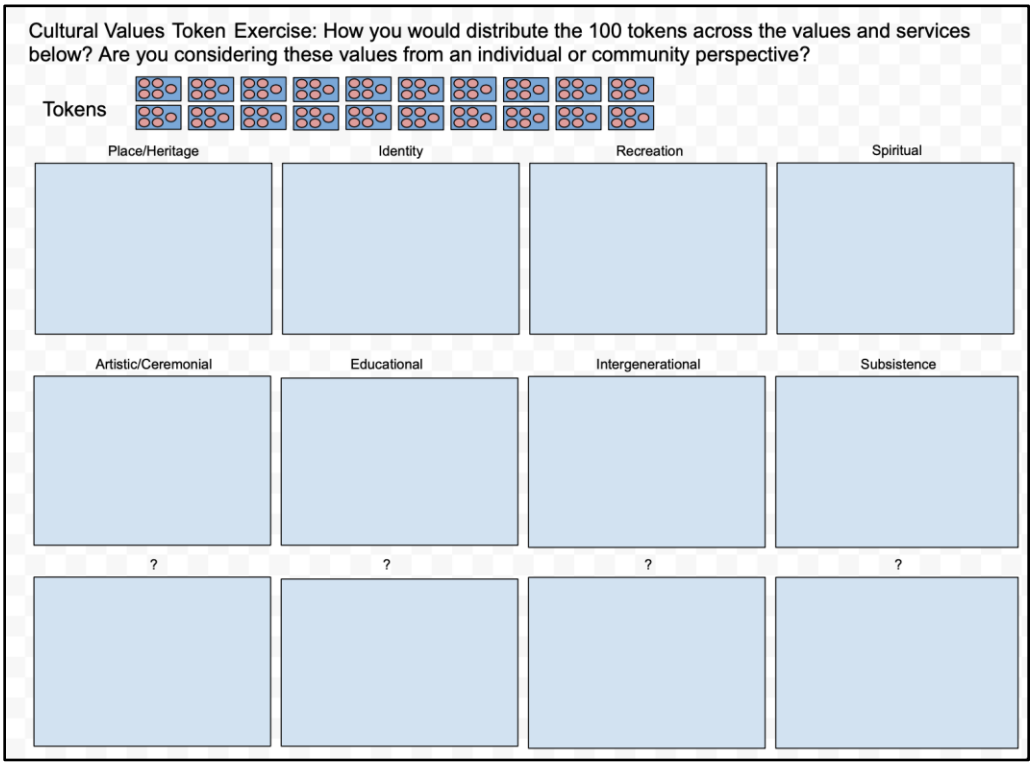

Figure 6. The template for the non-monetary token exercise

Developed the Non-Monetary Ecosystem Service Value Indicators Database

In Project Year 2, workshop participants in Hawai'i and Puerto Rico suggested that developing jurisdiction-tailored indicators would be an appropriate way to describe non-monetary cultural ecosystem services and values. These indicators could include social indicators like stories or examples of key cultural concepts. They can also include biogeophysical indicators that are tied to cultural use, such as population abundance of key species. Workshops focused on drawing out this indicator approach. The approach continued to develop in the following project years, resulting in a new nonprofit Form 990 data collection and extraction protocol, and a new database, detailed below.

Nonprofit Form 990

Late in Project Year 4, the project team added an additional approach to directly address stakeholder feedback about communicating with organizations or reaching out to various organizations working with reefs. In the Year 4 jurisdictional stakeholder workshops, stakeholders recommended connecting with different organizations in their jurisdictions to learn about resources and indicators of value, such as volunteers or jobs. Attempts to find online reports based on these recommendations resulted in a few added resources, and the project team sought a more systematic approach. The team determined that conducting a methodological communications strategy aimed at organizations involved in coral reef work (e.g., advocacy, restoration, volunteer, educational), asking for their reports or published results, and then extracting resources and valuation information would require more effort than was possible, and may be hindered by the same Paperwork Reduction Act issues that have limited the number of interviews. Instead, the project team developed a systematic approach to learning about these organizations.

Form 990[9] is an annual information return that tax-exempt organizations in the United States must file with the Internal Revenue Service, providing details on their finances, governance, and activities. These documents are publicly available and can often be downloaded via the website GuideStar,[10] a rating platform for nonprofits. The project team searched for non-profits in each jurisdiction that primarily worked with coral reefs. Once the Form 990 was downloaded, the project team extracted key data focusing on the organization's mission statement, website, number of volunteers the nonprofit engaged with for that given year, and the listed number of employees.

This approach has several inherent limitations. First, U.S. territories (Guam, American Samoa, Puerto Rico, USVI, and CNMI) may have different forms of governance associated with organizations that resemble 501(c)(3) nonprofits. These organizations—including subsets of larger nonprofits (e.g., The Nature Conservancy), nongovernmental organizations (a more catch-all term for service- or research-oriented organizations acting internationally), and semi-independent branches of local territorial governments—occasionally appear on the GuideStar platform, but they are more often excluded because their Form 990 was applicable to a larger geographic area, rather than a particular jurisdiction. Another limitation is the simple fact that some Form 990s are not available on GuideStar if the nonprofit is out of compliance or if they have a special status, such as revenue that is below the necessary reporting minimum for a full Form 990. For example, Form 990-Ns have a shorter format with less details and are for organizations with less than $50,000 in annual revenue. While imperfect, this approach sought to address stakeholder recommendations about organizational outreach and indicators in a systematic and replicable manner. The primary benefits of this approach are that it responds to stakeholder recommendations and provides indicators of coral reef value related to volunteers and jobs associated with reefs.

[9] https://www.irs.gov/forms-pubs/about-form-990?utm

[10] https://www.guidestar.org/

Non-Monetary Ecosystem Service Indicators Database

The Non-Monetary Ecosystem Service Indicators Database that the project team created provides an organized repository for all types of quantitative and qualitative data that can be used to communicate value. For example, quantitative information includes the number of meals from fishing on reefs, the number of jobs associated with coral reefs, and the percent of local fishers who report sharing their catch with family. Qualitative data include excerpts from interviewees and expressions of qualitative value from academic literature, gray literature, or online oral histories. The project team categorized data by ecosystem service as well as the valuation type and method families from the IPBES's *Summary for Policymakers of the IPBES Methodological Assessment Report on the Diverse Values and Valuation of Nature* (Table 3 and Table 4). The information included in the database is organized by use category (use, non-use), extraction category (extractive, non-extractive), ecosystem service, IPBES specific value, IPBES indicator type, IPBES method type, jurisdiction, region, information type where applicable (e.g., number of people, percent of respondents), and whether the data are qualitative or quantitative. Developing and filling out indicators required incorporating readily available data from the non-monetary cultural ecosystem services literature review, interviews, and nonprofit Form 990 search. The project team added any additional sources provided by workshop attendees or found through the annually updated literature searches concerning non-monetary values to this collection.

Table 3. IPBES Value Typology Concepts, Adapted from Figure SPM 2 of the *Summary for Policymakers* (2022)

Typology Concept	Description	Examples
Specific values: Judgements regarding the importance of nature in specific situations.	Instrumental: Means to an end, nature as a resource and asset, satisfaction of needs and preferences, usefulness for people	Commercial fishery stock, health benefits of recreation on the river
	Intrinsic: Inherent worth of biodiversity as ends in and of themselves, regardless of humans	Fish as beings with inherent worth
	Relational: Importance of desirable, meaningful, and often reciprocal human relationships	Cultural meanings of fishing, sense of place of a fishing community
Value indicators: Quantitative measures and qualitative descriptors that denote nature's importance.	Biophysical	Tons of fish, physiological effects of being in nature
	Sociocultural	Gender-specific participation in fishing, ratings of special places

Table 4. IPBES Valuation Method, Adapted from Table SPM 1 of the *Summary for Policymakers* (2022)

Valuation Method Families	Examples of methods and approaches	Examples of typical valuation "products"
Nature-based valuation	Biodiversity inventory, ecosystem services mapping, Delphi method, participatory mapping of ecological values	• Biodiversity indices, maps of priority areas for policy/management action • Improved understanding of the importance of components of nature
Statement-based valuation	Group discussions, Q-methodology, contingent valuation, choice experiments, deliberative methods	• Ranked importance of nature's contributions to people • Monetary value for protection of areas of biodiversity significance • Explanations for why people value nature
Behavior-based valuation	Participant observation, travel cost method, cost-based methods, hedonic pricing, livelihood dependence, photo-series analysis	• Ranked importance of nature and nature's contributions to people • Additional costs due to degradation (e.g., changes in time to collect fuelwood) • Explanations for how people value nature
Integrated valuation	Ecosystem service valuation, cost-benefit analysis, multi-criteria decision analysis, integrated modelling. scenario building. deliberative decision methods	• Ranked policy options • Evaluation of socioeconomic and environmental impacts of policy options • Improved understanding of conflicts and shared values of nature

Workshops

Throughout the project, the project team held two types of workshops: jurisdictional and socioeconomic. Jurisdictional workshops sought to introduce and vet the project approach with local stakeholders, while the socioeconomic workshop series sought to gather insight from academics and technical experts—including economists, cultural valuation experts, social scientists, and anthropological researchers—on the project team's valuation approaches.

Jurisdictional Workshops

The project team held 13 virtual jurisdictional workshops over the course of the project. The goals of the workshops were to:

- Share the project approach and updates.
- Identify priority ecosystem goods and services and their primary beneficiaries in the jurisdiction.
- Discuss priority cultural ecosystem services and understand how those cultural services are conceptualized.
- Share draft values.

The project team use the feedback for the workshops to refine the project approach, add sources, and ensure the ensuing work is aligned with place-based considerations. As detailed in Table 5, the team held one to two workshops per jurisdiction during the jurisdictions' respective valuation years.

Table 5. Jurisdictional Workshop Details and Outcomes

Jurisdiction	Workshop Details and Outcomes
South Florida	**South Florida Workshop 1: October 13, 2022** Workshop 1 introduced the project goals and approach and provided an initial list of ecosystem services to include in the monetized results. Key outcomes and feedback from this workshop is summarized below: ● Stakeholders provided insight on the nuances and differences of ecosystem service subcategories, which the project team used to refine the list of ecosystem services excluded in this assessment. ● Stakeholders identified 2014 as a critical year in changing reef conditions, suggesting the year as a threshold when assessing transferability of sources. ● Stakeholders advocated for overtourism to be explicitly addressed in a valuation of South Florida's ecosystem services. For example, services (e.g., tourism, recreation, coastal protection) may be of high economic value but have surpassed a threshold of social and ecological sustainability. **South Florida Workshop 2: January 31, 2023** Workshop 2 presented draft results and discussed methods for communicating ecosystem service values. The main feedback from this workshop is summarized below: ● Impact values are more salient for decision-makers and stakeholders, so guidance is needed for communicating ecosystem service benefits. ● Stories are helpful in communicating value and enriching monetized values. ● Participants requested more granularity across a few key areas, such as recreation types and identity value for different stakeholder groups.
Guam	**Guam Workshop 1: October 7, 2022** Workshop 1 shared the project approach and identified priority coral reef ecosystem services in the area. The main feedback from this workshop is summarized below: ● Cultural values are perhaps the most important values for Guam residents; they are also the most threatened. These values should feature prominently in future reports and valuation efforts. ● The services that can be monetized do not necessarily benefit Guam residents uniformly, and special consideration of these delineations can enrich valuation efforts. **Guam Workshop 2: January 31, 2023** Workshop 2 presented draft results on ecosystem good and service values in Guam. The main feedback from this workshop is summarized below: ● Better explanations about the process of benefit transfer might help make monetary values clearer. ● Expanding non-monetary values could include incorporating facts and stories from important cultural sites, practices, and beliefs.

Jurisdiction	Workshop Details and Outcomes
Hawai'i	**Hawai'i Workshop 1: August 4, 2023** The purpose of the first workshop with Hawai'i was to introduce the project, confirm the ecosystem services to include in the analysis, share draft monetary values, and share and solicit feedback on the project team's approach for collecting non-monetary values. Main outcomes from the workshop are summarized below: ● A new lens toward coral reef subsistence food systems was suggested by an attendee. The directive was to explore food system values beyond fishing in future assessments. ● Several new ecosystem services were identified: customary exchange, Indigenous aquaculture (e.g., fish ponds), and limu gathering. ● New indicators were suggested: educational indicators, such as curricula and informal learning, and news media in both English and Hawaiian languages. ● Attendees provided additional sources both during the workshop and afterward via email. ● A strong emphasis on the innate challenge of valuing coral reefs in general, but specifically with monetary methods. Attendees offered examples of cases where monetary valuation would be inadequate, including broad perspectives about the appropriateness of monetary approaches to assessing cultural heritage, and the priceless nature of traditional practices and culture. ● Attendees provided valuable feedback on different methods to explore and offered several new approaches: ○ Broadening the kinds of data and knowledge included in the study. ○ Acknowledging the historical practices, such as harvesting limu near coral reefs, that are now impossible due to ecological changes. **Hawai'i Workshop 2: November 20, 2023** The second workshop provided an update on non-monetary valuation efforts and discussed methods for communicating ecosystem service values. Main outcomes from the workshop are summarized below: ● The indicator approach is better than previous approaches but needs better attention to detail. ○ Biocultural indicators could be a good place to look. ■ Species that inform language, food practices, teaching. ○ Attention to beneficiaries is key. ○ Indicators and values to add or explore include limu, Hawaiian surfing, school curricula, and key cultural species. ○ Attention to reciprocity is important for some of these indicators, such as opportunities for intergenerational teaching. ● The exercise of allocating tokens is inappropriate for cultural service valuation, but if such an approach is used, it should employ a holistic interpretation of ecosystem services. ● Monetary value reporting would benefit from additional details, such as beneficiaries and sample populations (e.g., U.S. mainland public versus Hawaiian Island public).
Puerto Rico	**Puerto Rico Workshop 1: August 15, 2023** The purpose of the first workshop with Puerto Rico was to introduce the project, confirm the ecosystem services to include in the analysis, share draft monetary values, and share and solicit feedback on the project team's approach for collecting non-monetary values. Key outcomes from this workshop are summarized below: ● Stories are an important communication mechanism for stakeholders in Puerto Rico. ● The breakout groups revealed a strong need for balance between monetary and non-monetary valuations. ● Recreation values should include as many types of values as possible, and if possible, aggregate recreation values should be itemized by type.

Jurisdiction	Workshop Details and Outcomes
	Puerto Rico Workshop 2: December 8, 2023 The second workshop provided an update on non-monetary valuation efforts and discussed methods for communicating ecosystem service values. Key outcomes from this workshop are summarized below: ● Additional indicators include use of coral reef terms in common language, spatial data, social media information, and news media. ● Blue mind—or improved mental health from being near, on, or in water—associated with coral reefs could be determined via a simple survey, and certainly exists in Puerto Rico, but the concept is hard to describe. ● The tokens exercise was challenging to do in such a short time span, and better directions about how to fill out the exercise could have provided clarity. ● The monetized coastal protection value may be low given the centrality of coral reefs to discussions about hurricane damage in Puerto Rico.
PRIA	The project team did not hold a workshop for PRIA because conversations with NOAA staff knowledgeable about the area, and with a non-federal expert on PRIA, strongly suggested that a productive workshop for PRIA was not possible at that time, for two main reasons. First, the ongoing controversy about the designation of the Pacific Remote Islands National Marine Sanctuary would have likely strongly influenced the workshop discussion despite the project team's explicit focus on shallow coral reef systems (this was confirmed by an interview held with a CNMI resident). Second, the PRIA expert suggested that a workshop for PRIA should be framed as an "Uninhabited Areas Workshop," which for this project also includes FGBNMS.
USVI	These workshops were facilitated by a USVI-based facilitator but held virtually. **USVI Workshop 1: July 12, 2024** The purpose of the first workshop in USVI was to share and solicit feedback on the project team's approach for collecting non-monetary values and solicit feedback on the ecosystem services included in the project team's monetary valuation. Key outcomes from this workshop are summarized below: ● Connecting with organizations in USVI would be a good way to collect new types of information. ● Tourism is very important for USVI, but it is also a stressor. ● Quantitative and qualitative indicators are both important for USVI and can complement each other. However, quantitative indicators are more aligned with coral reef work. **USVI Workshop 2: February 6, 2025** During the second workshop, the project team presented and discussed updated findings and approaches for representing non-monetary values through quantitative indicators. The team also piloted the tokens exercise for estimating relative importance among ecosystem service values and solicited feedback on a draft communications product. Key outcomes from this workshop are summarized below: ● Participants provided several new sources to review for the non-monetary indicator search. ● Participants provided feedback about extrapolating non-monetary indicators where possible for USVI. They noted that, in many cases, extrapolating would be inappropriate, but there may be situations where it could be useful for decision-makers. ● Participants provided feedback on draft communications materials, including insights on who and how study results could be used and on framing values.

Jurisdiction	Workshop Details and Outcomes
American Samoa	One hybrid workshop was held in American Samoa, facilitated by a local stakeholder. While the project team planned to host a series of smaller group discussions as a second engagement effort, scheduling difficulties and local capacity prevented these discussions. **American Samoa Workshop 1: August 27, 2024** This workshop shared the non-monetary valuation methodology and solicited feedback on its usefulness and appropriateness. The workshop also solicited feedback on draft monetary values. Key outcomes from this workshop are summarized below: ● Non-monetary values are very important in American Samoa. It is critical to capture them thoroughly in this report to fully capture the value of American Samoa coral reefs in a way that can support management purposes. ● Participants expected interviews could provide some valuable and powerful information (e.g., quotes), but there was some concern regarding if the interview sample size would be representative. Participants noted the perspectives of American Samoa residents vary by island, age group, and background. While there was no issue with interviews as an appropriate method for capturing non-monetary values, the project team should explore other avenues to better collect diverse perspectives, since the number of interviews possible is limited. ● Traditional knowledge is the only way many indicators and qualitative information are available. Traditional knowledge and values captured by American Samoa oral tradition need to be further explored to fully represent these non-monetary values.
FGBNMS	There was one virtual workshop held for FGBNMS. While originally scheduled for fall of 2025, the workshop was delayed to 2026 due to the lapse in federal funding. Given the timeline for the project and the limited number of stakeholders and professionals involved with FGBNMS, one workshop was deemed sufficient for this uninhabited jurisdiction. **FGBNMS Workshop: January 14, 2026** The purpose of this workshop was to share the project team's non-monetary valuation process and solicit feedback on its appropriateness and usefulness. The workshop also aimed to identify any sources or data the project team had not considered and to solicit feedback on draft monetary valuation estimates. Key outcomes from this workshop are summarized below: ● Most participants agreed monetized valuations were low across biodiversity, recreation, and research due to uniqueness and healthy condition of the reef. Participants strongly suggested additional effort to collect information about the option value of corals in FGBNMS, stressing that the corals in FGBNMS are a rare example of a healthy reef in the Caribbean and can provide future value in restoration efforts in the region. ● Participants identified a wide range of unique aspects of FGBNMS coral reefs that provide non-monetary values, including its status of a bucket-list destination for divers, the hope and restoration potential it provides due to its healthy reef condition, the ability of FGBNMS to act as a biodiversity stepping stone, and its function as a "bread basket" for fisheries in the region.
CNMI	There was one hybrid workshop held in CNMI, with in-person facilitation assistance from local stakeholders. Given the feedback stakeholders provided in the first workshop, it was determined by the project team a second engagement would be inappropriate. **CNMI Workshop: September 18, 2025** This workshop shared the non-monetary valuation methodology and solicited feedback on its usefulness and appropriateness. The workshop also solicited feedback on draft monetary values. Key outcomes from this workshop are summarized below: ● Interviews are only appropriate when approached as a reciprocal exchange that invests time in trust-building and community context. Quick, extractive approaches are ineffective, while locally rooted methods such as "talk story" or village-based interviews by trusted locals yield more

Jurisdiction	Workshop Details and Outcomes
	meaningful results. Locally trained interviewers and broad, representative participation across ages, roles, and cultural groups are needed to avoid bias and ensure interviews capture diverse perspectives. ● Both qualitative and quantitative indicators are valuable, but they must be clearly explained and represent community realities. Holistic measures should go beyond extractive or commercial values to capture cultural meaning, recreation, health benefits, language, research, and stewardship activities. Narrative and visual observations can highlight non-monetary values, such as seasonal fish changes, that quantitative data miss. Health benefits from everyday reef interactions are also a major non-monetary value that deserve recognition. ● The project team should present findings in plain, non-technical language and in formats that resonate with the community, such as videos or stories. Outputs need to be transparent, clearly show how results will be used, and provide accessible data and products that support community use and decision-making, not just external researchers. Non-monetary values also shift with age, so incorporating the perspectives of youth and elders will strengthen representation and outcomes. ● Traditional practices and Indigenous stewardship, which have sustained reef health for generations, must be acknowledged and incorporated. Embedding these perspectives strengthens valuation, ensures local relevance, and provides a foundation for future education, reef management, and community engagement.

TWG Workshops

During each project year, the project team held workshops with socioeconomic researchers and experts—including experts in classical economics as well as cultural values and anthropology—to solicit guidance on overall methods across both the monetary and non-monetary valuation approaches. The team held two to three meetings per project year (a total of 11 across the project). Scoping year workshops focused on developing and refining methods. In subsequent project years, meetings focused on reviewing that year's results and discussing the theoretical and practical challenges of the project team's approach, such as providing non-monetary estimates for uninhabited regions, combining monetary and non-monetary results for maximum impact, and communicating results to different audiences. These meetings, initially referred to as Socioeconomic Expert Workshops, evolved into a more formal TWG. Insights arising from workshops and later TWG meetings, detailed in Table 6, helped drive the development of the methods, stakeholder communication, and ultimately the recommendations within this report.

Table 6. Socioeconomic Experts Workshop Details and Outcomes

Project Year	Workshop Details and Outcomes
Year 1	**Coral Reef Ecosystem Services Academics/Researchers Workshop 1: November 14, 2022** ● Participants identified creative and evocative data visualization as a key component in effectively incorporating non-monetary values into valuation efforts. Suggested examples included a spider leg plot showing values across different groups, an interactive map of reefs and the services they provide, or a visualization of value conflicts. **Coral Reef Ecosystem Services Academics/Researchers Workshop 2: February 21, 2022** ● Participants recommended using visualizations to effectively communicate both the overall approaches being used (e.g., a cube with each approach represented as a side or window into the interior, which contains the ecosystem service context in question), as well as the value estimates and ecosystem services themselves.
Year 2	**Coral Reef Ecosystem Services Academics/Researchers Workshop 1, Non-Monetary Values Focus: September 22, 2023** ● There may also be local costs associated with conceptualized benefits at the state, national, or international levels that are secured or realized via conservation. For example, if Hawai'i's reefs provide monetary value in recreation benefits, and imposing conservation measures on them secures that benefit, there will still be costs at the local level that could be both monetary and non-monetary. ● In pursuing local input and direction for non-monetary value indicators, the project team should acknowledge that a comprehensive approach is not feasible, and that the team cannot possibly include every voice, to the detriment of the whole project. This is an inherent limitation in place-based non-monetary valuation. ● When developing indicators, the project team should: ○ Aim for standardized indicators while also making room for place-based indicators. ○ Ensure there are not too many indicators to manage. ○ Refrain from falling back on narratives as a way to consider cultural ecosystem services; this is often seen as an easy way to do so, but it also was said to sideline cultural values. ○ Tie indicators to their beneficiaries. ● Data sovereignty should be better managed and discussed with stakeholders. The project team should determine how to manage data from the non-monetary part of the project, share data with stakeholders or provide them access to the data, and/or gather data management input from stakeholders. ● Presenting hypotheticals to stakeholders when requesting input on values and indicators may be advisable. Consulting with several of the workshop attendees would be prudent in this regard. **Coral Reef Ecosystem Services Academics/Researchers Workshop 2, Monetary Values Focus: September 25, 2023** ● When possible, reporting should include values for the unit of analysis (e.g., households, trips). ● Reassessing the defensibility approach might be prudent, and attendees offered guidance on how to start.
Year 3	**TWG Meeting: September 23, 2024** ● As long as methodologies are transparent and clearly presented, the overlap between the monetary and non-monetary values is not a concern. Transparency will be key when communicating results. ● The concept of a lower bound may not be appropriate for non-monetary values, as it implies a quantitative scale. The TWG encouraged careful

Project Year	Workshop Details and Outcomes
	and radical thinking when communicating results and leading with dollar values. The project team may want to highlight that it can only put a dollar value on a fraction of the value. ● In reporting results, lead with the non-monetary values. ● Different audiences may require different products. The project team is encouraged to think outside the box in its presentation. Examples also include communicating the losses beyond just the loss of an ecosystem service (e.g., how a loss impacts people's lives and the community). **TWG Meeting: January 17, 2025** ● The TWG did not agree on the appropriateness of non-monetary benefit transfer. Some members saw it as inappropriate in almost all cases, and others saw it as conceptually and philosophically equivalent to monetary benefit transfer. ● Some of the discrepancy in opinions related to the types of values extrapolated. Some kinds of quantitative indicators may lend themselves to extrapolation or scaling up, but this should be done carefully, with assumptions clearly stated and with consideration to influential factors (e.g., ecological health, social factors such as access). ● For other kinds of quantitative indicators, the TWG identified extrapolating and scaling up as potentially problematic approaches due to the place-based nature of some indicators. Informed judgement and consideration of the uniqueness of sites can help determine when extrapolation is appropriate, but most importantly, any extrapolated values should be clearly labeled and explained. ● The TWG was comfortable with summaries of qualitative indicators that generalize across geographical regions, provided those generalizations are clearly supported by evidence. **TWG Meeting: March 13, 2025** ● Communicating values requires careful consideration of what would be helpful, or potentially harmful, to stakeholders in the relevant jurisdictions. ● The legal basis for centering non-monetary values may work in some jurisdictions, especially in the Pacific.
Year 4	**TWG Meeting 1: October 17, 2025** ● Participants recommended that when presenting relational values to the public or to policymakers, it can be helpful to appeal to emotions by using images and stories and to distill the information into something succinct that resonates with the intended audience. ● The TWG recommended including examples of applications of non-monetary values in existing decision support tools, such as threshold analysis and habitat equivalency analysis. The TWG felt that only using these values in policy memos and one-pagers is unsatisfactory. The non-substitutability of some cultural services may render the application of threshold analysis or habitat equivalency analysis inappropriate when transferring from one site to another since cultural values can be explicitly place-based. **TWG Meeting 2: April 10, 2026** ● Participants discussed the relationship between monetary and non-monetary values, highlighting that monetary approaches are quite established, while non-monetary approaches rely on a broader range of methodologies and more limited data. The TWG suggested clearly describing the limitations of each approach and the appropriate uses of each approach. ● The TWG discussed ways in which this report could be used, such as acting as a tool to support deliberation, highlighting the values that monetary valuation leaves out, and bringing a broader set of public values into decision-making. The TWG recommended clearly defining the intended uses of the report. ● The TWG noted that this report is likely to be used differently over time and by different audiences. The TWG also emphasized the importance of defining key terms and clearly describing methodologies to support future use.

III. Results

This section summarizes the monetary and non-monetary results for each jurisdiction. All monetary results have met or surpassed the defensibility criteria mentioned in the Approach section. Non-monetary results have been selected to represent key ecosystem services identified by stakeholders.

Using These Results

These results convey the best estimates for ecosystem service benefits and impacts as found in the peer-reviewed academic literature and government reports. Several key considerations require explanation:

Monetary Values

- **Low vs. high monetary values**: Where possible, this report presents ranges for both benefits and impacts. In some cases, the range may be from a single study where the author provided both low and high estimates. In other cases, where two different studies provided values that measure the same ecosystem service at the same scale, the report lists both in order of magnitude. For example, Bartelet et al. (2024) used Spalding et al.'s (2017) dataset and only parsed out value-added impacts. These two studies can thus be used to represent a range of the same value. If no range is provided or can be inferred, values are assumed to be high. The driving assumption here is that coral reefs have degraded significantly across the globe, but the change in ecosystem service provision from the time of a study to present is not considered in the analysis. For this reason, the project team has taken a conservative approach and assumed that the study value, adjusted for inflation, may represent a different and possibly higher level of ecosystem service provision than is currently experienced.

- **The monetary values are not necessarily transferable**. Values for one jurisdiction do not, in most cases, translate to other jurisdictions, or to coral reef contexts beyond those included in this project. It is inappropriate to generalize these results beyond their specific context.

- **The monetary values are not necessarily summable across different jurisdictions**, **regions, or nationally**, with the exception of the selected studies in the National-Scale Estimates section. The variety of estimation methods used in the source literature, and the varying services being evaluated, prohibited easy aggregation of results. Caution should be exercised when aggregating values that express different value types, and even when aggregating similar values. Studies that provide estimates for multiple jurisdictions (e.g., Storlazzi et al., 2019) are easily summable, but attention to how the specific contexts related to factors such as access to coral reefs and ecosystem health still influence the relative value and the present-day value is recommended.

- **The monetary values do not necessarily comprehensively represent any particular ecosystem service, but they do comprehensively represent the available and defensible estimates published by specialists in the field. While** monetized valuations of ecosystem services allow easy incorporation into current decision-making frameworks, they often do not fully capture the value of a service and in some cases are incapable of accurately valuing certain services (Gould et al., 2025).

- **Careful consideration of the language used in communicating these results is of paramount importance.** These values are estimates based on a particular method of research conducted

during a particular time and, in many cases, in a particular place. Some meta-analyses provide larger-scale or more generalizable estimates, but they are still estimates. The figures reported below should not be communicated as the *de facto* amount of any given ecosystem service, but rather as an estimate based on a referenced study.

- **The various units used to develop estimates represent the best available information.** Studies often rely on units such as the number of households or number of trips. These figures change in each jurisdiction from year to year. The project team sought up-to-date information for each instance when such units were used. Links and references are provided in the footnotes for each jurisdiction-level monetary result table.

- **For most jurisdictions, per-acre estimates were developed based on coral reef area estimates from the U.S. Coral Reef Task Force and NOAA CRCP**. Other NOAA sources were used when necessary, and for Puerto Rico, a report from The Nature Conservancy was used (The Nature Conservancy, n.d.). The per-acre estimates are reported to make these results adaptable to different calculations of coral reef area. Any application of the per-acre results should consider the context in question. For example, the amenity per-acre value should not be applied to an acreage for Hawai'i that includes the Northern Hawaiian Islands, where very little property and economic activity exists.

- **Values were adjusted to 2025 USD price levels** using the local Consumer Price Index (CPI) where possible. Values for uninhabited areas were adjusted based on the overall U.S. CPI from the Bureau of Labor Statistics (BLS). American Samoa values were adjusted based on the U.S. CPI due to the lack of localized data. CNMI values were adjusted to 2024 USD due to the lack of updated 2025 local CPI data at the time of writing.

Non-Monetary Values

- **The non-monetary approach resulted in hundreds of indicators of coral reef ecosystem service value overall, including between 13 (PRIA) and 161 (CNMI) values for each jurisdiction.** Presenting every indicator in this report would be impractical. The indicators included for each jurisdiction were selected to provide good examples of the ecosystem services identified as important in that area and to represent an array of indicator types.
- **This project's approach to non-monetary valuation closely followed current international understandings of effective ecosystem valuation.** As described in the Approach section, this is an ongoing area of research that lacks methods standardization; this report's particular combination of methods can thus be seen as exploratory. This report can be considered as describing an incomplete baseline in terms of the types of information and ecosystem services: it reports on ecosystem services as described in the sources available based on the scope and capacity of the project. The available sources included academic literature, government reports, nonprofit Form 990 documents, and roughly four interviews with expert informants per jurisdiction.
- **Some non-monetary values are more complete representations of ecosystem service value than others**. For example, a statement about the value of recreational fishing for well-being is self-evident and probably requires no additional contextual information to be understood. On the other hand, quantitative data about jobs associated with coral reefs or the number of visitors to a particular area often benefit from additional context not included in the measure presented here. These latter examples are instances where non-monetary indicators may be most informative when used in dialogue with monetary information, or with more in-depth ecosystem

service descriptions from qualitative sources. The Recommendations section provides further discussion of this challenge.

- **As with monetary indicators, the non-monetary values developed for this report were directly influenced by the types of data this project was able to collect.** The resulting dataset from the academic literature, government reports, nonprofit Form 990 documents, and interviews is far from comprehensive. It is thus not appropriate to draw conclusions about predominant themes (for instance, it would be incorrect to assume that a certain value is less important in a jurisdiction for which we found fewer indicators of that value). The Limitations and Recommendations sections discuss how future work could expand the scope of non-monetary valuation.

Summary of Monetized Results

National-Scale Estimates

National-Scale Economic Benefits

Monetary results are presented in this section as a series of summable estimates from studies applied consistently across multiple jurisdictions using benefit transfer, and as per-acre values. **This means only that these specific ecosystem service estimates are summable at the national scale within each of these tables. We do not recommend adding values together from different tables.** Several key studies have been used in each jurisdiction as primary sources. These are Storlazzi et al. (2019), a study concerning coastal protection ecosystem services; Spalding et al. (2017), a study on recreation benefits (this study excluded American Samoa); Londoño and Johnston (2012), a global-scale meta-analysis of coral reef recreation; and FEMA (2022), a study of ecosystem services across a variety of ecosystems in the United States, including coral reefs. For these sources, summing to a national level is appropriate. These estimates have been developed using each jurisdiction's local CPI. Note that the values included here are, in most cases, considered as the high end of a given range. (See the Using These Results section for an explanation of the rationale for listing most estimates as "High.") The national-level summary tables are split into two subsections, economic benefits and economic impacts. Benefits estimates are presented in Tables 7, 8, and 9. Impact estimates are presented in Tables 10, 11, and 12.[11]

Coastal Protection

In Table 7, the economic benefits of coastal protection are represented by the **total present value (TPV) of buildings protected by reefs**. Estimates are provided in the table for TPVs, annualized values, and per-acre values. To estimate TPV, the project team applied discount rates (DRs) of 3.1% and 7% over a 30-year period, reflecting alternative assumptions about the social rate of time preference and the opportunity cost of capital, respectively. Based on the direction of OMB Circular A-94, the team applied a risk-adjusted social DR of 3.1% (OMB, 2023). Specifically, a 2% risk-free DR was adjusted upward to incorporate a default risk premium of 1.1%. The 7% rate reflects expected returns to private capital; reporting both provides a standard sensitivity range for policy analysis. See OMB Circular A-4 guidance and updates (OMB, 2003).

[11] The project team chose to exclude PRIA from both sets of tables. Although some estimates, such as FEMA's biodiversity and research values, could be applied to PRIA based on the assumption that there is indeed a value of the biological function and that researchers are present in PRIA, the lack of primary research in this jurisdiction suggests that the extent of these services is unknown. Applying benefit transfer to a region where values of any kind have yet to be estimated and established is assumed to be ill-advised.

Table 7. National-Scale Economic Benefit Estimates for Coastal Protection (in 2025 USD)

Jurisdiction	Low TPV (30-year, 7% DR) (millions of USD)	High TPV (30-year, 3.1% DR) (millions of USD)	Annual Value (millions of USD)	Per-Acre Annual Value (USD)
Guam	$136.25	$212.45	$10.98	$407.64
South Florida	$7,064.10	$11,015.10	$569.27	$255.97
Hawai'i	$6,328.83	$9,868.58	$510.02	$1,244.86
Puerto Rico	$1,030.61	$1,607.04	$83.05	$648.86
American Samoa	$473.62	$738.51	$38.17	$521.81
USVI	$414.46	$646.27	$33.40	$675.83
CNMI [a]	$76.10	$118.66	$6.13	$153.19
Total	$15,523.97	$24,206.61	$1,251.02	$3,908.16
Per-Acre Average	--	--	--	$558.31

[a] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Amenity and Biodiversity

Table 8 presents the national-scale annual economic benefit estimates for aesthetic/amenity value and biodiversity, which are based on the FEMA (2022) study. For **aesthetic/amenity values**, FEMA relied largely on hedonic pricing and stated-preference studies prioritizing broader meta-analytic estimates to improve national applicability. For **biodiversity values**, FEMA drew on ecological-economic studies that quantify reefs' role in supporting biodiversity and fisheries, synthesizing across multiple sources. These values reflect the contribution of reefs as nursery and species-support systems. The total values are determined by the per-acre values and are subject to the size of the coral reef area in each jurisdiction.

Table 8. National-Scale Annual Economic Benefit Estimates for Aesthetic/Amenity Value and Biodiversity (in 2025 USD)

Jurisdiction	Aesthetic/Amenity Value		Biodiversity Value	
	Total Value (millions of USD)	Per Acre Value	Total Value (millions of USD)	Per Acre Value
Guam	$3.87	$143.77	$75.48	$2,802.28
South Florida	$318.49	$143.21	$6,207.82	$2,791.36
Hawai'i	$54.90	$134.01	$1,070.16	$2,612.05
Puerto Rico	$16.62	$129.84	$323.93	$2,530.71
American Samoa	$9.91	$135.44	$193.10	$2,639.99
USVI	$7.73	$156.36	$150.62	$3,047.74
CNMI [a]	$4.64	$115.81	$90.36	$2,257.30
FGBNMS	N/A	N/A	$271.01	$2,639.99
Total	$416.16	$958.44	$8,382.48	$21,321.42
Per-Acre Average	--	$136.92	--	$2,665.18

[a] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Recreation

Table 9 presents the national-scale annual economic benefit estimates for recreation, which are based on the Londoño and Johnston (2012) study. That study compiled and standardized data from multiple **coral reef recreation** WTP valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. For this application, and based on Londoño and Johnston's recommendations, the project team restricted the dataset to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions. In the table, the wide range of values for NOAA jurisdictions are a function of variation in the number of annual visitors and acres of coral reef. FGBNMS is excluded here because all of the studies used to inform Londoño and Johnston's study were from coastal contexts whereas FGBNMS is a fully submerged and remote jurisdiction.

Table 9. National-Scale Annual Economic Benefit Estimates for Recreation (in 2025 USD)

Jurisdiction	Total Value (millions of USD)	Per Acre Value
Guam	$111.58	$4,142.77
South Florida	$384.95	$173.09
Hawai'i	$55.41	$135.25
Puerto Rico	$479.66	$3,747.32
American Samoa	$0.25	$3.42
USVI	$106.05	$2,145.94
CNMI [a]	$4.59	$114.64
Total	$1,142.49	$10,426.43
Per-Acre Average	--	$1,494.63

[a] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

National-Scale Economic Impacts

Coastal Protection

In Table 10, the economic impacts of coastal protection are represented by the **value of economic activity protected by reefs**. Estimates are provided in the table for TPVs, annualized values, and per-acre values. To estimate the TPV of economic impacts from coastal protection, the project team applied DRs of 3.1% and 7% over a 30-year period, reflecting alternative assumptions about the social rate of time preference and the opportunity cost of capital, respectively. Based on the direction of OMB Circular A-94, the team applied a risk-adjusted social DR of 3.1% (OMB, 2023). Specifically, a 2% risk-free DR was adjusted upward to incorporate a default risk premium of 1.1%. The 7% rate reflects expected returns to private capital; reporting both provides a standard sensitivity range for policy analysis. See OMB Circular A-4 guidance and updates (OMB, 2003).

Table 10. National-Scale Economic Impact Estimates for Coastal Protection

Jurisdiction	Low TPV (30-year, 7% DR) (millions of USD)	High TPV (30-year, 3.1% DR) (millions of USD)	Annual Value (millions of USD)	Per-Acre Annual Value (USD)
Guam	$202.31	$315.46	$16.30	$605.29
South Florida	$6,331.64	$9,872.97	$510.24	$229.43

Jurisdiction	Low TPV (30-year, 7% DR) (millions of USD)	High TPV (30-year, 3.1% DR) (millions of USD)	Annual Value (millions of USD)	Per-Acre Annual Value (USD)
Hawai'i	$9,071.96	$14,145.95	$731.08	$1,784.42
Puerto Rico	$1,832.92	$2,858.09	$147.71	$1,153.98
American Samoa	$133.09	$207.52	$10.73	$146.63
USVI	$477.85	$745.11	$38.51	$779.19
CNMI [a]	$109.86	$171.30	$8.85	$221.15
Total	$18,159.63	$28,316.40	$1,463.42	$4,920.09
Per-Acre Average	--	--	--	$702.87

[a] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Research and Education

Table 11 presents the national-scale annual economic impact estimates for **research and education**, from FEMA relied on a meta-analysis from Brander and Van Beukering (2013), which itself focused on research spending in NOAA jurisdictions. The total values are determined by the per-acre values and are subject to the size of the coral reef area in each jurisdiction.

Table 11. National-Scale Annual Economic Impact Estimates for Research and Education (in 2025 USD)

Jurisdiction	Total Value (millions of USD)	Per Acre Value
Guam	$0.78	$29.01
South Florida	$64.26	$28.89
Hawai'i	$11.08	$27.04
Puerto Rico	$3.35	$26.20
American Samoa	$2.00	$27.33
USVI	$1.56	$31.55
CNMI [a]	$0.94	$23.37
FGBNMS	$2.81	$27.33
Total	$86.78	$220.72
Per-Acre Average	--	$27.59

[a] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Tourism

Table 12 presents national-scale annual economic impact estimates for recreation and tourism, which are based on a study by Spalding et al. (2017). That study estimated the values of **tourism expenditures for reef-adjacent and on-reef tourism** across 102 countries, U.S. states, and U.S. territories. To isolate reef-related tourism within these areas, the researchers used a multi-layered filtering process focusing on coastal, non-urban areas within 30 kilometers of a coral reef. The data analyzed included national tourism expenditure and arrival statistics, location data for 125,498 hotels, 40 million to 50 million geo-located Flickr photographs annually, and crowd-sourced data from over 4,000 dive shops and 8,938 dive sites. Based on the source materials, include supplementary materials, and the labels for locations included, we

assume American Samoa was not included in the study. FGBNMS was a gain excluded due to the coastal nature of the Spalding et al. study.

Table 12. National-Scale Annual Economic Impact Estimates for Recreation and Tourism (in 2025 USD)

Jurisdiction	Total Value (millions of USD)	Per Acre Value
Guam	$487.23	$18,089.42
South Florida	$1,732.65	$779.09
Hawai'i	$1,691.40	$4,128.38
Puerto Rico	$773.51	$6,043.05
American Samoa [a]	N/A	N/A
USVI	$370.02	$7,487.02
CNMI [b]	$63.12	$1,576.87
Total	$5,117.93	$38,103.83
Per-Acre Average	--	$6,350.64

[a] American Samoa was not included in Spalding et al., (2017)
[b] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Tabulated Annual Per-Acre Results

Table 13 and Table 14 contain the annual per-acre estimates for each ecosystem service by jurisdiction. Table 13 reports the economic benefits, while Table 14 reports the economic impacts. In some cases, these per-acre values are presented as a range, which is consistent with how the estimates were developed in the specific jurisdiction tables in the Results by Jurisdiction section.

Table 13. Summary of Monetized Ecosystem Service Annual Benefits per Acre (in 2025 USD)

Ecosystem Service [a]	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI [b]	FGBNMS
Acres of coral reef	**N/A**	**26,934**	**2,223,945**	**409,700**	**128,000**	**73,143**	**49,421**	**40,031**	**102,656**
Amenity	**N/A**	$143.77	$143.21	$134.01–$190.95	$129.84	$135.44	$156.36–$1,146.49	$109.34–$115.81	-
Biodiversity	**N/A**	$396.17–$2,802.28	$2,791.36–$22,257.39	$51.47–$165,819.33	$899.52–$2,530.71	$2,639.99	$1,178.63–$3,047.74	$2,257.3	$63,059.84–$192,782.94
Coastal protection	**N/A**	$407.64	$255.97	$1,244.86	$648.86	$521.81	$675.83	$153.19	-
Fishing	**Recreational fishing**	-	$65.80–$73.47	-	-	-	$75.99	-	-
	Subsistence fishing	-	-	-	-	$1.70	-	-	-
	Traditional fishing	$78.81–$548.01	-	-	-	-	-	$6.07–$33.43	-
Non-use/passive use	**Bequest value to future generations**	-	-	-	$990.5	-	-	-	-
	Existence value to current generations	-	-	$35,150.77	$1,437.72	-	-	-	-
	Option value to current generations	-	-	-	$908.56	-	-	-	-
	Non-use values (unspecified)		-	-	-	$245.89	-	-	-
Recreation/ tourism	**Recreation—all types combined**	$4,142.77	$173.09	$135.25	$37,47.32	$3.42	$2,145.94	$114.64	-
	Recreation—swimming/fishing	-	-	-	-	-	-	-	-
	Recreation and tourism—diving and snorkeling	-	$515.97	$636.44	-	$1.17	-	-	-
	Recreation—artificial reefs	-	$14.01	-	-	-	-	-	$0.12–$0.88
	Recreation—natural reefs	-	$19.30	-	-	-	-	-	$0.20–$2.05

Note: Blank cells reflect data limitations and gaps; they do not indicate that particular ecosystem services are not available in certain jurisdictions.
[a] See the Results by Jurisdiction section below for additional study details, and for source material for the coral reef area in acres.
[b] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Table 14. Summary of Monetized Ecosystem Service Annual Economic Impacts per Acre (in 2025 USD)

Ecosystem Service [a]	Sub-Category	Guam	South Florida	Hawai'i	Puerto Rico	American Samoa	USVI	CNMI [b]	FGBNMS
Acres of coral reef	**N/A**	**26,934**	**2,223,945**	**409,700**	**128,000**	**73,143**	**49,421**	**40,031**	**102,656**
Coastal protection	**N/A**	$605.29	$229.43	$1,784.42	$1,153.98	$146.63	$779.19	$221.15	-
Fishing	**Commercial fishing**	$0.31–$4.81	$42.37–$56.66	$2.69–$10.96	$16.33–$20.50	$0.30–$2.05	$24.69–$44.57	$1.35–$2.13	$19.46
	Recreational fishing	-	$239.71	-	-	-	-	-	$2.28
	Subsistence fishing	-	-	$23.18–$41.70	-	$13.32	-	-	-
	Artisanal fishing	-	-	-	-	$2.66	-	-	-
Recreation	**Recreation—all types combined**	$8,654.78–$18,089.42	$779.09	$2,011.29–$4,128.38	$6,043.05–$18,189.69	$34.43	$7,487.02	$857.29–$1,576.87	-
	Recreation and tourism—trip-related expenses and durable goods (from trips)	-	-	-	-	-	-	-	-
	Recreation and tourism—diving and snorkeling	-	$563.72	$815.56	-	$0.54	-	$36.94–$154.33	-
	Recreation and tourism—fishing (artificial reefs)	-	$1,733.66	-	-	-	-	-	-
	Recreation and tourism—diving (artificial reefs)	-	$853.27	-	-	-	-	-	-
Research	**N/A**	$29.01	$28.89	$27.04–$49.87	$26.20	$27.33	$31.55	$23.37	$27.33–$28.41

Note: Blank cells reflect data limitations and gaps; they do not indicate that particular ecosystem services are not available in certain jurisdictions.
[a] See the Results by Jurisdiction section below for additional study details, and for source material for the coral reef area in acres.
[b] CNMI values are represented in 2024 USD. An updated local CPI with 2025 data was unavailable for CNMI. All other values are in 2025 USD based on a local CPI, with the exception of American Samoa, which was determined with the national-level CPI from the BLS.

Summary of Non-Monetized Results

Interview and Token Exercise Results

While the interviews and token exercise results were not representative of any given jurisdiction, when aggregated at the regional level or national level, the results provide a view into the ecosystem service preferences amongst the group of coral reef experts that were interviewed (n=24). For example, the project team observed several differences when aggregating results from Atlantic jurisdictions (South Florida, Puerto Rico, USVI, FGBNMS) and Pacific jurisdictions (Guam, PRIA) (see Figure 7 and Figure 8). First, the Atlantic jurisdictions' responses signal the importance of coral reef recreation and tourism as a non-monetary value. Respondents from the two Pacific jurisdictions highlight the intergenerational importance of coral reefs. Responses from both regions placed importance on education, heritage, and identity as non-monetary services from coral reefs. Across inhabited jurisdictions, recreation is also featured prominently when looking at total token counts (Figure 9) but is less prevalent when the counts are averaged (Figure 10), suggestion that even remote jurisdictions provide important opportunities for recreation.

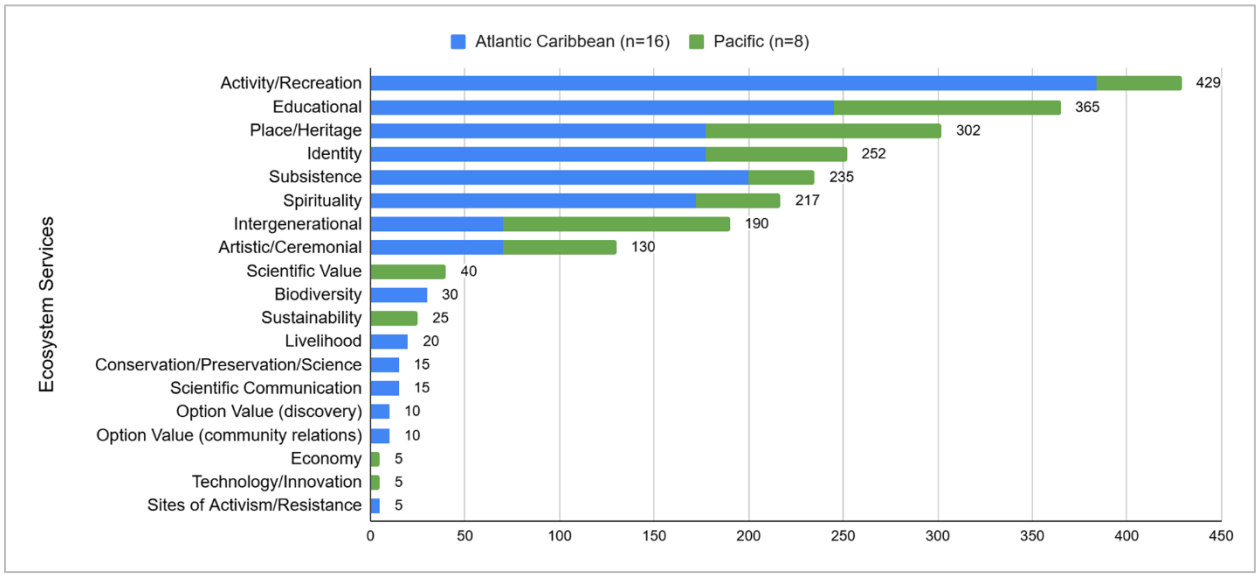

Figure 7. Total token counts for both regions

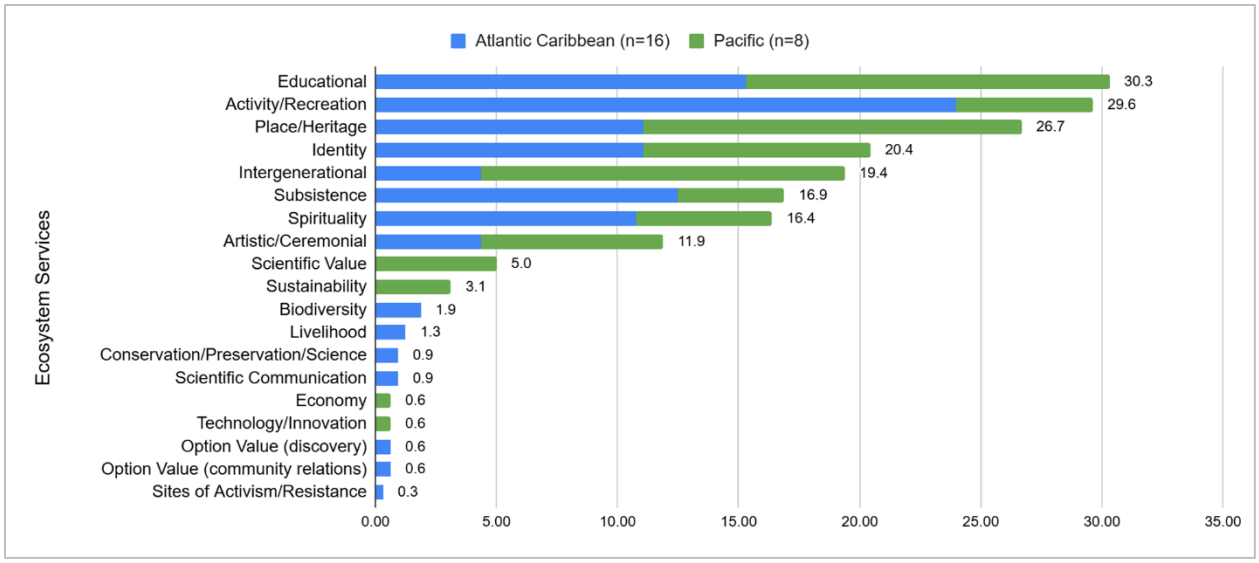

Figure 8. Averaged ecosystem service token counts per interviewee in both regions

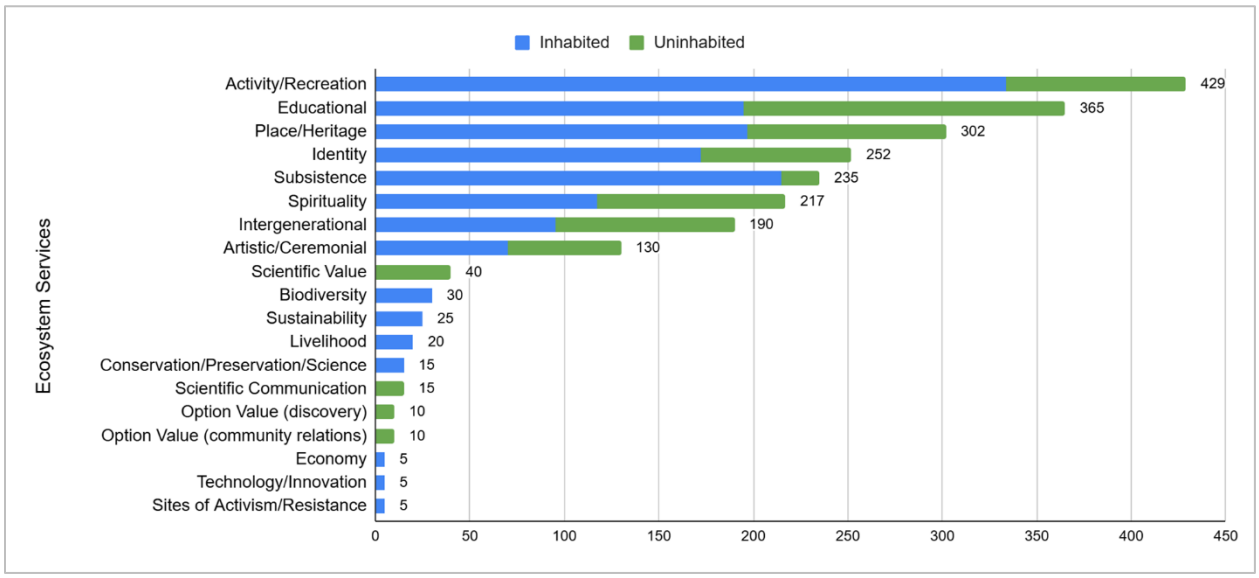

Figure 9. Total token counts for both inhabited and uninhabited jurisdictions

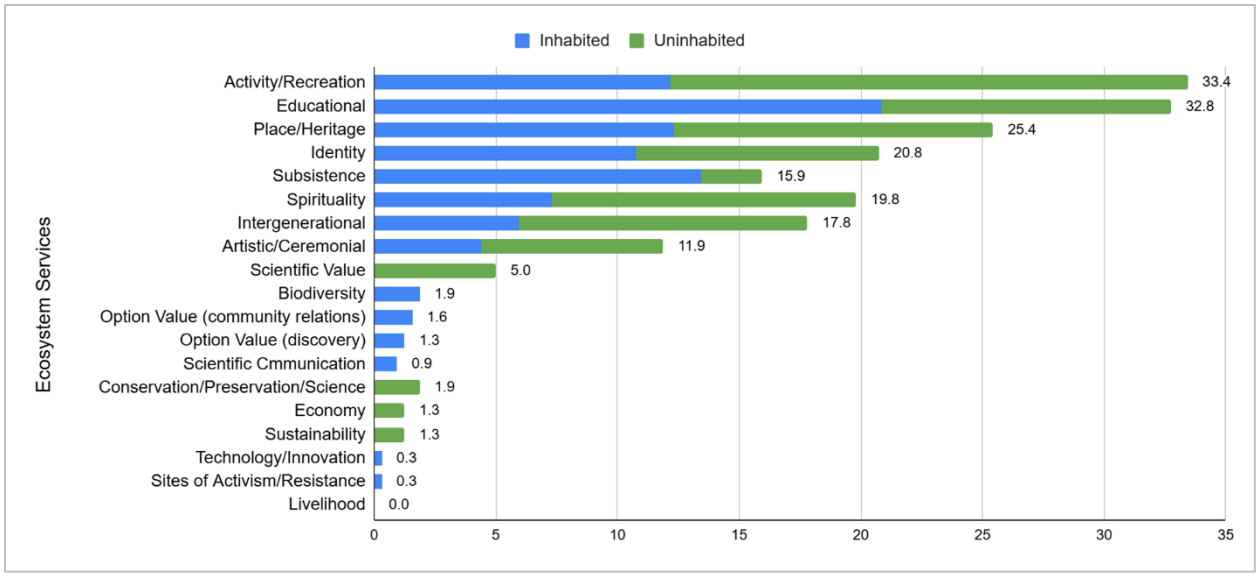

Figure 10. Averaged ecosystem service token counts per interviewee in inhabited and uninhabited jurisdictions

Non-Monetary Ecosystem Service Indicators Database Results

Results from the Non-Monetary Ecosystem Service Indicators Database provide a way to explore themes and trends within the limited non-monetary dataset compiled over the course of the project. While the database split indicators into two broad categories—quantitative and qualitative—the quantitative indicators included a wide range of data types to characterize coral reef ecosystem service values. As shown in Table 15, fourteen recurring quantitative data types and four unique ones were documented in the database over the course of the project. In the table, indicator frequencies reflect the number of specific data points associated with these data types. Single studies can contain multiple types of data, and multiple instances of the same data type. The data presented here do not reflect the number or types of studies.

Table 15. Quantitative data types included in the database

Data Type	Indicator Frequency
% of people	86
# of people	38
# of jobs	34
# of volunteers	29
% of catch	11
# of publications	8
# of hours	5
# of pounds caught	4
# of events	3
# of dives	3
% of trips	2
# of person days	2
# of permits	2
# of corals outplanted	2
# of trips	1

Data Type	Indicator Frequency
# of pounds of trash/debris	1
# of fish	1
# of artifacts	1

The effort to collect both quantitative and qualitative data resulted in varied representations of data across the jurisdictions.

Table 16 shows the quantitative and qualitative non-monetary indicator counts for each ecosystem service and jurisdiction. Qualitative descriptions of coral reef ecosystem service value were somewhat fewer than quantitative metrics, but the proportion of the two data types was different in different jurisdictions (Figure 11).

Table 16. Quantitative and Qualitative Non-Monetary indicator counts per ecosystem service and Jurisdiction

Ecosystem Services	Data Type	Guam	South Florida	Hawai'i	PRIA	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS	Total
Aesthetics	*Qual*	0	0	2	1	1	0	0	0	0	4
	Quant	0	0	0	0	0	0	0	0	0	0
Aquaculture	*Qual*	0	0	0	0	0	0	0	0	0	0
	Quant	0	0	1	0	0	0	0	0	0	1
Biodiversity	*Qual*	0	5	4	1	0	0	0	0	1	11
	Quant	0	0	0	0	0	0	0	0	0	0
Commercial fishing	*Qual*	0	0	0	0	0	1	0	0	0	1
	Quant	1	0	0	0	1	2	1	14	0	19
Cultural heritage	*Qual*	1	2	14	4	1	2	5	20	1	50
	Quant	6	1	2	1	0	1	0	11	0	22
Ecological knowledge	*Qual*	0	4	9	0	0	2	1	7	0	23
	Quant	3	0	0	0	0	0	0	1	0	4
Existence	*Qual*	0	0	0	0	0	0	0	0	2	2
	Quant	0	0	0	0	0	0	0	0	0	0
Identity	*Qual*	1	1	0	1	6	0	2	0	3	14
	Quant	0	0	0	0	0	0	0	0	0	0
Intergenerational relationships	*Qual*	0	0	1	0	0	0	0	0	0	1
	Quant	1	0	0	0	0	0	0	2	0	3
Knowledge systems	*Qual*	0	0	4	0	0	0	0	11	0	15
	Quant	0	0	0	0	0	0	0	0	0	0
Learning/education	*Qual*	2	2	2	1	0	0	3	2	2	14
	Quant	1	0	1	1	0	3	6	0	10	22
Non-commercial fishing	*Qual*	0	0	4	0	1	1	1	4	0	11
	Quant	11	4	3	0	0	5	0	30	4	57
Recreation	*Qual*	0	4	4	0	0	0	2	0	0	10

Ecosystem Services	Data Type	Guam	South Florida	Hawai'i	PRIA	Puerto Rico	American Samoa	USVI	CNMI	FGBNMS	Total
	Quant	2	4	1	1	0	6	0	0	3	17
Security	*Qual*	1	0	1	1	1	1	2	0	0	7
	Quant	5	4	4	0	4	4	4	6	0	31
Sense of place/belonging	*Qual*	0	1	0	0	2	0	0	0	2	5
	Quant	0	0	0	0	0	0	0	0	0	0
Social capital/social cohesion	*Qual*	1	2	0	0	2	0	0	0	1	6
	Quant	0	0	0	0	0	0	0	0	0	0
Social responsibility	*Qual*	1	1	0	0	0	2	1	1	0	6
	Quant	2	0	2	0	0	0	0	8	0	12
Spiritual	*Qual*	1	0	4	1	1	0	0	2	2	11
	Quant	2	0	0	0	0	0	0	2	0	4
Stewardship	*Qual*	0	1	6	0	0	0	2	5	1	15
	Quant	4	23	22	0	1	0	20	14	1	85
Subsistence	*Qual*	1	0	0	0	1	0	0	0	0	2
	Quant	7	0	0	0	0	0	0	11	0	18
Tourism	*Qual*	0	0	0	0	0	0	1	0	0	1
	Quant	1	1	1	0	1	0	0	3	0	7
Wellbeing	*Qual*	0	1	0	0	0	0	2	2	2	7
	Quant	2	0	0	0	0	0	0	5	0	7
	Total	**57**	**61**	**92**	**13**	**23**	**30**	**53**	**161**	**35**	**525**

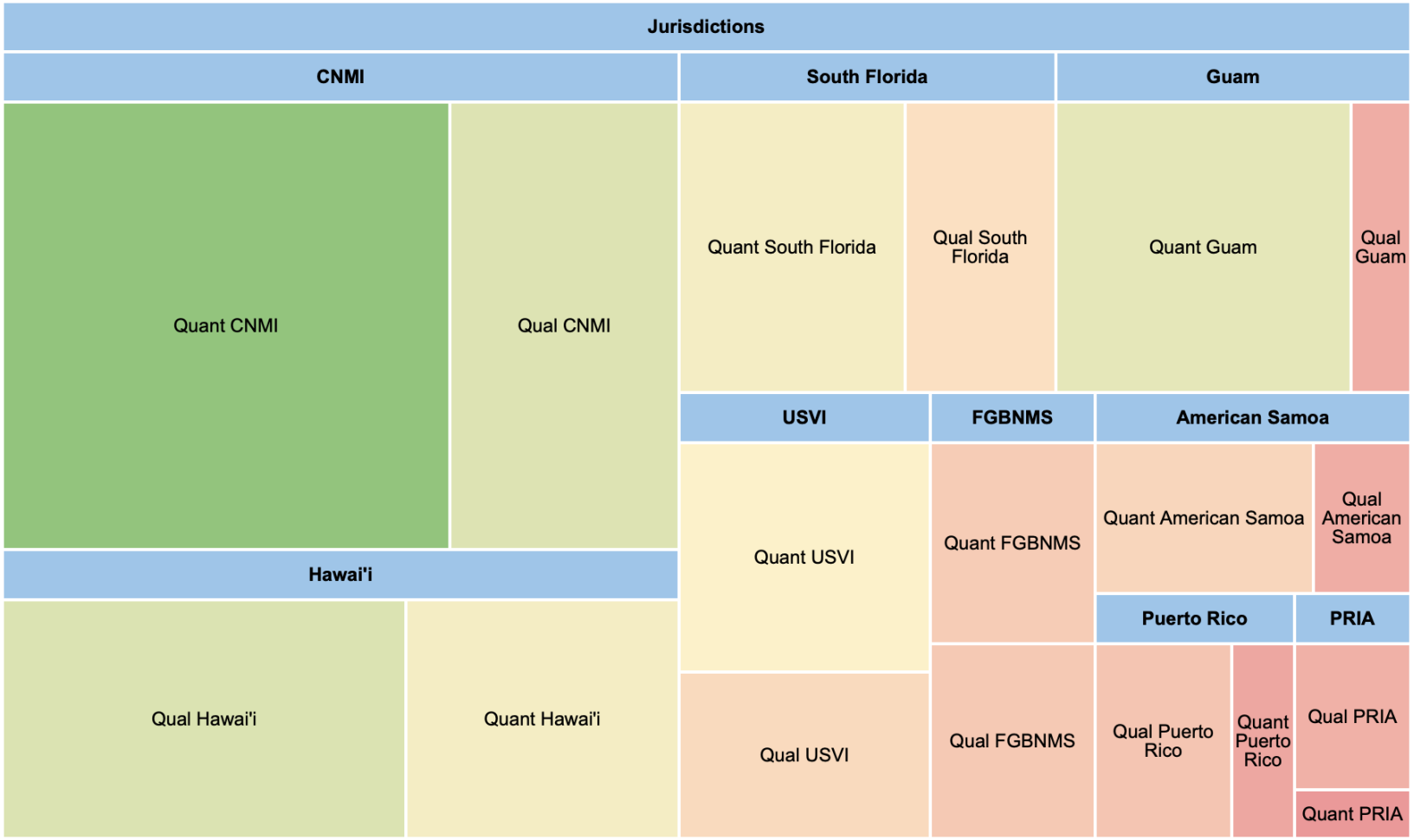

Figure 11. Treemap detailing the distribution of qualitative and quantitative indicators across jurisdictions. The size of the block corresponds to the relative number of indicators in the dataset. Quantitative indicators for CNMI constitute the largest proportion of the database, while quantitative indicators for PRIA are the smallest.

Results by Jurisdiction

Guam

Guam's coral reefs include fringing, barrier, and patch reefs. Guam's reefs span nearly 27,000 acres and are home to around 400 reef-building coral species and 1,000 nearshore fish species (U.S. Coral Reef Task Force, n.d.-d).

In Guam, the 2016 National Coral Reef Monitoring Program Socioeconomic survey (Gorstein et al., 2018) found that 97% of a representative sample of residents consider coral reefs to be important to Guam's culture. Adding to the strong perception of heritage value are studies showing $2.12 million to $14.76 million per year in traditional fishing value (Van Beukering et al., 2007), economic benefits of $10.98 million per year in the form of coastal protection (Storlazzi et al., 2019), and varied recreation values. Other key indicators of ecosystem services associated with Guam's reefs include the non-monetary research and biodiversity value of the University of Guam's 1,800 marine specimens; recent research suggesting the genetic uniqueness of important fish species within Guam's coral ecosystems (Priest et al., 2012); and Guam's role as a stepping stone for larval transport in the wider South Pacific (Kendall et al., 2019). Guam's coral reefs provide ecosystem services well beyond what can be monetized.

Monetary Results

Table 17 presents a summary of economic benefits for Guam.

Table 17. Summary of Annual Economic Benefits from Guam (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$143.77 per acre	26,934 acres [c]	N/A	$3.87	N/A	$143.77
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$10.98	N/A	$407.64
Biodiversity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$2,802.28 per acre	26,934 acres [c]	N/A	$75.48	N/A	$2,802.28

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Biodiversity	Grafeld et al. (2016) Choice experiment (CE) that estimated the value of potential improvements to coral reefs among divers. The sample for this study consisted of adult SCUBA divers, aged 18 and older, who were actively diving in Guam during August 2013. Researchers used purposive sampling to recruit 220 participants from various locations, including seven beaches, one harbor, one dive shop, and two dive boats. Values are based on a specific set of improved conditions from the CE (low to high biomass, low to high diversity, low to high Napoleon wrasse abundance, and shark/turtle presence).	$26.72 per dive (2025 USD)	Low # of dives: 399,391; High # of dives: 798,782 [d]	$10.67	$21.34	$396.17	$792.33
Traditional fishing	Van Beukering et al. (2007) The study team performed a choice experiment on Guam to estimate values for aspects of coral reefs. The sample for the traditional fisheries component of the study consisted of 130 respondents from a larger household survey of 400 local residents, selected through a random sampling process within neighborhoods across the island. These participants represented the main ethnic and socioeconomic groups in Guam.	Low: minimum fishing household share (45%) * minimum annual value ($91.50) High: maximum fishing household share (100%) * maximum annual value ($286.30)	51,555 households [e]	$2.12	$14.76	$78.81	$548.01
Recreation—all	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$72.20 per person-day of activity	1,545,386 reef-related trips [f]	N/A	$111.58	N/A	$4,142.77

N/A: Not applicable.
Note: Source of local CPI data: Guam Bureau of Statistics and Plans (n.d.-b).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Guam's coral reefs cover 26,934 acres. Source: U.S. Coral Reef Task Force (n.d.-d).
[d] The number of dives (399,391–798,782) was derived by recreating the methods for estimating dives based on visitor statistics found in Van Beukering et al. (2007). The values were updated with data from Guam Visitors Bureau (2020).

[e] Source for Guam households: Guam Bureau of Statistics and Plans (n.d.-a).
[f] This value was calculated using data from Guam Visitors Bureau (2020). The project team began by determining the number of visitors to Guam, averaged for the years 2017 to 2024 (excluding 2021 due to COVID-19). The team then used visit-length data from Guam Visitors Bureau to develop a total person-day value (5,151,286). Guam Visitors Bureau determined that 30% of recreation and tourism is marine-related based on their exit surveys. The project team applied that figure (0.30 x 5,151,286) to the total person-days to get 1,545,386.

Guam Economic Impact Range

Table 18 provides a summary of annual economic impacts for Guam. The lower and upper bounds for Guam's economic impact range are based on the ranges developed through a number of studies. Coastal protection values are from Storlazzi et al. (2019); commercial fishery values are from Western Pacific Regional Fishery Management Council (WPRFMC, 2021b, 2024c); recreation values are from Bartelet et al. (2024) and Spalding et al. (2017); and research values are from FEMA (2022). The project team calculated a range of $233.12 million to $504.44 million per year for Guam.

Table 18. Summary of Annual Economic Impacts for Guam (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represents the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$16.30	N/A	$605.29
Commercial fishing	Low: WPRFMC (2024c); High: WPRFMC (2021b) Based on revenue for the top 10 reef fish species. A value-added ratio of 0.60 (Grafeld et al., 2017) is applied.	N/A	N/A	$0.01	$0.13	$0.31	$4.81

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Recreation and tourism	Low: Bartelet et al. (2024) Bartelet et al., used data from Spalding et al. (2017), the value-added contribution of coral reefs to the economy can be estimated by subtracting the cost of intermediate inputs from the market revenue produced by the coral reefs (in this case, expenditures by tourists and landed values of reef fish). High: Spalding et al. (2017) The study estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study.	N/A	N/A	$233.11	$487.23	$8,654.78	$18,089.42
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$29.01 per acre	26,934 acres [c]	N/A	$0.78	N/A	$29.01

N/A: Not applicable.
Note: Source of local CPI data: Guam Bureau of Statistics and Plans (n.d.-b).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Guam's coral reefs cover 26,934 acres. Source: U.S. Coral Reef Task Force (n.d.-d).

Non-Monetary Results

Table 19 presents selected non-monetary indicators for Guam. Sources for each indicator are in parentheses following the indicator.

Table 19. Selected Non-Monetary Indicators for Guam

Ecosystem Service(s)	Indicator
Recreation	Each year, 256,000 –340,000 dives occur on Guam's reefs. *(Grafeld et al., 2016)*
Subsistence	Nearly 70% of residents in Guam consumed seafood from local coral reefs at some point during the year. *(Allen et al., 2024)*
Cultural heritage	In Guam, 97% of residents considered coral reefs as important to Guam's culture. *(Gorstein et al., 2018.*
Learning/education	"So for me personally, but also even when I used to take students sort of out onto the reef to talk about its resources and talk about the culture involved with the reef. It's just, it is just sort of an outdoor classroom." *(Guam Interviewee #1)*
Social relations	"When I was at a younger age, we had more fish, an abundance of fish. We'd get a couple 300, 400 pounds of fish, easy, and that's half a day, and we always share it. We share our fish. We sell some of the fish to make up for some of our expenses, obviously, like gas or whatever, but most of it is kept, and most of it is shared amongst family." *(Guam Interviewee #2)*

On Guam, coral reefs are understood as communities themselves and as spaces that reinforce communal values, stewardship, and intergenerational responsibility, particularly in the context of ongoing colonial pressures and environmental change. Despite significant declines in coral cover and fish abundance driven by development, military activity, tourism, and recreation, reefs remain central to grounding CHamoru culture through language, fishing practices, and traditions such as full-moon fishing and canoe making. Educational efforts—both formal, through the University of Guam, and informal, through elders and families—play a key role in sustaining traditional practices, while ecological knowledge of reef species continues to inform both cultural continuity and scientific discovery.

Figure 12 summarizes the non-monetary token exercise outcomes for Guam.

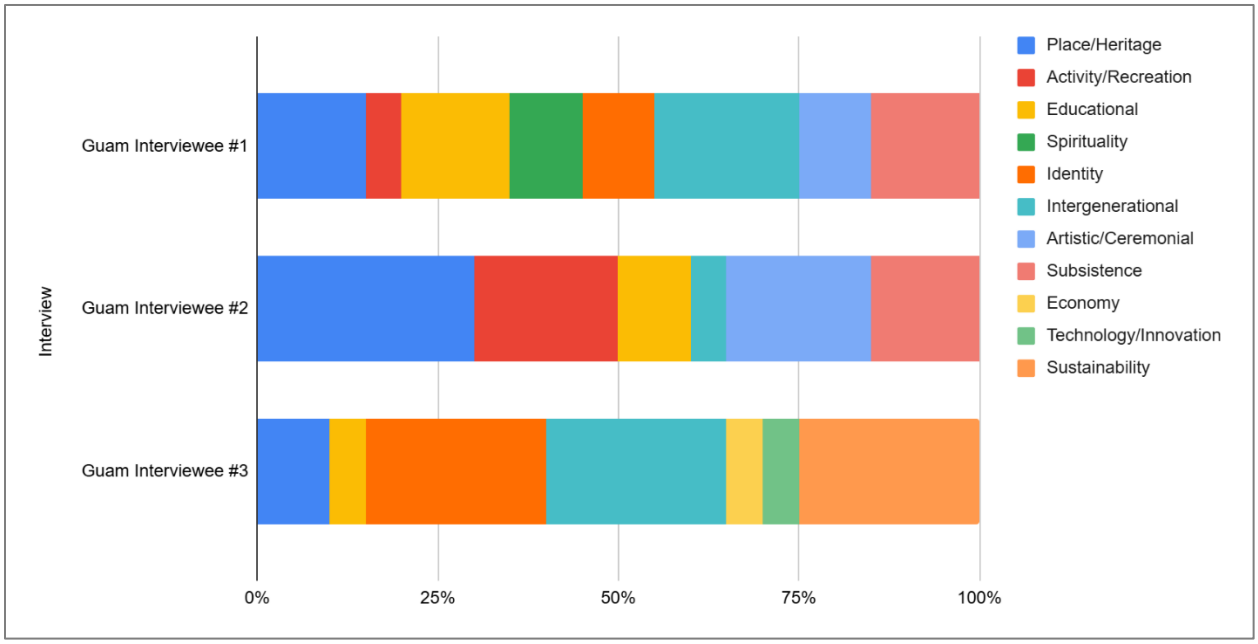

Figure 12. Non-monetary token exercise outcomes for Guam

South Florida

Florida's coral reef is the only near-shore, stony coral reef track in the continental United States. Stretching over 350 miles and covering over 2.2 million acres, the reef consists primary of barrier reefs. The reef is home to over 600 fish species and over 600 invertebrate species (U.S. Coral Reef Task Force, n.d.-c; NOAA, 2014).

The Florida Fish and Wildlife Conservation Commission (2026) reports that Florida's coral reef fishery results in an estimated $94.23 million to $126.02 million per year in direct economic impact. Not reflected in this value are the various non-monetary values associated with fishing or working on the water. Fishing communities in Florida rely on fishing to build social capital and inform their sense of place, which promotes collective action, helps to foster relationships with officials, decreases transaction costs associated with fishing, and builds lifelong attachment to Florida's resources (Shivlani, 2013; Stolz et al., 2021).

The recreational fishing value alone for Southeast Florida residents' use of the coral reefs is $533.11 million per year (Wallmo, Lovell, et al., 2021). Non-monetary values for stewardship, a reciprocal cultural service, enrich this recreation value by informing stakeholders and decision-makers about how reef users have been involved in sustaining coral reef recreation. For example, the Coral Restoration Foundation (2021) reported that over 170,000 corals have been outplanted in Florida since 2007 through a partnership with NOVA Southeastern University. These restored reefs and outplanted corals can now contribute to recreation by enhancing the experience for snorkelers and divers. Furthermore, results from Harper (2015) suggest that visiting coral reefs was the strongest predictor of sustainable seafood purchasing behavior amongst Florida anglers—more significant than factors such as climate change perceptions, trust in food labels, and seafood budget. So, not only does on-reef recreation provide an economic benefit for Florida, it may also indirectly contribute to sustainable behavior. Communicating the

interactions between these services—recreation and stewardship—can illustrate the positive impacts humans can have on corals, contrasting with the common perception that ecosystem services are a one way relationship.

Both monetized and non-monetary service values can also be used to illustrate the severity of threats to coral reefs in Florida. Threats such as rising sea surface temperatures, disease, pollution, and even over-tourism (a concern highlighted by workshop participants) could reduce the value derived from corals. These threats could certainly influence the monetary contribution from coral reefs if fewer people participate in recreational activities, but social networks associated with coral reef conservation would also suffer. While the latter may be more difficult to measure, it is clear that the reciprocal services delivered via these networks would be affected by declining reef health. Examples of these reciprocal services include cultivating social responsibility toward marine resources (Allen at al., 2022) and building social capital between lobster trappers (Shivlani, 2013). It is also worth considering how increases in values from services such as commercial fishing might negatively impact other services. Including non-monetary values in these trade-off considerations can lead to a more comprehensive understanding of the value of coral reefs in general.

Monetary Results

Table 20 presents a summary of economic benefits for South Florida.

Table 20. Summary of Annual South Florida Economic Benefits (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$143.21 per acre	2,223,945 acres [c]	N/A	$318.49	N/A	$143.21
Biodiversity	**Low**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. **High**: Cavasos and Bhat (2020) This study evaluated U.S. household WTP a federal tax that would raise funds for combined marine reserves and restocking of staghorn corals in the Florida Reef Tract. The study focused on a sample (n=1061) from Southeastern states (Florida, Alabama, Georgia, and Mississippi) but found that distance was not a significant driver of WTP. We applied the WTP estimates to the total U.S. households.	**Low**: $2,791.36 per acre **High**: WTP per household: $383.04	Low: 2,223,945 acres [c] High: 129,227,496 U.S. households [d]	$6,207.82	$49,499.21	$2,791.36	$22,257.39
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$569.27	N/A	$255.97
Recreational	Huth et al. (2014)	Resident license	Resident	$146.35	$163.40	$65.80	$73.47

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
fishing (artificial reefs)	The study performed a contingent valuation survey among recreational fishers (n=6,442) to estimate WTP for developing artificial reefs that would support recreational fishing. The core fishing surveys targeted the entire 2013 Florida Fish and Wildlife Conservation Commission saltwater fishing license database, which contained 1,073,642 records categorized into Florida residents (926,481), nonresidents (143,331), and charter boat operators (3,830). Recruitment for these groups was primarily conducted via email, with supplemental postcard mailings sent to a random sample of license holders without available email addresses to assess potential systematic bias.	holder WTP: Low, $48.60; High, $63.62 Nonresident license holder WTP: Low, $46.05; High, $67.33 Resident charter trip WTP: Low, $48.60; High, $48.60 Nonresident charter trip WTP: Low, $46.05; High, $46.05	licenses: 926,481 Nonresident licenses: 143,413 [e] Resident charter boat trips: 619,954 Nonresident charter boat trips: 1,403,396 [e]				
Recreational diving (artificial reefs)	Huth et al. (2014) The study performed a contingent valuation survey among divers (n=250) to estimate WTP for developing a program to reduce lionfish pressure via diving fees. The study sampled active scuba divers through two specialized surveys: one distributed via a link on ScubaBoard—an online forum with more than 250,000 registered users—and another targeting divers recruited through charter operators in the Florida Keys.	WTP: $367 per trip	Resident trips: 2,327,588 Nonresident trips: 797,414	N/A	$1,147.49	N/A	$515.97
Recreation (natural reefs)	Allen and Wallmo (2022) Allen and Wallmo estimated the WTP to visit natural reefs among Florida residents and nonresident tourists. The sample for this study included adults aged 18 and older residing in Southeast Florida (Broward, Martin, Miami-Dade, Monroe, and Palm Beach Counties), the rest of Florida, and out-of-state within the rest of the United States. This geographic range target included both residents in close proximity to coral features and potential tourists from across the country. Results shown are the product of combining the total Florida state WTP and the U.S. WTP.	Florida WTP (2025 USD): $14.25 US WTP (2025 USD): $14.81	Florida resident trips: 436,932[f] Tourist annual trips: 2,477,296 [f]	N/A	$42.91	N/A	$19.30
Recreation	Allen and Wallmo (2022)	Florida WTP (2025	Florida	N/A	$31.17	N/A	$14.01

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
(artificial reefs)	Allen and Wallmo estimated the WTP to visit artificial reefs among Florida residents and nonresident tourists. The sample for this study included adults aged 18 and older residing in Southeast Florida (Broward, Martin, Miami-Dade, Monroe, and Palm Beach Counties), the rest of Florida, and out-of-state within the rest of the United States. This geographic range target included both residents in close proximity to coral features and potential tourists from across the country. Results shown are the product of combining the total Florida state WTP and the U.S. WTP.	USD): $11.15 US WTP (2025 USD): $10.62	resident trips: 436,932[f] Tourists annual trips: 2,477,296[f]				
Recreation—all	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$61.18 per person-day of activity	6,292,000 reef related trips [g]	N/A	$384.95	N/A	$173.09

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (n.d.-b).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Florida's coral reefs cover 2,223,945 acres. Source: NOAA (2014).
[d] Source for U.S. households: U.S. Census Bureau (n.d.-b).
[e] Source: NOAA. (n.d.-b).
[f] These estimates were derived from data from Florida's Statewide Comprehensive Outdoor Recreation Plan report, Appendix G. We used the combined number of participants in Saltwater Beach (fishing excluded) and Saltwater Fishing activities as a best estimate for a starting point. Next, we used Spaulding et al.'s (2017) estimate that 4 percent of coastal tourism is on-reef and we assumed
[g] Total trips estimates are based on visitation data from State of Florida, Executive Office of the Governor (2025) and Spalding et al.'s (2017) estimate that 0.44% of all Florida tourism is reef-related.

South Florida Economic Impact Range

Table 21 presents a summary of annual economic impacts for South Florida. The lower bound of economic impacts for Florida is based on commercial fishing values from the Florida Fish and Wildlife Conservation Commission (2026) and estimates for recreational fishing and diving from Wallmo, Edwards, et al. (2021) and Wallmo, Lovell, et al. (2021). Although the latter two studies focus on all fishing and diving and Huth et al. (2014) focuses more narrowly on artificial reefs, the project team assumed that estimates from the Wallmo studies could be included as part of Huth et al.'s (2014) estimates; thus, the project team treated them as part of the range and not in tandem. The upper bound is based on coastal

protection values from Storlazzi et al. (2019), Huth et al.'s (2014) estimates for economic output from recreational fishing and diving on artificial reefs, and FEMA's (2022) research values. This brings the range of annual impacts to $1.88 billion to $4.56 billion per year.

Table 21. Summary of Annual Economic Impacts for South Florida (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represent the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$510.24	N/A	$229.43
Commercial fishing	Florida Fish and Wildlife Conservation Commission (2026) This source provides dockside values (2021–2024) for reef species across the "Food and Bait" and "Marine Life" (ornamental) categories. Data are incomplete for 2025. Low and high values represent the sum of the lowest and highest dockside values from the two categories from the 2021–2024 period.	N/A	N/A	$94.23	$126.02	$42.37	$56.66
Tourism	Spalding et al. (2017) The study estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study.	N/A	N/A	N/A	$1,732.65	N/A	$779.09
Recreational fishing (artificial reefs)	Huth et al. (2014) The study used a Regional Economic Models, Inc. (REMI) computable general equilibrium model to assess the economic output associated with saltwater recreational fishing on Florida's artificial reefs. [c] Labor Income: $1,588.39 (2025 USD) Florida State Revenue: $317.8 (2025 USD) Recreational fishing also supports an estimated 25,821 jobs.	N/A	N/A	N/A	$3,855.57	N/A	$1,733.66

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Recreational diving (artificial reefs)	Huth et al. (2014) The study used a REMI computable general equilibrium model to assess the economic output associated with SCUBA diving on Florida's artificial reefs. [c] Labor Income: $769.71 (2025 USD) Florida State Revenue: $144.17 (2025 USD) Recreational diving also supports an estimated 13,297 jobs.	N/A	N/A	N/A	$1,897.62	N/A	$853.27
Recreational fishing	Wallmo, Lovell, et al. (2021) Wallmo, Lovell, et al. provide estimates for the economic output of reef-related recreational fishing to Broward, Martin, Miami Dade, Monroe, and Palm Beach counties and the Florida economy. Recreational fishing also supports an estimated 3,787 jobs.	N/A	N/A	N/A	$533.11	N/A	$239.71
Recreation—diving and snorkeling	Wallmo, Edwards, et al. (2021) Wallmo, Edwards, et al. provide estimates for the economic output of reef-related recreational snorkeling and diving to Broward, Martin, Miami Dade, Monroe, and Palm Beach counties and the Florida economy. Recreational diving and snorkeling also supports an estimated 8,668 jobs.	N/A	N/A	N/A	$1,253.69	N/A	$563.72
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$28.89 per acre	2,223,945 acres [d]	N/A	$64.26	N/A	$28.89

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (n.d.-c).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] The REMI model is a dynamic computable general equilibrium (CGE) framework that integrates input–output relationships, econometric estimation, and general equilibrium theory to simulate how changes in policy, investment, or economic conditions affect regional economies over time. It captures interactions among industries, households, labor markets, and prices, allowing analysts to estimate impacts on employment, income, output, and migration under various scenarios.
[d] Florida's coral reefs cover 2,223,945 acres. Source: NOAA (2014).

Non-Monetary Results

Table 22 presents selected non-monetary indicators for South Florida. Sources for each indicator are in parentheses following the indicator.

Table 22. Selected Non-Monetary Indicators for South Florida

Ecosystem Service(s)	Indicator
Tourism	Coral reef–related tourism directly sustains 3,787 jobs in Florida. (Wallmo, Lovell, et al., 2021)
Stewardship	Since 2007, 174,264 corals have been outplanted, covering an area of 25,000 square meters. (Coral Restoration Foundation, 2021)
Cultural heritage, sense of place	"We have one highway that comes through the keys. You can see the lighthouses, you know, as you're coming down the Keys, and so I think it's, you know, something that everyone is aware of. You know that these things are marking reefs." (South Florida Interviewee #1)
Identity	"I think people that are naturalists, explorers, ocean lovers just in general, fish nerds, whatever you wanna call yourself, or what you really get into, you know, then a coral reef could be very impactful for how you identify who you are." (South Florida Interviewee #3)

For many Floridians, coral reefs are closely associated with shipwrecks, which often serve as named, accessible entry points for understanding and engaging with the South Florida Reef Tract. Reefs and wrecks function as important cultural spaces, hosting gatherings, holidays, and major life events, and carrying particular significance for specific communities, such as the Black diving community at the *Henrietta Marie* (a shipwrecked vessel that carried slaves). At the same time, access to reefs is uneven, with economic and logistical barriers limiting who can experience them. Interviewees described a sense of loss tied to reef degradation, noting that past practices such as sponging and turtling have disappeared and that relationships with reefs have become less intimate for many people. While reefs continue to support subsistence activities, identity formation, spiritual renewal, and political engagement for some users, the overall tone reflected declining ecosystem services, tensions between recreation and conservation, and dissatisfaction with federal management and public engagement efforts.

Figure 13 summarizes the non-monetary token exercise outcomes for South Florida.

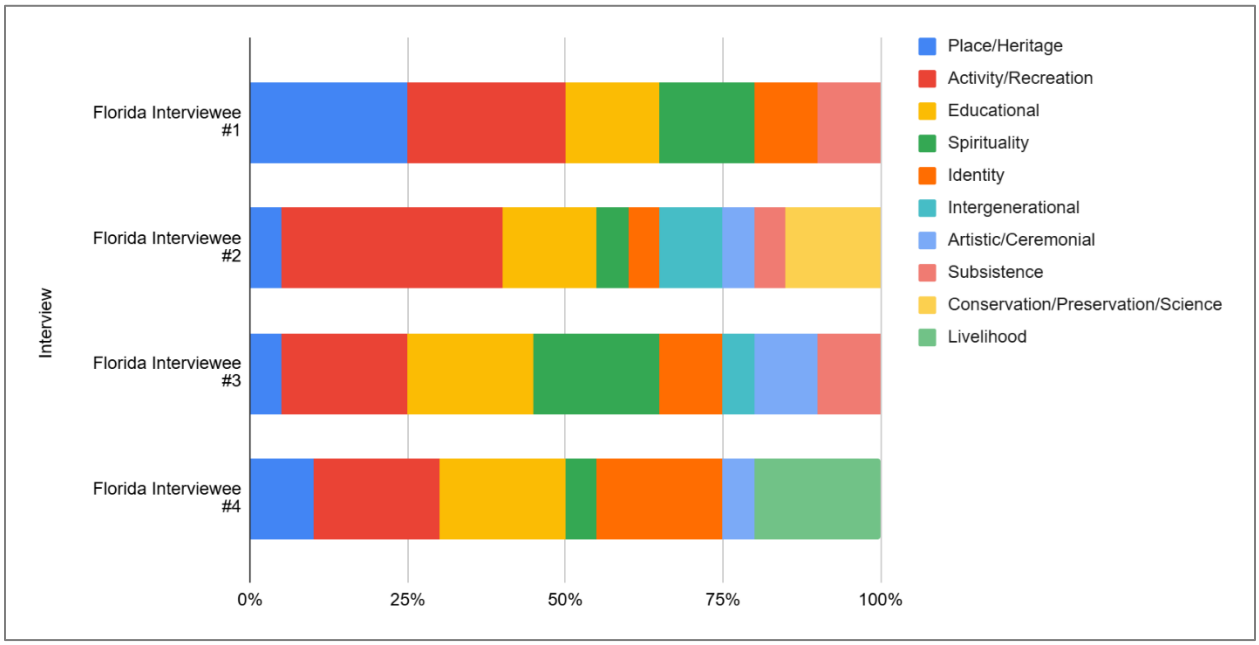

Figure 13. Non-monetary token exercise outcomes for South Florida

Hawai‘i

Hawai‘i has nearly 410,000 acres of coral reef across its main islands. Hawai‘i’s reefs, which are fringing and barrier reefs, host more than 1,250 endemic species, or species that are found exclusively in Hawai‘i (U.S. Coral Reef Task Force, n.d.-e).

Hawai‘i’s ecosystem service valuation in Project Year 2 focused largely on the dissonance between conventional monetary valuation approaches and those that would be appropriate in Hawai‘i based on its colonial history, the confiscation of land and other natural resources belonging to Native Hawaiians, and the ongoing revitalization of traditional Hawaiian cultural practices and natural resource management. Stakeholders and workshop participants emphasized the need for a Hawai‘i-specific and holistic approach to determining values for ecosystem services.

Coral reefs in Hawai‘i protect people, landscapes, infrastructure, and property. They provide an estimated annual economic benefit of $510.02 million and protect economic activity worth $731.08 million (Storlazzi et al., 2019). This estimate was determined via a complex combination of oceanographic, coastal engineering, ecosystem, geospatial, social, and economic models. However, corals in Hawai‘i provide more than just protection from storms; they also contribute to a system of measurement for storm strength that requires no models or technologies. An understanding of corals’ value is reflected in ‘ōlelo no‘eau—proverbs or wise sayings that serve as a means of passing on information from generation to generation. Several ‘ōlelo no‘eau compiled by Pukui (1983, cited in Gregg et al., 2015) attest to the strength of corals and how they relate to storms or rough seas (Gregg et al., 2015). Thus, corals not only directly provide protection from storms, but have also long contributed to Hawaiians’ understanding of storm severity. Moreover, these particular ‘ōlelo no‘eau highlight the important role that corals play in education in Hawaiian culture, as they convey the resilience people need in the face of adversity, using corals as an example.

A close examination of reef fishing in Hawai‘i provides an opportunity to see the value of coral reefs through different lenses. Commercial fishing ($1.10 million to $4.49 million per year) and subsistence fishing ($9.50 million to $17.08 million per year) certainly provide income and indirect value to Hawaiians (Grafeld et al., 2017; WPRFMC, 2024). However, adding a non-monetary lens enriches these values by putting them in different terms. Just as monetary values can be widely understood, the value of reef fishing can be readily understood in terms of the number of meals it provides. Kittinger et al. (2015) determined that in Kīholo Bay, 33% (~10,000 meals per year) of artisanal fish catch is shared, and 21.4% (~6,400 meals per year) is used for pā‘ina (cultural functions). Additionally, the value of these fishing practices is evidenced by their contribution to Kōkua aku, kōkua mai—the presence of strong social ties and social networks (Pascua et al., 2017). So, fishing on coral reefs in Hawai‘i contributes not only to Hawaiian incomes and economic welfare, but also to Hawaiian culture and the relationships between Hawaiians.

There are many other examples in Hawai‘i of how corals’ material and practical utility often intertwines with their significant meaning to many facets of life. Gregg et al. (2015) sum up the importance of corals in Hawai‘i in this way: “Corals are a foundation of life in Hawai‘i. Throughout the Native Hawaiian understandings of natural processes, intimate, reciprocal relationships between man and coral have been nurtured in both spiritual and practical realms” (p. 114).

It is critical to note that studies (Bishop et al., 2011; Taylor, 2011) that emphasize the economic benefits that accrue to mainland U.S. residents and households may be in direct conflict with local Hawaiian values and place-based conceptualizations of ecosystem services. These estimates of monetary value may provide useful information for federal-scale ecosystem service accounting. However, by centering questions about how much mainland U.S. residents would pay for Hawaiian reef biodiversity, they have the effect of sidelining and deemphasizing Native Hawaiian understandings of reef relationships.

Monetary Results

Table 23 presents a summary of economic benefits for Hawai‘i.

Table 23. Summary of Annual Hawai‘i Economic Benefits (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity	**Low**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. **High**: Cesar and Van Beukering (2004) This study relied on expert judgments from real estate agents to determine amenity values. The interviews targeted professionals in the hotel, condominium, and residential property markets to estimate what proportion of beachfront property value is directly attributable to the health of the marine ecosystem. Based on data from 2001.	FEMA (2022): $134.01 per acre	FEMA (2022): 409,700 acres [c]	$54.90	$78.23	$134.01	$190.95
Biodiversity	**Low**: Peng and Oleson (2017) This survey targeted generic beach users at lifeguard-protected beaches on O‘ahu, including both Hawai‘i residents (62%) and nonresidents (38%). Sampling was distributed across sites in proportion to annual visitation rates, based on lifeguard log sheet data from the City and County of Honolulu. A total of 263 in-person interviews were completed between June and November of 2014. Estimated WTP value reflects the scenario provided to respondents in a choice experiment. The estimate reflects the value of increasing the number of fish species found during a trip to a reef from 9 to 27. **High**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	Peng and Oleson (2017): $13.02 FEMA (2022): $2,612.05 per acre	Peng and Oleson (2017): Hawai‘i households: 492,453 [d]; O‘ahu coral reef acres: 124,541 [e] FEMA (2022): 409,700 acres [c]	$6.41	$1,070.16	$51.47	$2,612.05

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Biodiversity	Bishop et al. (2011) This study used a survey of the U.S. general population (18 years old and up) across all 50 states (n=3,183) to estimate WTP for two scenarios: (1) protecting and restoring degraded coral reef ecosystems in Hawai'i, and (2) restoring reefs after localized injuries. Estimates provided here reflect the combined value of both scenarios, referred to in the study as "achieving both goals." Although per-household values are provided, the project team used the range of values provided in the study and adjusted for changes in price levels.	WTP: $438.51 per U.S. household (not used to calculate values)	N/A	$34,425.42	$67,936.19	$84,025.90	$165,819.33
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$510.02	N/A	$1,244.86
Existence value	Taylor (2011) This study, a master's thesis, estimates the WTP to mitigate the effects of climate change on coral reefs in Hawai'i. The study uses a sample of respondents from both Hawai'i and the mainland U.S. population. Hawai'i total: $95.45 million U.S. mainland total: $14,509.08 million Values presented represent a "plausible scenario" for climate change and the WTP to mitigate that scenario to a plausible outcome. The WTP estimate was derived from the model as part of a decision-support tool created as part of the research.	Hawai'i WTP: $193.26 U.S. mainland WTP: $111.13	Hawai'i households: 492,453 [d] U.S. mainland households: 128,735,043 [f]	N/A	$14,401.27	N/A	$35,150.77

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Recreation—diving/ snorkeling	Cesar and Van Beukering (2004) This study examined consumer surplus for diving/snorkeling trips. The authors conducted a specialized survey interviewing 50 scuba divers and 260 snorkelers. This sample was used to determine users' perceptions of various coral habitats, their total holiday and travel costs, and their WTP for reef management.	N/A	N/A	N/A	$260.75	N/A	$636.44
Recreation—lost due to bleaching event	Fezzi et al. (2023) This study estimates the value of lost welfare associated with the 2014–2015 bleaching event in Maui. It does not explicitly estimate the total value of recreation; it just estimates value lost due to the bleaching event.	Lost recreation value per resident: $301.44	Maui residents: 127,510 [g] Maui coral reef acres: 16,000 [h]	N/A	$38.44	N/A	$2,402.31
Recreation—all	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$57.25 per person-day of activity	967,942 reef-related trips [i]	N/A	$55.41	N/A	$135.25

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (2026).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Hawai'i's coral reefs cover 409,700 acres in the Main Hawaiian Islands. Source: U.S. Coral Reef Task Force (n.d.-e).
[d] Source for Hawai'i households: U.S. Census Bureau (n.d.-b).
[e] Peng and Oleson (2017) is based in O'ahu only, so the acreage has been adjusted to reflect only the extent of O'ahu's coral reefs: 124,541 acres. Source: Pacific Islands Benthic Habitat Mapping Center (n.d.).
[f] Source for U.S. mainland households: U.S. Census Bureau (n.d.-b). Hawai'i's households were subtracted from the U.S. total.
[g] Source for Maui residents: U.S. Census Bureau. (n.d.-c).
[h] Fezzi et al. (2023) is based in Maui only, so the acreage has been adjusted to reflect only the extent of Maui's coral reefs: 16,000 acres. Source: Field at al. (2019).
[i] Total trips is based on Spalding et al.'s (2017) estimate that 9.99% of all Hawaiian tourism is specifically reef-related. Source: Hawai'i Tourism Authority. (2024).

Hawai'i Economic Impact Range

Table 24 presents a summary of annual economic impacts for Hawai'i. To develop a range of economic impacts, the project team assumed that the lower bound is comprised of WPRFMC (2024b) commercial fishing values, Grafeld et al.'s (2017) non-commercial fishing value, Bartelet et al.'s (2024) recreation value, and FEMA's (2022) research value. The team assumed that Cesar and Van Beukering's (2004) recreation value is subsumed by the Bartelet et al. study. For the upper bound, the project team used Storlazzi et al.'s (2019) coastal protection value, Grafeld et al.'s (2017) commercial and non-commercial fishing values, Spalding et al.'s (2017) recreation value, and Cesar and Van Beukering's (2004) research value. This brings the range of economic impacts to $845.71 million to $2.46 billion per year.

Table 24. Summary of Annual Economic Impacts for Hawai'i (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represent the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$731.08	N/A	$1,784.42
Commercial fishing	**Low**: WPRFMC (2024b); **High**: WPRFMC (2022) Based on revenue for the top 10 reef fish species. A value-added ratio of 0.60 (Grafeld et al., 2017) is applied.	N/A	N/A	$1.10	$1.19	$2.69	$2.90
Commercial fishing	Grafeld et al. (2017) This value-added estimate for commercial fishing was calculated by applying a cost-price ratio of 0.60 to the landing price. Additional value is estimated by subtracting the landing price from the market price and applying specific ratios based on the dealer type: 0.60 for wholesalers, 0.64 for grocery/retail, and 0.70 for restaurants. Fisher-level data was derived from mandatory commercial catch reports and mean landing prices provided by the Hawai'i Division of Aquatic Resources (DAR). Dealer-level calculations utilized voluntary purchase reports from the DAR commercial purchase database.	N/A	N/A	$4.10	$4.49	$10.01	$10.96

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Non-commercial fishing	Grafeld et al. (2017) Valued using a "farm gate" pricing approach, which estimates value based on the market or landing price of the fish minus the recurring costs of fishing. A value-added ratio of 0.90 is applied to the total estimated catch value. Catch estimates are derived from NOAA's Marine Recreational Information Program and the Pacific Islands Fisheries Science Center. Market prices were compiled from observations by NOAA and The Nature Conservancy.	N/A	N/A	$9.50	$17.08	$23.18	$41.70
Tourism	**Low**: Bartelet et al. (2024) Using data from Spalding et al. (2017), the value-added contribution of coral reefs to the economy can be estimated by subtracting the cost of intermediate inputs from the market revenue produced by the coral reefs (in this case, expenditures by tourists and landed values of reef fish). **High**: Spalding et al. (2017) The study estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study.	N/A	N/A	$824.03	$1,691.40	$2,011.29	$4,128.38
Recreation—diving/ snorkeling	Cesar and Van Beukering (2004) Direct snorkeling/diving expenses (e.g., gear, entry fees, transport) are assumed to generate 25% value added, while indirect tourism spending—for which marine activities account for 18% of visitor motivation—contributes 25% (hotels) and 2% (airfare) as value added. These impacts are then scaled using a 1.25 economic multiplier for Hawai'i.	N/A	N/A	N/A	$334.14	N/A	$815.56

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Research	**Low**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. **High**: Cesar and Van Beukering (2004) The sample frame for the scientific value of biodiversity included all potential research candidates involved in coral reef–related projects in Hawai'i. These organizations and projects, such as the National Marine Fisheries Service and the University of Hawai'i, were asked to provide their annual budgets for the year 2001.	FEMA (2022): $27.04 per acre	FEMA: 409,700 acres [c]	$11.08	$20.43	$27.04	$49.87

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (2026).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Hawai'i's coral reefs cover 409,700 acres in the Main Hawaiian Islands. Source: U.S. Coral Reef Task Force (n.d.-e).

Non-Monetary Results

Table 25 presents selected non-monetary indicators for Hawai‘i. Sources for each indicator are in parentheses following the indicator.

Table 25. Selected Non-Monetary Indicators for Hawai‘i

Ecosystem Service(s)	Indicator
Stewardship, learning/education	“And so there are a lot of things that are happening. Exciting things, new technology, novel, unique things that are actually coming on board. People working in restoration, people looking at the genetics of corals. And this is exciting. There is hope. Even though it is a critical time right now, we have the opportunity to actually do something. We have the chance to say to our grandchildren and great-grandchildren, no, we actually did something to save the coral reefs. We didn’t just sit around.” (Rodgers, 2022)
Cultural heritage, recreation	In reference to surfing locations: “Hauwa is the large, very shallow reef that begins at the western edge of Ha‘ena Bay; surfers call it Cannons. The waves that break here are so hollow that they often “spit” out a blast of compressed air and sea spray, and early surfers who rode the break likened the blast to the firing of a cannon.” (Charles “Chipper” Wichman, Jr., cited in Herman, 2003)
Cultural heritage, social responsibility	33% of artisanal fish catch from Kīholo Bay is shared (~10,000 meals per year). In addition, 21.4% is used for pā‘ina (cultural functions) (~6,400 meals per year) (Kittinger et al., 2015)
Learning/educational, cultural heritage, intergenerational value	“Lawai‘a ‘Ohana (Fishing Families) Camp Program has been active for six years (2015) and has held 39 camps in 13 communities on 6 islands, welcoming ~2,400 participants, 1,076 of whom were children, with the goal of sharing traditional fishing knowledge within the community and with future generations.” (Grafeld et al., 2017)
Spirituality	“The predominant Hawaiian creation chant, the Kumulipo, describes the first creation of life following the male and female as the coral polyp, which in turn gave rise to subsequent organisms. Hā nau ka ‘uku ko‘ako‘a, hā nau kā na, he ‘ako‘ako‘a, puka. (Born was the coral polyp, born was the coral, came forth.)” (Jokiel et al., 2010)

Hawai‘i was the first jurisdiction to decline interviews as a data-collection method for non-monetary values. Stakeholders felt that the limited number of interviews could not possibly capture the breadth of values associated with corals, nor reach the necessary number of groups with relevant and important viewpoints on corals’ value. This preference for interviews was pronounced, and stakeholders emphasized to the project team the need to tailor valuation approaches to each jurisdiction, based on local feedback. As one notable manifestation of this, the project team consistently presented its plan for non-monetary valuation as a suite of options and solicited feedback on each component of the plan, noting that there was flexibility to modify the plan to accommodate the jurisdictional context.

Puerto Rico

Puerto Rico has approximately 128,000 acres of coral reefs, which are home to 65 hard coral species, 112 soft coral species, and almost 250 reef fish species. Coral reefs in Puerto Rico are some of the most expansive coral reef systems in the Caribbean (U.S. Coral Reef Task Force, n.d.-f; The Nature Conservancy, n.d.).

In Puerto Rico, the ecosystem service valuation hinged on several key studies, resulting in a few new cultural ecosystem service examples and indicators, but suffered from low stakeholder involvement. Low

attendance at jurisdictional workshops resulted in less guidance when compared to the high involvement from Hawai‘i stakeholders.

For non-monetary valuations, several studies provided examples of the importance of small-scale and artisanal fishing for cultural heritage and social capital in Puerto Rico. These values are central to life for Puerto Ricans near the coast, specifically in the southeast. One interviewee described the challenge associated with understanding these values, saying, “There’s a lot of catching fish near reefs that never even makes it to the economic ledger, it just gets given away in reciprocity networks and that value gets lost a lot” (Puerto Rico Interviewee #1). Nonetheless, values reported by Agar et al. (2006) and estimates based on FEMA’s (2022) per-acre value are $2.09 million and 2.62 million per year for commercial fishing, respectively. While it’s possible to know what percentage of the total catch commercial or reciprocity networks include, monetary valuation efforts have failed to capture the full value of coral reef fisheries to Puerto Ricans.

Puerto Rico has been rocked by several severe storms in recent years, but its coral reefs have provided protection against storm surge and flood. In total, Storlazzi et al. (2019) determined Puerto Rico’s reefs protect $147.71 million per year of economic activity. On top of this value, which could be considered a form of natural capital, one interviewee described their conversation with real estate developers—direct beneficiaries of the coastal protection services—and indicated the developers would benefit from incorporating the value the reefs provide into their decision-making process:

> “If you want to sell the view, you have to protect the coral reefs, because coral reefs are going to keep the waters clean, the coral reefs are going to provide the ways to enjoy the blue waters that we enjoy here…So one idea we idea we threw to some of these people is that you have to consider coral reefs as part of your working capital. If you don’t have coral reefs, if you don’t invest in them, you won’t have beaches to sell.” – Puerto Rico Interviewee #2

Leeworthy et al. (2018) estimated the economic impact of recreation associated with Puerto Rico’s reefs to be $2.32 billion per year, including that the reefs are associated with 30,000 jobs. Further, interviewees spoke frequently about the connection coral reef users develop with reef ecosystems, and even specific corals or landmarks on a reef. For those Puerto Ricans who work in the high-value recreation industry, beyond providing the monetary value and supporting their livelihoods, the reefs also provide a sense of identity.

Monetary Results

Table 26 presents a summary of economic benefits for Puerto Rico.

Table 26. Summary of Annual Puerto Rico Economic Benefit Estimates (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$129.84 per acre	128,000 acres [c]	N/A	$16.62	N/A	$129.84
Bequest value	Estudios Técnicos (2007) The authors conducted a contingent valuation survey among residents of Puerto Rico. The random sample (n=899) consisted of adults aged 18 and older living in households across all of Puerto Rico (including the islands of Vieques and Culebra) with an active residential telephone.	$98.22 per household	Households: 1,290,866 [d]	N/A	$126.78	N/A	$990.50
Biodiversity	Low: Estudios Técnicos (2007) The authors conducted a contingent valuation survey among residents of Puerto Rico. The random sample (n=899) consisted of adults aged 18 and older living in households across all of Puerto Rico (including the islands of Vieques and Culebra) with an active residential telephone. High: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	Low: $89.19 per household High: $2,530.71 per acre	Low: 1,290,866 households [b] High: 128,000 acres [c]	$115.14	$323.93	$899.52	$2,530.71
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus	N/A	N/A	N/A	$83.05	N/A	$648.86

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
	depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.						
Existence value	Estudios Técnicos (2007) The authors conducted a contingent valuation survey among residents of Puerto Rico. The random sample (n=899) consisted of adults aged 18 and older living in households across all of Puerto Rico (including the islands of Vieques and Culebra) with an active residential telephone.	$142.56 per household	Households: 1,290,866 [d]	N/A	$184.03	N/A	$1,437.72
Option value	Estudios Técnicos (2007) The authors conducted a contingent valuation survey among residents of Puerto Rico. The random sample (n=899) consisted of adults aged 18 and older living in households across all of Puerto Rico (including the islands of Vieques and Culebra) with an active residential telephone.	$90.09 per household	Households: 1,290,866 [d]	N/A	$116.30	N/A	$908.56
Recreation—all types combined	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$47.81 per person-day of activity	10,032,424 person-days [e]	N/A	$479.66	N/A	$3,747.32

N/A: Not applicable
Note: Source of local CPI data: International Monetary Fund. (n.d.).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated the units based on current visitation/reef use.
[c] Puerto Rico's coral reefs cover 128,000 acres. Source: The Nature Conservancy (n.d.).
[d] Source for Puerto Rico households: U.S. Census Bureau. (n.d.-a).
[e] Source for Puerto Rico recreation person-days: NOAA (n.d.-d).

Puerto Rico Economic Impact Range

Table 27 presents a summary of economic impacts for Puerto Rico. Storlazzi et al. (2019) provided estimates of coastal protection of $147.41 million per year for Puerto Rico. The project team assumes the estimate from Spalding et al. (2017) estimate is the low value for recreation and tourism, while the estimate from Leeworthy et al. (2018) is the high value. For a low bound, the project team added commercial fishing (Agar et al., 2006) and recreation values (Spalding et al., 2017). For the high bound, the team added coastal protection values (Storlazzi et al., 2019), commercial fishing (FEMA, 2022), recreation values (Leeworthy et al., 2018), and research values (FEMA, 2022). Through this process, the team arrived at a total estimated economic impact of between $775.60 million per year and $2.48 billion per year.

Table 27. Summary of Annual Puerto Rico Economic Impact Estimates (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represents the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$147.71	N/A	$1,153.98
Commercial fishing	**Low**: Agar, et al. (2006) Agar, et al. performed a survey of trap fishing operations to determine revenues and various costs. The values reported reflect the net revenue. The sample for this study comprised 421 fish trap fishers across Puerto Rico and USVI, specifically St. Croix, St. Thomas, and St. John. To ensure the selection captured the full diversity of the fleet, the population was stratified into two or three tiers based on the scale of operation, which was defined by the number of traps owned. From this stratified framework, a target of 100 fishers was established for voluntary, in-person interviews using a simple random sampling method. The Puerto Rico sub-sample for this study consisted of 60 completed interviews. **High**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	Low: $9,564.34/per boat High: $20.50/acre	Low: 139 boats [b] High: 128,000 acres [c]	$2.09	$2.62	$16.33	$20.50

Recreation	**Low**: Spalding et al. (2017) The study estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study. **High**: Leeworthy et al. (2018) Leeworthy et al. conducted an IMPLAN-based economic impact analysis for reef-related recreation. Includes reported trip-related costs and durable goods costs from a survey of reef users. Trip-related costs cover immediate travel expenditures like lodging, food, transportation, and recreation. Durable goods costs represent long-term investments in assets visitors keep in Puerto Rico, specifically condos and RVs. The study reports combined total economic output. The sample (n=2000) for this study comprised reef-using visitors to Puerto Rico who accessed the island by air, specifically excluding local residents. Data collection occurred via an on-site airport survey conducted at the San Juan Airport between October 2016 and May 2017.	N/A	N/A	$773.51	$2,328.28	$6,043.05	$18,189.69
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$26.20/acre	128,000 acres [c]	N/A	$3.35	N/A	$26.20

N/A: Not applicable.

Note: Source of local CPI data: International Monetary Fund. (n.d.).

[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.

[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.

[c] Puerto Rico's coral reefs cover 128,000 acres. Source: The Nature Conservancy (n.d.).

[d] Trap fishery boat number source: Agar et al. (2017).

Non-Monetary Results

Table 28 presents selected non-monetary indicators for Puerto Rico. Sources for each indicator are in parentheses following the indicator.

Table 28. Selected Non-Monetary Indicators for Puerto Rico

Ecosystem Service(s)	Indicator
Recreation/tourism	Coral reef related tourism sustains approximately 30,000 jobs in Puerto Rico. (Leeworthy et al., 2018)
Non-commercial fishing	"There's a lot of catching fish near reefs that never even makes it to the economic ledger, it just gets given away in reciprocity networks and that value gets lost a lot." (Puerto Rico Interviewee #1)
Commercial fishing	An estimated 66% of Puerto Rico's commercial fish catch in 2019 contained fish associated reefs. (Pauly, Zeller, & Palomares, 2020)
Amenity	"If you want to sell the view, you have to protect the coral reefs, because coral reefs are going to keep the waters clean, the coral reefs are going to provide the ways to enjoy the blue waters that we enjoy here… So one idea we idea we threw to some of these people is that you have to consider coral reefs as part of your working capital. If you don't have coral reefs, if you don't invest in them, you won't have beaches to sell." (Puerto Rico Interviewee #2)
Identity, commercial fishing	"Fishing means life, because as long as there is a variety of [fish and shellfish] species near our coasts, we fishers will be able to survive." (Lázaro, a fisher from Patillas, Puerto Rico [García-Quijano, 2009])

In Puerto Rico, coral reefs are closely intertwined with other coastal ecosystems and with everyday cultural life. Reefs are salient to Puerto Ricans in multiple ways; for instance, reefs frequently appear in media coverage related to reef degradation, reef restoration, and major events such as Hurricane Maria, which marked a shift in public awareness of their importance. Reefs support culturally important species and provide spaces for fishing, festivals, and tournaments, fostering strong emotional and place-based connections, particularly among those who work on the reefs. While Puerto Rican identity is often framed as terrestrial and agrarian, reefs reflect a deeply rooted coastal and fishing-based identity that is expressed through art, poetry, toponymy, and material culture, and that persists even among those who leave the island.

Figure 14 summarizes the non-monetary token exercise outcomes for Puerto Rico.

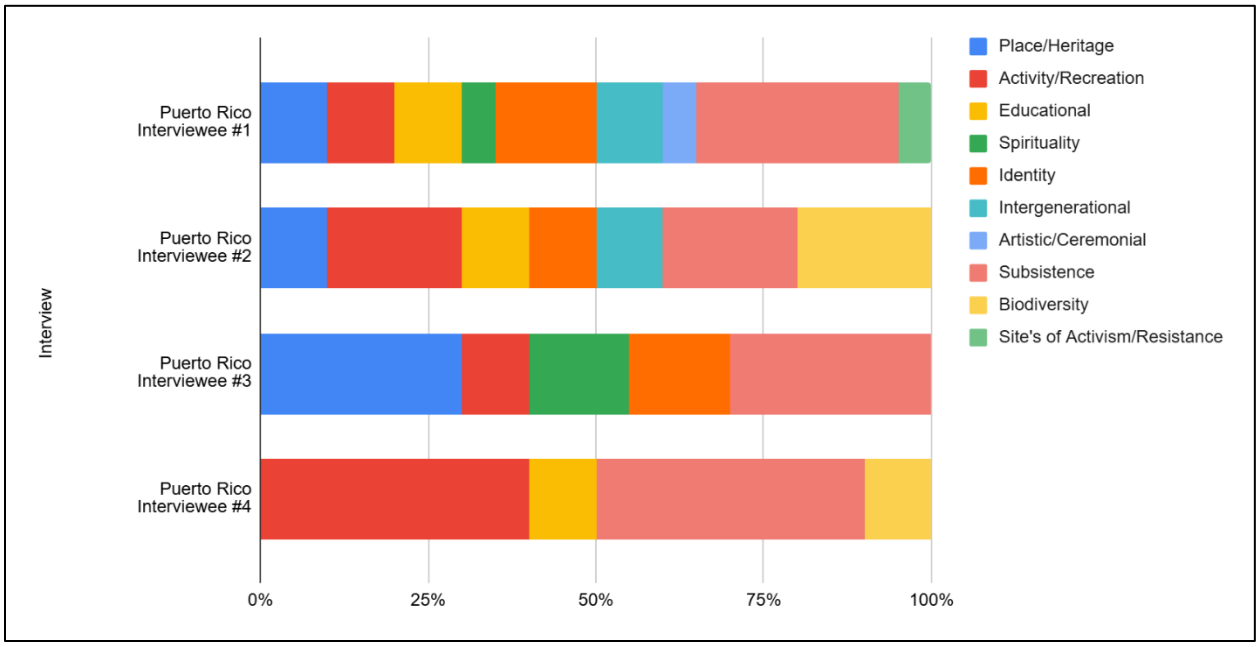

Figure 14. Non-monetary token exercise outcomes for Puerto Rico

Pacific Remote Island Areas

The Pacific Remote Island Areas consist of seven uninhabited islands and atolls in the central Pacific Ocean. The waters surrounding these islands and atolls host coral reefs that vary in size, ranging from about 2 square kilometers at Howland Island to 94 square kilometers at Johnston Atoll. Because of their remoteness, the reefs in the Pacific Remote Island Areas are considered some of most pristine reefs in the world (Boyle et al., 2017).

Finding values for PRIA was very challenging. This vast and rarely visited region simply doesn't involve a significant amount of interactions between humans and coral reefs (to represent instrumental and relational values), nor are its intrinsic values widely catalogued. Yet, PRIA has immense value. Its islands are important locations for Micronesian, Polynesian, and Hawaiian cultural heritage, and they provide an irreplaceable baseline of coral reef health for the U.S. public and coral reef researchers worldwide. While these reefs can be integral to the identities of Pacific Islanders, they also exist to a lesser extent as part of America's global heritage. In that sense, they are part of America's natural heritage just like other protected areas.

For researchers, coral reefs in PRIA are valuable because of their relatively untouched nature compared to other reef ecosystems. Several interviewees shared this perspective, while also noting the aesthetic value of PRIA's reefs is related to their health and represents a major unquantifiable value. Interviewee #2 states "There's just such a rich palate out there, and it's both biological and physical… you have a diversity of different lifeforms that are differentiating themselves by color… One of the things that is really most different beyond diversity in PRIA is the robustness of that color." Additional work to engage with individuals who have experienced reefs in PRIA might make the values associated with corals in these remote locations clearer.

Monetary Results

Sufficient data to perform benefit transfer for PRIA was not identified in the project period.

Non-Monetary Results

Table 29 presents selected non-monetary indicators for PRIA. Sources for each indicator are in parentheses following the indicator.

Table 29. Selected Non-Monetary Indicators for PRIA

Ecosystem Service(s)	Indicator
Cultural heritage	"As part of Pacific Island culture, the Western Pacific territories support conservation measures that sustainably use and conserve natural resources. We depend on these resources for food, recreation, our economy, and to practice indigenous Chamorro and Refaluwasch cultures." (Private citizen [NOAA, 2023])
Cultural heritage, existence	"People from Santa Barbara to Omaha, Nebraska really appreciate just knowing that there is a spot out there where sea turtles are breeding where sharks at densities doing their thing the way they have been doing that for hundreds of years. That adds some richness to their sense of what American National heritage and biodiversity and wilderness - again, some of those terms are a little problematic -... adds some richness to folks' perspective about what biodiversity is part of our national jurisdiction." (PRIA Interviewee #2)
Spirituality	"So much of our culture and history is about traversing the ocean, writ large, so that the ocean itself and that which is within it is sacred… The spirituality elements of the ocean, and PRIA, recognizing that there is an opportunity for all these different pacific island communities to reconnect with the sacredness that is in that spot, and in some ways to create new sacredness with the corals, and the islands, and those locations." (PRIA Interviewee #3)
Learning/educational	"These places that are uninhabited or have very low anthropogenic stressors are very few and far between these days and without that baseline we have no idea what we could have or what we had in the 1900s or we had in the 1800s so we lose that and then that baseline shifts to the next most pristine place and then that gets impacted and then if shifts to the next. So these shifting baselines are scary if we don't have places like Palmyra or Jarvis, or I mean there are a few places…So, to the scientific community over the last 15 or 16 years I've seen just a massive amount of scientific research carried out at Palmyra and critical learnings coming from that work that have international impact." (PRIA Interviewee #4)

In the Pacific Remote Island Areas (PRIA), coral reefs are valued for their exceptional health, rarity, and relative lack of human disturbance, which distinguishes them from many degraded reef systems worldwide. Despite limited public information and extreme inaccessibility, people invest significant resources to reach these reefs for diving, recreation, and research, reflecting their perceived importance. PRIA reefs provide critical baselines for understanding what healthy reefs look like, supporting research of international significance while also offering cultural and historical connections for Pacific Islanders, including ties to ancestors who navigated these islands. Although access remains a major barrier, these reefs hold value beyond science, contributing to artistic expression, natural history, and the transmission of stewardship ethics that can extend to coral reefs elsewhere.

Figure 15 summarizes the non-monetary token exercise outcomes for PRIA.

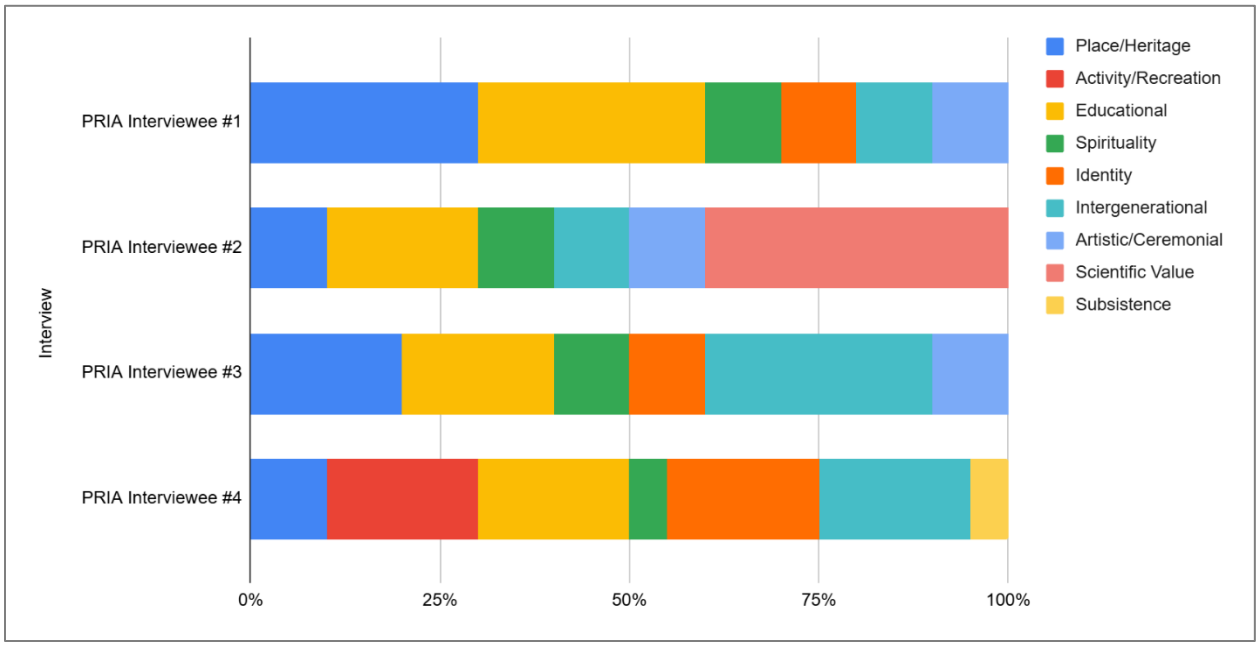

Figure 15. Non-monetary token exercise outcomes for PRIA

American Samoa

American Samoa's coral reefs are primarily fringing reefs. Spanning over 73,000 acres, these reefs are home to 200 coral species and nearly 900 fish species (U.S. Coral Reef Task Force, n.d.-a).

American Samoans place a great deal of importance on fishing as a facet of cultural heritage and social responsibility. Residents in Vatia (53%), Aunu'u (71%), and Faga'alu (53%) villages reported that they never fish for income; rather, they fish for food; for sharing with family, a pastor, or a village leader; or for fun (Levine & Kilarski, 2014). Outside of these use cases, subsistence and artisanal fisheries add $1.16 million per year to American Samoa's economy ($0.97 million per year and $0.19 million per year, respectively) (Spurgeon et al., 2004).

Diving and snorkeling recreation on American Samoa's reefs provide an economic impact of $0.04 million per year (Spurgeon et al., 2004). However, coral reefs also provide a public non-use benefit valued at approximately $17.99 million per year, suggesting that these resources potentially contribute far more to public welfare than is realized in the economy (Spurgeon et al., 2004). American Samoans hold important cultural events tied to reefs, such as the annual palolo harvest (Levine & Sauafea-Le'Au, 2013), family gatherings and ceremonies (fa'alavelave), and Sunday meals (to'onai) where fish are shared as part of a perceived social responsibility (Severance et al., 2013).

Monetary Results

Table 30 presents a summary of economic benefits for American Samoa.

Table 30. Summary of Annual American Samoa Economic Benefits (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity/ property	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$135.44 per acre	73,143 acres [c]	N/A	$9.91	N/A	$135.44
Biodiversity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$2,639.99 per acre	73,143 acres [c]	N/A	$193.10	N/A	$2,639.99
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$38.17	N/A	$521.81
Non-commercial fishing	Spurgeon et al. (2004) The study determined the direct consumer surplus for fishing via a benefit-transfer approach.	N/A	N/A	N/A	$0.12	N/A	$1.70
Non-use values	Spurgeon et al. (2004) The study estimated existence, option and bequest values (including elements of social and cultural value). Non-use values were based on the sum of WTP for coral reefs by American Samoan residents, visitors, and the U.S. general public. The American Samoa sample for this study's survey consisted of 300 residents from 44 villages across the islands of Tutuila, Ofu, and Olosega. Respondents were selected to be reasonably representative of the territory's population distribution and socioeconomic characteristics such as gender, age, and place of	U.S. households WTP: $0.07 American Samoan residents WTP: $178.95 Tourists WTP: $14.49	U.S. households: 129,227,496 [d] American Samoan residents: 49,710 [e] Tourists (2024):	N/A	$17.99	N/A	$245.89

	birth. Conducted in both Samoan and English by trained assistants in February 2004, the survey aimed to elicit WTP values to assess the importance of coral reefs to local residents.		19,320 [f]				
Recreation—diving/ Snorkeling	Spurgeon et al. (2004) The study estimated the consumer surplus for snorkeling based on a combination of the authors' experience and observations in American Samoa and values reported by NOAA (2004) (Florida) and Cesar (2002) (Hawai'i).	N/A	N/A	N/A	$0.09	N/A	$1.17
Recreation—all	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$54.36 per person-day of activity	4,595 reef related trips [g]	N/A	$0.25	N/A	$3.42

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (n.d.-b).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] American Samoa's coral reefs cover 73,143 acres. Source: U.S. Coral Reef Task Force (n.d.-a).
[d] Source for U.S. households: Census Bureau (n.d.-b).
[e] Source for residents in American Samoa: U.S. Census Bureau (n.d.-c).
[f] Spurgeon et al. (2004) reports that 58% of tourists to American Samoa are Americans. The project team applied this fraction to the tourist count for 2024 (46,000) to avoid double counting of U.S. households and tourists. Source: American Samoa Visitors Bureau (2026).
[g] Total trips is based on Spalding et al.'s (2017) estimate that 99.9% of all Hawaiian tourism is reef-related. The project team applied that percentage to the American Samoa tourist count for 2024 (46,000). Source: American Samoa Visitors Bureau (2026).

American Samoa Economic Impact Range

Table 31 presents a summary of annual economic impacts for American Samoa. Coastal protection from coral reefs affects $10.73 million per year in economic activity (Storlazzi et al., 2019). Spurgeon et al. (2004) provided values for subsistence fishing ($0.97 million per year), artisanal fishing ($0.19 million per year), and expenditures on diving and snorkeling trips ($0.04 million per year). Bartelet et al. (2024) provide a more comprehensive recreation value ($2.52 million per year) that presumably includes diving and snorkeling. FEMA's (2022) estimate for research ($2.00 million per year) has been included for American Samoa as well. For a lower bound, the project team combined the WPRFMC (2024a) lower value ($0.02 million per year) and Barlelet et al.'s (2024) recreation value. For an upper bound, the team combined Storlazzi et al.'s (2019) coastal protection value, Spurgeon et al.'s (2024) non-commercial fishing values, FEMA's (2022) research value, and the higher estimate for commercial reef fisheries from the WPRFMC (2022) ($0.15 million per year). These produce a range of $2.54 million to $14.04 million per year. Fishing values

in Spurgeon et al. (2004) were explicitly for fish harvested for personal consumption, while the WPRFMC's values were for boat-based commercial fishing. We exclude Spurgeon et al. (2004) from the range, assuming it is subsumed within Bartelet et al. (2024).

Table 31. Summary of Annual Economic Impacts for American Samoa (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represents the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$10.73	N/A	$146.63
Commercial fishery	**Low**: WPRFMC (2024a); **High**: WPRFMC (2022) Estimates based on revenue for the top 10 reef fish species. A value-added ratio of 0.60 (Grafeld et al., 2017) is applied.	N/A	N/A	$0.02	$0.15	$0.30	$2.05
Non-commercial fishing (subsistence fishing)	Spurgeon et al. (2004) Estimate based on producer surplus (added value) of fishery products for consumption, with values based on the retail value of locally caught reef fish and lobster.	N/A	N/A	N/A	$0.97	N/A	$13.32
Non-commercial fishing (artisanal fishing)	Spurgeon et al. (2004) Estimate based on direct harvest of fishery products for sale. Includes producer surplus (added value) for reef species and reef-associated bottom-fish.	N/A	N/A	N/A	$0.19	N/A	$2.66
Recreation—diving and snorkeling	Spurgeon et al. (2004) Estimate based on producer surplus (added value) for direct (e.g., gear) and indirect (e.g., accommodation) expenditures.	N/A	N/A	N/A	$0.04	N/A	$0.54

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Recreation	Bartelet et al. (2024) The value-added contribution of coral reefs to the economy was estimated by subtracting the cost of intermediate inputs from the market revenue produced by the coral reefs (in this case, expenditures by tourists). In other jurisdictions, Bartelet et al. (2024) is considered the low estimate when compared to Spalding et al. (2017). Spalding et al. (2017) did not appear to include American Samoa in their analysis, but this jurisdiction was included by Bartelet et al., with the original data used to calculate American Samoa's value-added portion of revenue remaining unclear. To be consistent with the other Pacific jurisdictions, we consider Bartelet et al. (2024) as a lower bound.	N/A	N/A	$2.52	N/A	$34.43	N/A
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$27.33 per acre	73,143 acres [c]	N/A	$2.00	N/A	$27.33

N/A: Not applicable.
Note: Source of local CPI data: Bureau of Labor Statistics (n.d.-b).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] American Samoa's coral reefs cover 73,143 acres. Source: U.S. Coral Reef Task Force (n.d.-a).

Non-Monetary Results

Table 32 presents selected non-monetary indicators for American Samoa. Sources for each indicator are in parentheses following the indicator.

Table 32. Selected Non-Monetary Indicators for American Samoa

Ecosystem Service(s)	Indicator
Recreation/non-commercial fishing	More than half of surveyed American Samoans in Vatia (53%), Aunu'u (71%), and Faga'alu (53%) villages reported that they never fish for income; rather, they fish for food; for sharing with family, a pastor, or a village leader; or for fun. This finding, combined with reports that well over half of fish caught in these villages are from sloping reefs, highlights that coral reef fisheries are important to American Samoans for reasons other than monetary gain (Levine & Kilarski, 2014). Levine et al. (2016) report very similar findings about the reason for fishing (62% never fish for income, with similar alternative reasons), based on a survey of a larger set of villages on Tutuila that excluded those in Levine & Kilarski (2014). *(Levine et al., 2016; Levine & Kilarski, 2014)*
Social relationships	Fishing is often not strictly for subsistence, but for fa'alavelave (sharing at a family function or ceremony), for feasoasoani (general help), for to'onai (Sunday meal), or for tautua (service gifts for village chief or clergy). *(Severance et al., 2013*)
Cultural heritage/identity	"To catch palolo, you needed to 'style up' and be clean; you couldn't just walk in the ocean and catch palolo with a dirty shirt; you need to look as if you are going to dance! The palolo was abundant back in the days. Sometimes people couldn't harvest all of it . . . but nowadays, once the palolo comes, wherever you are, you just go out and catch it without following the traditional ways"—American Samoan fisher. Traditions associated with the palolo[12] harvest have changed, but the practice of harvesting palolo remains in American Samoa. *(Levine & Sauafea-Le'au, 2013)*
Security	Number of children protected by coral reefs from flooding, by island: Tutuila, 383; Ofu and Olosega, 2; Ta'ū, 6 (Total = 391). *(Storlazzi et al., 2019)*

Interviews were not completed in American Samoa based on guidance from the NOAA Liaison and concerns voiced during the first American Samoa stakeholder workshop. The primary concern was that the interviews should be representative of all the reef-related perspectives on American Samoa (e.g., fishers, community leaders, cultural experts, etc.). However, some participants at the workshop supported the idea of conducting interviews, or at least expressed that some interviews are better than none.

The project team was also aware of several other federal projects and efforts related to marine conservation in American Samoa and was sensitive to the issue of survey fatigue and potential biases that may arise from other engagements. Alternative methods for collecting non-monetary values from

[12] Palolo are a species of polychaete worm harvested in American Samoa during October. They are known as Samoan caviar and are considered a delicacy. The species is declining in some locations due to the decline in coral reef habitat quality. See Levine A., Sauafea-Le'Au F, (2013) for details.

residents were deemed inappropriate as well, for the same reasons as described above and due to the challenge of logistics and planning for such interactions.

U.S. Virgin Islands

Coral reefs in the USVI cover almost 50,000 acres and include fringing, bank-barrier, and patch reefs. These reefs are home to more than 580 fish species and over 40 reef-building coral species (U.S. Coral Reef Task Force, n.d.-g).

In the USVI, ecosystem services are an issue tied to historical legacies of colonialism, fortress conservation, and demographic change. Unlike Pacific jurisdictions, where many Indigenous residents still relate to the coral reefs in longstanding traditional ways, many locations in the Caribbean no longer contain robust communities of pre-colonial Indigenous peoples. Demographic change and development in the USVI have prevented other modern-day native Virgin Islanders, such as the Frenchie fishermen mentioned by one USVI interviewee, from accessing marine resources.

The tourism industry in the USVI, which provides economic benefits of $89.67 million per year (Londoño and Johnston, 2012) and impacts up to $370.02 million per year (Spalding et al., 2017) in reef-associated activity, dwarfs other reef-related ecosystem services. While this is a critical service, stakeholders in the jurisdictional workshops brought up the notion of over-tourism. However, tourists can also be drivers for coral reef conservation. Van Beukering et al. (2011) estimated tourists' WTP for biodiversity among USVI coral reefs at $58.25 million per year—and that is the low end of the range, with FEMA's (2022) estimate potentially indicating a biodiversity benefit of up to $150.62 million per year. Balancing these tradeoffs of tourism and access is likely going to be an ongoing concern in the USVI. Several interviewees, representing both the tourism and conservation communities, highlighted the importance of reefs for tourism and recreation, often citing reefs as a relaxing refuge from the stress of everyday life. On the other hand, USVI Interviewee #3, a native Virgin Islander and cultural expert, cited the importance of the reefs to the USVI's culinary traditions, but also mentioned that overtourism limits access to the marine resources necessary for these traditions. USVI Interviewee #1, a native Virgin Islander and coral reef educator, highlighted how renewed efforts to educate students in the USVI about coral reefs is resulting in the spread of information and values from students to their families and the broader community. Nonprofits in the USVI are certainly pitching in. They provide dozens of jobs related to coral reef restoration and education, and they also engage with hundreds of residents and tourists (Coral Bay Community Council, 2023; Coral World Ocean and Reef Initiative, 2023; Friends of Virgin Islands National Park, 2023; St. Croix Environmental Association, 2023).

Monetary Results

Table 33 presents a summary of economic benefits for USVI.

Table 33. Summary of Annual USVI Economic Benefits (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity/ property	Low: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. High: Van Beukering et al. (2011) The study provided a measure of surplus housing value in the vicinity of healthy marine systems. The study used a dataset from the USVI Tax Office consisting of 5,905 houses sold between 1993 and 2007. After cleaning for extreme values or contaminated data, the final dataset included 5,895 data points, representing approximately 12% of the housing units in the USVI.	FEMA (2022): $156.36 per acre	49,421 acres [c]	$7.73	$56.66	$156.36	$1,146.49
Biodiversity	Low: Van Beukering et al. (2011) The study estimated the WTP for reef conservation among visitors to USVI. Data were collected from a sample of 443 respondents. The criteria for inclusion were that participants must be older than 18, non-native to the USVI, and visiting for leisure purposes. The sample was composed of cruise ship visitors and stay-over (airplane) tourists. High: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	FEMA (2022): $3,047.74 per acre	49,421 acres [c]	$58.25	$150.62	$1,178.63	$3,047.74
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and	N/A	N/A	N/A	$33.40	N/A	$675.83

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
	without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.						
Recreational fishing	Van Beukering et al. (2011) The study estimated WTP to avoid a total loss in fish availability for recreational fishing. The sampling plan was based on 2000 Census data, with the islands divided into districts to ensure a representative geographic distribution. The recreational fishing group is a subset of the 779 USVI households interviewed for the local resident survey. Approximately 20% of the total sample (151 households) participated in recreational fishing.	$290.18	USVI households: 57,257 [d]	N/A	$3.76	N/A	$75.99
Recreation—all types combined	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$52.58 per person-day of activity	2,017,016 person-days [e]	N/A	$106.05	N/A	$2,145.94

N/A: Not applicable.
Note: Sources of local CPI data: U.S. Virgin Islands Bureau of Economic Research (n.d.); U.S. Virgin Islands Bureau of Economic Research (2022); GeoFactbook (n.d.).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] The USVI's coral reefs cover 49,421 acres. Source: U.S. Coral Reef Task Force (n.d.-g).
[d] Source for USVI households: U.S. Census Bureau (2021).
[e] Person-days is based on Spalding et al.'s (2017) estimate that 20.97% of all USVI tourism is reef-related. The project team multiplied the total number of USVI tourist visitors in 2024 (2.6 million) by 20.97% and then by the average length of hotel stays in 2024 (3.7 days per the USVI Bureau of Economic Research). Source: USVI Bureau of Economic Research (2025).

USVI Economic Impact Range

Table 34 presents a summary of annual economic impacts for USVI. The lower bound is defined by FEMA's (2022) commercial fishing estimate ($1.22 million per year). The upper economic impact estimates for USVI are a combination of Storlazzi et al.'s (2019) coastal protection value ($38.51 million per year), Van Beukering et al.'s (2011) values for USVI's commercial reef fishery ($2.20 million per year), and the value for Spalding

et al.'s (2017) recreation estimate ($370.02 million per year). Research values from FEMA (2022) add an estimated $1.56 million per year. After summing the fishery, recreation, and research values, the range for USVI economic impacts is estimated to be $1.22 million to $412.29 million per year.

Table 34. Summary of Annual Economic Impacts for USVI (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represents the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$38.51	N/A	$779.19
Commercial fisheries	**Low:** FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. **High:** Van Beukering et al. (2011) The study estimated net factor income for reef-associated catch based on catch data from the USVI Department of Natural Resources.	FEMA (2022): $24.69 per acre	49,421 acres [c]	$1.22	$2.20	$24.69	$44.57
Reef-associated tourism	Spalding et al. (2017) The study estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study.	N/A	N/A	N/A	$370.02	N/A	$7,487.02

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$31.55 per acre	49,421 acres [c]	N/A	$1.56	N/A	$31.55

N/A: Not applicable.

Note: Sources of local CPI data: U.S. Virgin Islands Bureau of Economic Research (n.d.); U.S. Virgin Islands Bureau of Economic Research (2022); GeoFactbook (n.d.).

[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.

[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.

[c] The USVI's coral reefs cover 49,421 acres. Source: U.S. Coral Reef Task Force (n.d.-g)

Non-Monetary Results

Table 35 presents selected non-monetary indicators for the USVI. Sources for each indicator are in parentheses following the indicator.

Table 35. Selected Non-Monetary Indicators for the USVI

Ecosystem Service	Indicator
Recreation, tourism	Survey respondents ranked tourism and its economic impact as the most significant reason for marine conservation in USVI. *(Settar & Turner, 2010)*
Stewardship	Fishers and scuba divers/snorkelers were found to have higher levels of knowledge and stewardship behavior related to corals and coral reef species such as turtles. *(Settar & Turner, 2010)*
Cultural heritage, intergenerational value	"It's a generational thing, you know… I'm thinking about the legacy of the Frenchie fishermen, and for generations, you know, grandfather, great grandfather, and their children today, going out and fishing certain areas. You know, if they're not, if that dies off and they're not able to do that, you're losing, well, it's also loss of wealth and loss of a living. If they don't have that available to pass down." *(USVI Interviewee # 2)*
Cultural heritage	"And so they used a lime kiln where they collect the coral from the ocean and they burnt it in this pit, a lime kiln, or pit, and then added shells or molasses, and lime and water… The historical structures are living structures, to this day, they're breathing. It's a living breathing thing… For example, the Fort in Christiansted, you cannot use cement because the Fort is living… So here you have a connection to the reef by the Fort and structures in the islands that the common people have no idea, they don't have no idea. It's more than a Fort, it's a living organism." *(USVI Interviewee # 3)*
Stewardship	Volunteers spent 7,733 hours cleaning up [Virgin Islands National Park], including reefs and beaches, in 2023 alone. *(Friends of Virgin Islands National Park, 2024)*

In the USVI, many residents and visitors have a limited understanding of the value of coral reefs, a gap that is often linked to low swimming ability and limited direct access to reef environments. On-reef educational programs can create life-changing experiences for students and serve as a pathway for broader household learning, as children share information about corals and reef-friendly behaviors with their parents. Reefs are closely tied to beaches, coastal waters, and tourism, and snorkeling can offer powerful exposure to these "other worlds," though for those familiar with the reefs, these experiences can also evoke sadness due to reef degradation. Interviewees emphasized the loss of traditions associated with reefs, noting that foodways, festivals, and fishing once provided stronger connections. Reefs also carry difficult historical meaning as sites of trauma from earlier colonial periods. Despite ongoing roles in subsistence and cultural cuisine, and despite providing spiritual relief for some divers, reefs remain undervalued and poorly understood by much of the population.

Figure 16 summarizes the non-monetary token exercise outcomes for the USVI.

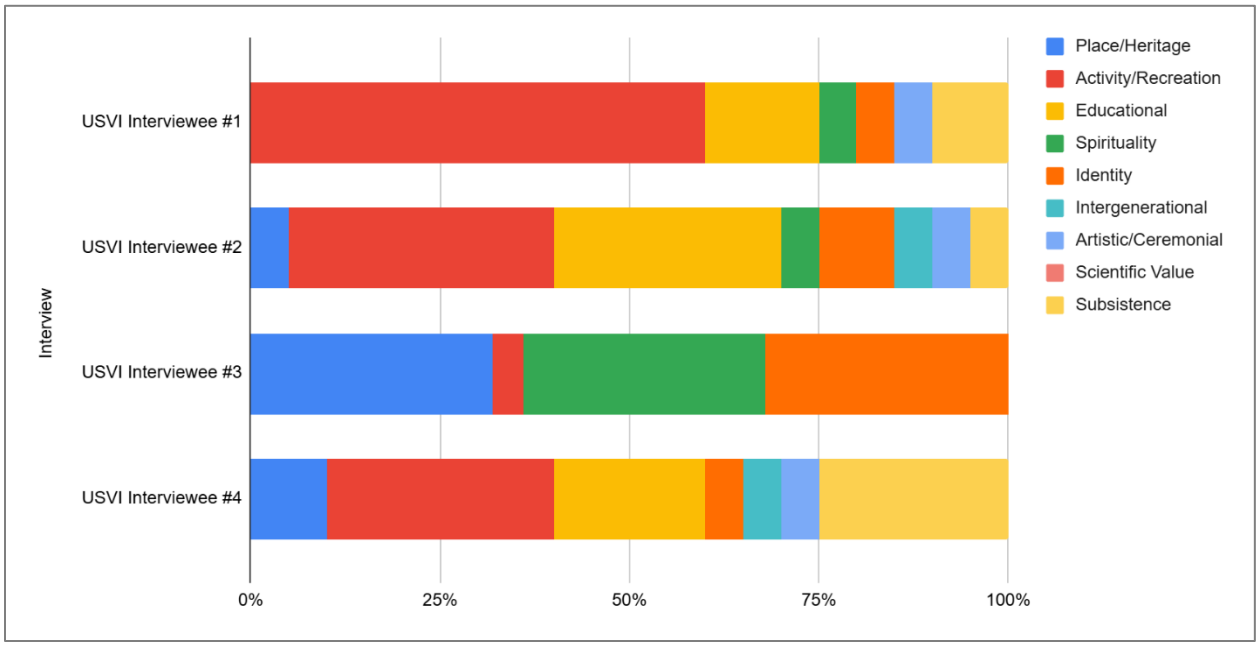

Figure 16. Non-monetary token exercise outcomes for the USVI

Commonwealth of the Northern Mariana Islands

Coral reefs in CNMI cover over 40,000 acres and are home to over 250 coral species. These reefs also support over 1,000 fish species (U.S. Coral Reef Task Force, n.d.-b).

Coral reefs are central to the identities and heritage of CNMI residents, primarily through connections to the various forms of fishing throughout CNMI, as well as through relational values such as connections to ancestors, the influence of coral reefs on local language, and stewardship of the resource. Fishing is an important activity for CNMI reef users, with benefits ranging from $0.24 million to $1.34 million per year (ERG, 2019). These values are clearly central to stakeholders in CNMI. The importance of fishing is buoyed by the benefits associated with biodiversity on CNMI's reefs, which equal $90.36 million per year (FEMA, 2022), along with property values and recreational importance.

Monetary Results

Table 36 presents a summary of economic benefits for CNMI.

Table 36. Summary of Annual CNMI Economic Benefit Estimates (in 2024 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Amenity/property	**Low**: ERG (2019) This study's estimates rely on an update of a report by Van Beukering et al. (2006). The original figures used in the 2019 report were based on ERG's review of the 2006 values, with updated housing numbers for 2010. For this assessment, the project team considered that the number of housing units in CNMI has declined 12.3% since 2010. The project team did not change determinations made by Van Beukering et al. about the proportion of housing units at different distances to the reef, nor those made by ERG about property values in 2019. **High**: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	High: $115.81 per acre	40,031 acres [c]	$4.38	$4.64	$109.34	$115.81
Biodiversity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$2,257.30 per acre	40,031 acres [c]	N/A	$90.36	N/A	$2,257.30
Coastal protection	Storlazzi et al. (2019) Values represent expected annual benefits of avoided building damages. Benefit estimates were derived using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$6.13	N/A	$153.19

Non-commercial fishing	ERG (2019) This study's estimates rely on an update of a report by Van Beukering et al. (2006). The original figures used in the 2006 report were based on a discrete choice experiment based on Guam. ERG updated these estimates based on the purchasing power parity between these locations and updated household numbers.	Low: $38.00 [d] High: $98.00 [d]	14,282 per household [e]	$0.24	$1.34	$6.07	$33.43
Recreation—all	Londoño and Johnston (2012) The study compiled and standardized data from multiple coral reef valuation studies and applied regression-based meta-analysis to relate estimated values to site and study characteristics. In this application, the dataset was restricted to natural reef systems and excluded East African studies to improve consistency in underlying ecological and socioeconomic conditions.	$42.74 per person-day of activity	107,367 reef-related trips [f]	N/A	$4.59	N/A	$114.64

N/A: Not applicable.
Note: Source of local CPI data: CNMI Department of Commerce (n.d.-a).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] CNMI's coral reefs cover 40,031 acres. Source: U.S. Coral Reef Task Force. (n.d.-b).
[d] To calculate low and high values, the project team multiplied each value by the lower and upper bounds in the ERG (2019) study of the percent of households deriving cultural values from coral reef fishing (45% and 100%, respectively).
[e] Source for CNMI households: U.S. Census Bureau. (n.d.-b).
[f] Reef-related trips are based on data from the CNMI Department of Commerce (n.d.-c) on a 10-year average of annual trips (2014–2025), excluding 2024 due to lack of data, and a Spalding et al. (2017) estimate that 32.95% of trips in CNMI are reef related.

CNMI Economic Impact Range

Table 37 presents a summary of economic impacts for CNMI. Impact estimates include a coastal protection value of $8.85 million per year (Storlazzi et al. 2019), commercial fishing values of $0.05 million to $0.09 million per year (WPRFMC 2021b; WPRFMC 2024c), a research value of $0.94 million per year (FEMA, 2022), and several recreational values. The project team assumes estimates from Van Beukering et al. (2006) for diving and snorkeling ($1.48 million to $6.18 million per year) are included in analyses from Bartelet et al. (2024) and Spalding et al. (2017). The lower bound estimate consists of the commercial fishing value and Bartelet et al.'s (2024) recreation value. The upper bound consists of the coastal protection, upper commercial fishing value, research, and Spalding et al.'s (2017) recreation value. These values result in a range of $34.37 million to $73.00 million per year in economic impacts.

Table 37. Summary of Annual CNMI Impact Estimates (in 2024 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Coastal Protection	Storlazzi et al. (2019) The estimate from Storlazzi at al. represents the expected annual avoided losses in economic activity due to flooding damages. This estimate was calculated using a risk-based valuation framework that combines physics-based hydrodynamic modeling of wave-driven flooding (with and without coral reefs present), FEMA Hazus depth-damage functions applied to census-block-level building stock, and GDP-based estimates of economic activity disruption from displaced residents and businesses. Building and population exposure data reflect 2010 U.S. Census and Hazus inventories.	N/A	N/A	N/A	$8.85	N/A	$221.15
Commercial Fishery	**Low**: WPRFMC (2024c) **High**: WPRFMC (2021b) Based on revenue for the top 10 reef fish species, applying a value-added ratio of 0.60 (Grafeld et al., 2017).	N/A	N/A	$0.05	$0.09	$1.35	$2.13
Recreation - Diving/Snorkeling	Van Beukering et al. (2006) Van Beukering et al. conducted a household survey of 375 CNMI residents to determine local diving participation and a business survey of dive companies to establish market pricing. The household sample included every village on Saipan to ensure broad geographical representation, with a specific focus on seaside communities. Within neighborhoods, streets were randomly selected. For every selected street, interviewers approached every third house. Secondary data included tourist exit surveys (n=272) targeting international visitors (specifically random, Korean, and Japanese tourist samples) to gauge activity participation rates. Additionally, the project team used site-specific visitor data from the Marianas Visitors Authority and Tassi Tours for locations such as Laolao Bay, Managaha Island, Bird Island, and the Grotto for a "bottom-up" estimation of diving and snorkeling frequency. The project team updated visitor totals. The lower bound is based on CNMI Department of Commerce (n.d.-c) 2022 figures, while the upper bound is based on the 10-year average of pre-pandemic visits (2009–2019), also using CNMI Department of Commerce (n.d.-c) data. The percent of visitors participating in diving and snorkeling (13.3%), the cost per activity, and the cost price factor (0.4) are	N/A	N/A	$1.48	$6.18	$36.94	$154.33

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
	assumed to be the same today as they were during the original study.						
Research	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	FEMA: $23.37 per acre	40,031 acres [c]	N/A	$0.94	N/A	$23.37
Tourism (Reef Associated)	**Low:** Bartlett et al. (2024) Using data from Spalding et al. (2017), the value-added contribution of coral reefs to the economy can be estimated by subtracting the cost of intermediate inputs from the market revenue produced by the coral reefs (in this case, expenditures by tourists and landed values of reef fish). **High:** Spalding et al. (2017) Spalding et al. estimated the values of on-reef tourism. The reef-adjacent value can be combined with a value for on-reef recreation from another source. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study.	N/A	N/A	$34.32	$63.12	$857.29	$1,576.87

N/A: Not applicable.

Note: Source of local CPI data: CNMI Department of Commerce (n.d.-a).

[a] The rates listed here represent rates from the studies themselves and have been updated to USD 2024. 2025 CPI data is not available for CNMI.

[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.

[c] CNMI's coral reefs cover 40,031 acres. Source: U.S. Coral Reef Task Force. (n.d.-b).

Non-Monetary Results

Table 38 presents selected non-monetary indicators for CNMI. Sources for each indicator are in parentheses following the indicator.

Table 38. Selected Non-Monetary Indicators for CNMI

Ecosystem Service	Indicator
Security	Coral reefs protect 197 children from flooding in CNMI. *(Storlazzi et al., 2019)*
Stewardship	13.9% of CNMI residents have participated in coral reef restoration. *(Allen et al., 2025)*
Cultural heritage	43.8% of survey respondents who said they primarily target reef fish considered themselves cultural fishers. *(Hospital and Beavers, 2014)*
Subsistence	23% of survey respondents considered reef fishing an important source of food for their family. *(Van Beukering et al., 2006)*
Stewardship	The Mariana Islands Nature Alliance supported six employees and engaged with 20 volunteers in 2023. *(Mariana Islands Nature Alliance, 2023)*

The project team did not pursue interviews in CNMI due to direction from the NOAA liaison and jurisdictional stakeholders during the CNMI workshop.

Flower Garden Banks National Marine Sanctuary

Situated roughly 100 miles off the coasts of Texas and Louisiana, FGBNMS is home to over 102,000 acres of coral reef, including shallow-water corals, algal-sponge communities, and mesophotic reefs (NOAA, n.d.-a; NOAA, 2021).

Ecosystem services in FGBNMS are closely linked to commercial and recreational fisheries, research, and recreational diving. Although documentation of these ecosystem services is limited, the estimates in Table 39 reflect the services' associated economic activity and benefits. The dollar values for FGBNMS economic impacts are low for a few reasons. First, the sanctuary is at least several hours by boat from the coast, and is fully submerged, limiting access for users and researchers alike. Second, very little research has been published on economic valuation after the 2021 expansion of the sanctuary. Thus, ecosystem service values most certainly underestimate the current use and non-use values that can be associated with FGBNMS. However, the value of FGBNMS as a hub of biodiversity within the larger Gulf of Mexico ecosystem cannot be understated, with benefits ranging from $6,473.47 million to $19,790.33 million per year (Stefanski & Shimshack, 2016). Due to the remoteness and uniqueness of this jurisdiction, FGBNMS's coral reefs are also important because of their value to the research community as a place where young researchers can cement their careers as accomplished coral reef scholars.

Monetary Results

Table 39 presents a summary of economic benefits for CNMI.

Table 39. Summary of Annual FGBNMS Economic Benefit Estimates (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Biodiversity	Stefanski & Shimshack (2016) WTP study focused on how much people would be willing to pay for management of FGBNMS to achieve biodiversity criteria. The sample (n=1,526) for this study consisted of a nationally representative general population panel of U.S. residents. Roughly 19% of the sample resided in Gulf states, but the study purposefully included a broad national audience to inform the national marine policy debate without restricting analysis only to local residents or visitors.	Low WTP: $50.09 High WTP: $153.14	U.S. households: 129,227,496 [d]	$6,473.47	$19,790.33	$63,059.84	$192,782.94
Biodiversity	FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies.	$2,639.99 per acre	102,656 acres [c]	N/A	$271.01	N/A	$2,639.99
Recreation—natural reefs	Oh et al. (2008) Estimates based on the WTP for natural and artificial reefs based on randomly offered bid values between $15 and $400 (in 1997 USD) that represented a hypothetical increase in per-trip cost. The sample for this study consisted of scuba divers who used natural and artificial reef habitats in Texas offshore waters. To reach this population, researchers conducted an inventory of dive charter boat operators to obtain customer contact information. The researchers initially aimed for a balanced sample of 1,200 divers. For the natural reef group, 600 contacts were randomly selected from records of the single operator providing trips to FGBNMS. For the artificial reef group, another 600 contacts were selected in proportion to dive trips by region. Ultimately, 1,059 divers were sampled, including 614 who used FGBNMS and 445 who used artificial reefs, with the latter group being under-sampled due	$343.00 per trip	Low estimated annual trips: 60.0 High estimated annual trips: 445 [e]	$0.02	$0.21	$0.20	$2.05

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
	to limited cooperation from boat operators in certain regions.						
Recreation—artificial reefs	Oh et al. (2008) Estimates based on WTP for natural and artificial reefs based on randomly offered bid values between $15 and $400 (in 2007 USD) that represented a hypothetical increase in per-trip cost. The sample for this study consisted of scuba divers who used natural and artificial reef habitats in Texas offshore waters. To reach this population, researchers conducted an inventory of dive charter boat operators to obtain customer contact information. The researchers initially aimed for a balanced sample of 1,200 divers. For the natural reef group, 600 contacts were randomly selected from records of the single operator providing trips to FGBNMS. For the artificial reef group, another 600 contacts were selected in proportion to dive trips by region. Ultimately, 1,059 divers were sampled, including 614 who used FGBNMS and 445 who used artificial reefs, with the latter group being under-sampled due to limited cooperation from boat operators in certain regions.	$202.59 per trip	Low estimated annual trips: 60.0 High estimated annual trips: 445 [e]	$0.01	$0.09	$0.12	$0.88

N/A: Not applicable.
Note: Source of U.S. CPI: U.S. Bureau of Labor Statistics. (n.d.).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] FGBNMS's coral reefs cover 102,656 acres. Source: NOAA (2021).
[d] Source for U.S. households: U.S. Census Bureau. (n.d.-d).
[e] Based on estimates from FGBNMS staff.

FGBNMS Economic Impact Range

Table 40 presents economic impact values for FGBNMS. These values are unlikely to overlap with each other given their distinct samples (Leeworthy et al., 2020) and services (i.e., research versus fishing). Summing these values provides an annual economic impact range of $2.81 million to $7.20 million per year.

Table 40. Summary of Annual FGBNMS Economic Impact Estimates (in 2025 USD)

Ecosystem Service	Study	Study Rate (value per unit) [a]	Units [b]	Low Total Value (in millions of USD)	High Total Value (in millions of USD)	Low Per-Acre Value	High Per-Acre Value
Commercial Fishing	Leeworthy et al. (2020) The study surveyed commercial fishing operations (n=6) that actively use FGBNMS, initially identified from a list of 76 vessels (with approximately 40 owners) and refined through screening and operator referrals.	N/A	N/A	N/A	$2.00	N/A	$19.46
Recreational Fishing	Leeworthy et al. (2020) The study surveyed for-hire recreational fishing operations (n=8) with access to FGBNMS, identified through telephone directories, operator referrals, and other sources. The sample was almost inclusive of every for-hire recreational fishing vessel operating in the (Northern Gulf of Mexico.	N/A	N/A	N/A	$2.28	N/A	$22.19
Research Value	Low: FEMA (2022) FEMA's estimate is based on Brander and Van Beukering's (2013) meta-analysis of U.S. coral reef ecosystem service studies. " High: Angadi et al. (2026) The sample (n=18) for this study was drawn from a list of 62 researchers identified through a combination of site-provided records and a literature review of peer-reviewed studies conducted in FGBNMS. All identified researchers were invited via email to participate in the survey, resulting in 26 responses. After excluding ineligible respondents (e.g., non–principal investigators, projects outside the study period), 18 usable responses remained. Respondents provided details about their research project expenditures.	Low: $27.33 per acre	102,656 acres [c]	$2.81	$2.92	$27.33	$28.41

N/A: Not applicable.
Note: Source of U.S. CPI: U.S. Bureau of Labor Statistics. (n.d.).
[a] The rates listed here represent rates from the studies themselves and have been updated to 2025 USD.
[b] Units may include units from the studies, but in many cases the project team updated units based on current visitation/reef use.
[c] FGBNMS's coral reefs cover 102,656 acres. Source: NOAA (2021).

Non-Monetary Results

Table 41 presents selected non-monetary indicators for FGBNMS. Sources for each indicator are in parentheses following the indicator.

Table 41. Selected Non-Monetary Indicators for FGBNMS

Ecosystem Service(s)	Indicator
Recreation, non-commercial fishing	362 person-days of hook and line fishing in FGBNMS in 2013. (NOAA, 2020)
Recreation, non-commercial fishing	From 2006–2008, 10,237 anglers fished on three seamounts in FGBNMS. (Levesque & Richardson, 2011)
Recreation, non-commercial fishing	There are 34 total jobs in for-hire fishing operations: 12 full time, 9 part time, and 13 seasonal. (Leeworthy et al., 2020)
Identity, social cohesion	"There are people who do work at the Flower Gardens… That is definitely a community in and of itself. A subset of a subset of a subset… It's why I've been able to make as many professional and personal relationships because of the Flower Gardens… it's part of a community-building experience." (FGBNMS Interviewee #3)
Identity, learning/education	"As a student, getting to participate in research and join [researchers] for work is a catalyst for them. It serves as a benchmark for future job interviews, success in their career, new endeavors, and opportunities. It has the potential to become an incredibly important piece of their identity." (FGBNMS Interviewee #2)

According to interviewees, most people are unaware of the coral reefs in FGBNMS. However, a dedicated community of researchers, tourism operators, and divers views these reefs as intensely valuable. For the research community, the sense of ownership and responsibility over the reefs is very strong, and for diving students, an opportunity to dive at FGBNMS can be a career-defining experience with a lifelong impact. The reefs serve as a unique educational tool, bringing concepts like marine habitat connectivity into perspective.

Figure 17 summarizes the non-monetary token exercise outcomes for the FBGBNMS.

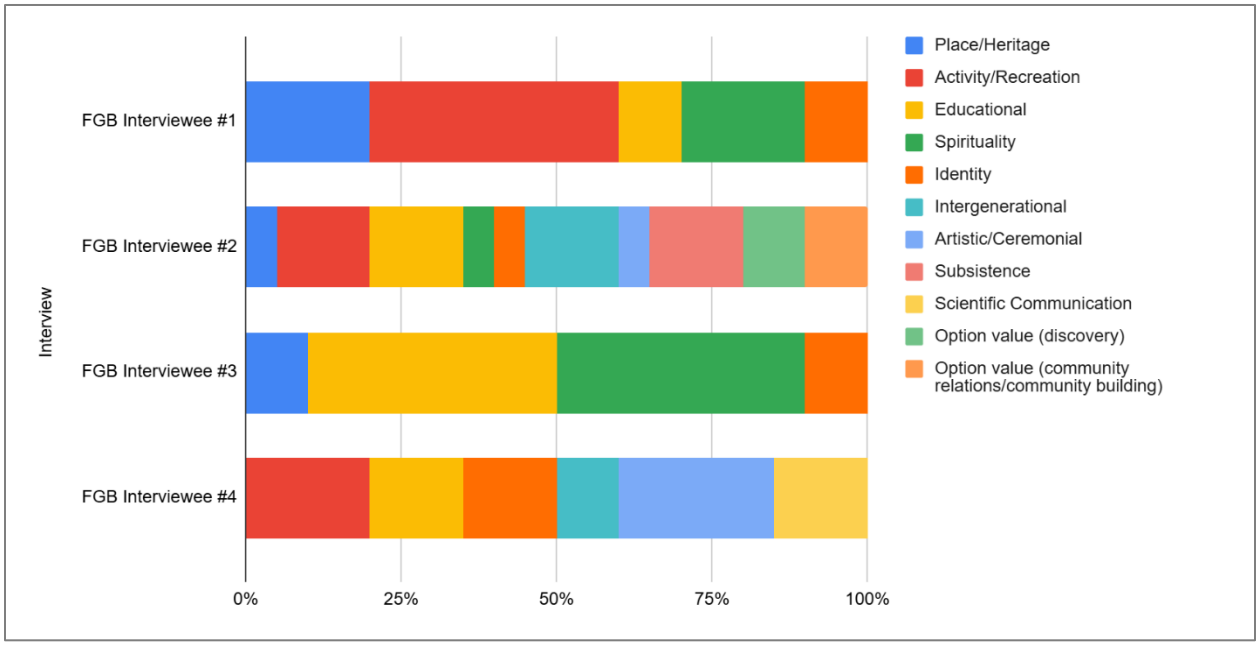

Figure 17. Non-monetary token exercise outcomes for FGBNMS

IV. Limitations

Monetary estimate limitations include the following:

- This analysis relies in part on a body of coral reef nonmarket valuation (different from non-monetary valuation) studies that exhibit well-documented methodological limitations, which constrain the reliability and comparability of results. Many legacy studies employ convenience or on-site sampling, poorly defined ecological baselines, and stated preference instruments that do not consistently pass validity tests (e.g., scope sensitivity). Travel cost models often struggle to account for multi-destination trips and non-use values. These issues introduce potential bias and limit the defensibility of transferring or aggregating values across contexts, meaning results should be interpreted as indicative rather than precise estimates of economic value.

- A benefit-transfer approach is limited to ecosystem services that have been evaluated in past studies. The project team's estimates are limited by available reliable studies. The team can only provide estimates in cases where the literature has provided a valid, reliable, and defensible value.

- Benefit transfer is, by definition, an inexact method to employ, even if all known variables are consistent from study site to policy site. As indicated in "A Primer on Nonmarket Valuation" (Rosenberger & Loomis, 2017), the median error absolute percentage transfer error of value transfers is 45%.

- Adding values across the ecosystem services may result in double counting. Due to the benefit-transfer approach, it is not clear when two (or more) studies are generating values that include overlapping elements. Nevertheless, the project team has provided ranges of total economic impact values based on summing subsets of values where double counting is least likely and then providing an indication of how the remaining values relate to this range.

- Reef quality was not a variable in producing ecosystem service estimates. The ecological quality of coral reefs around the world has suffered in recent years (Hughes et al., 2017). While this effort did consider coral reef threat events since the included studies publication dates to assess the defensibility of a study, the catalog of threat events was likely incomplete. Additionally, the scoring process did not include reef restoration events or recovery periods, which both lead to improved reef quality. The ecosystem service estimates may be high due to the lack of a mechanism for factoring in reef quality as a component of providing ecosystem services.

- Matching rates to units is difficult. In cases where the project team had a rate from a study (i.e., value per unit), the team had to identify a relevant number of units to multiply by the rate, which would generate a total value. In most cases, this involved making some simplifying assumptions and performing a series of calculations. For example, taking a 2010 study that estimates willingness to pay (i.e., value) per trip (i.e., unit) for snorkeling trips in Guam and applying that study to CNMI to fill a gap is a reasonable point value transfer to make given their geographic proximity and similar economies. However, this transfer may have to adjust the total value based on the number of snorkeling trips in CNMI. It may be that the years with snorkeling trip data are very different (e.g., the rate used in the Guam study was from 2010 and the latest comparable CNMI data are from 2023), thus representing a different time period for the snorkeling industry in general and on each island, which could translate to different snorkeling experiences overall.

Although the project team adjusted for inflation, results on willingness to pay are grounded in the experience of snorkelers over a decade and a half ago. The project team assumes these snorkeling experiences are comparable, but spatial *and* temporal differences are potential sources of error here. Each time the project team makes an assumption or requires a calculation to generate a unit, the team runs the risk of adding in some level of error to the estimates.

Non-monetary estimate limitations include the following:

- The non-monetary estimates included in this assessment likely reflect a small subset of the ecosystem service values that could be included in this project. The project team had minimal capacity to pull from sources beyond the academic literature, gray literature, and interviews, and many types of information remain excluded. For example, analyses of photographs, poetry, or news media would yield many expressions of value associated with coral reefs. Crafting approaches to systematically include these information types would require expert guidance, and only then could data collection commence. Capacity was the biggest limitation for many document- or artifact-based expressions of non-monetary ecosystem service value.

- The lack of standardized methods for non-monetary valuation meant the project team was developing procedures for collecting non-monetary data and categorizing different values at the same time data were being collected. The IPBES publication that ultimately guided the organization of the Non-Monetary Ecosystem Service Indicators Database was only published in 2022, after the project had begun engaging with non-monetary valuation. The project team designed the categories presented this assessment, and they may not represent the best system. Additionally, different jurisdictions may prefer different organization schemes for their non-monetary coral reef ecosystem service data.

- Interviews were limited by the Paperwork Reduction Act to nine per jurisdiction. While this limitation would have prevented representative sampling to begin with, the interview effort was limited by overall low engagement with interview requests. The project team conducted interview sampling via recommendations from NOAA liaisons, reached out via email, and followed up through several points of contact. The low number of initial recommendations and subsequent responses kept each jurisdiction's interview count below the nine-interview limit.

V. Recommendations

Potential Policy Applications for Non-Monetary Values

While monetized valuations of ecosystem services are easy to incorporate into current decision-making frameworks like benefit-cost analyses, these frameworks do not always include non-monetary values. This section demonstrates how non-monetary ecosystem services could be incorporated into existing decision support tools without forcing them into uncertain or non-credible monetary estimates. Rather than treating non-monetary values as ancillary or "unquantifiable," the approaches illustrated here make those values decision-relevant by clarifying the conditions under which they would influence outcomes.

The examples below apply two complementary frameworks—threshold (or break-even) analysis and service-to-service equivalency methods—to illustrate how cultural and ecological criteria can be considered within decision processes.

Threshold Analysis

Threshold—or break-even—analysis provides a structured way to evaluate non-monetary benefits or costs that cannot be readily expressed in dollar terms. In most threshold analysis applications, the costs are higher than the known benefits.

Instead of attempting a full monetization, the method asks a different question: How large would the unquantified non-monetary benefit values need to be in order to nullify an imbalance between the costs and benefits?

This reframing turns ambiguity into something concrete and analytically useful by mapping non-monetized ecosystem service values onto a monetized decision-making approach. This approach is not about assigning a dollar value to non-monetized benefits, nor is it a work around of willingness to pay. Rather than obscuring non-monetary values, threshold analysis aims to facilitate a conversation with more information and incorporate non-monetized benefits into an existing decision support framework. This can allow decision-makers to make judgements based on context and institutional priorities.

Habitat and Resource Equivalency Analysis

Habitat equivalency analysis (HEA) and resource equivalency analysis (REA) are service-to-service scaling methods used to determine how much ecological restoration is required to compensate for injuries to natural resources. These methods are commonly applied when habitat quality declines due to discrete events or chronic pressures that reduce the services ecosystems provide.

Rather than monetizing losses, HEA and REA translate both injuries and restoration gains into a common unit: the discounted service-acre-year (DSAY). A DSAY represents the value of all ecosystem services provided by one acre of habitat for one year, discounted over time. This unit bundles biological, ecological, and non-monetary services into a single accounting framework that allows losses and gains to be compared directly.

Crucially, these methods do not require services to be expressed in monetary terms. DSAYs can be derived from ecological indicators such as organism abundance, habitat structure, or productivity, and the

framework can be extended to incorporate qualitative or non-monetary service categories where appropriate.

General HEA/REA Implementation Steps

See the basic overview of the HEA/REA process below (NOAA, 1995).

1. Document the injury.
    - Estimate the spatial extent, severity, and duration of service loss.
    - Define recovery trajectories and baseline conditions.
2. Estimate restoration gains.
    - Quantify the ecological services produced by compensatory actions over time.
    - Account for lags in performance and discount future services.
3. Scale restoration to losses.
    - Size the compensatory project so discounted service gains equal discounted service losses.
4. Define costs or performance standards
    - Either estimate the cost of achieving equivalency or specify ecological and functional benchmarks restoration must meet.

Scenario: Disease-Driven Reef Degradation and Cultural Equivalency

Consider a coral reef that has experienced substantial ecological decline due to disease and thermal stress. Measurements of structural complexity and reef height indicate reduced capacity to provide coastal protection, biodiversity support, and recreational services. The reef was once a popular site for novice users and nearshore recreation, but visitation has declined as conditions have deteriorated.

Hypothetical Threshold Analysis Application

To apply non-monetary values within a threshold analysis, a ledger of the monetized costs and benefits is necessary to understand how to use non-monetary benefits when there is a gap between costs and measured (i.e., monetary) benefits. In the case of coral restoration, consider the following hypothetical example:

- Assume that one of the jurisdictions in this project has an annual total economic impact value of $5,000 per acre and a TPV of $101,747 per acre.[13]
- A recent global scale systematic review of costs associated with coral reef restoration found that median costs for coral gardening—a process of raising corals in a nursery and then planting them within an existing coral reef to improve coral cover and ecological functioning—was $213,469 per acre (Bayraktarov et al., 2019).
- Considering the long-term benefits (conceptualized as economic impacts over 30 years) and the one-time cost of restoring a 10-acre reef back to a level of full ecosystem service functioning leaves a difference of $1,117,216 ($111,722 per acre).

[13] Following OMB Circular A-94 (2003), the analysis applies a risk-adjusted social DR of 3.1% over 30 years. Specifically, a 2.0% risk-free DR is adjusted upwards to incorporate a default risk premium of 1.1%.

The goal of threshold analysis is to compare the non-monetized benefits to the difference between costs and monetized benefits. For example, if we assumed the restored reef would support an additional 1,000 fishing trips per year (30,000 over 10 years), then each trip would need to be valued at $37.24 (in present value terms) to offset the estimated difference between costs and monetized benefits.

Furthermore, fishing may be only one possible reef use. The restored reef may also support additional snorkeling and diving activities. Adding in those additional activities to the number of "trips" further reduces the per-trip value needed to offset the shortfall. However, evaluating multiple types of activities requires considering that different activities have different values. Finally, coral reefs provide services that are much more difficult to measure with monetary values such as intergenerational knowledge transfer, well-being, and spiritual value. Threshold analysis is meant to compare the total of the difference between costs and monetized benefits to the non-monetized benefits that would also occur.

Hypothetical HEA Application

Under an HEA framework, restoration planning would quantify the ecological service losses from the onset of degradation through recovery or stabilization at a new baseline. Compensatory actions—such as coral propagation, structural enhancement, or targeted disease intervention—would be evaluated based on the DSAYs they generate over time.

However, the reef also supports cultural and experiential values that are not fully captured by biophysical metrics alone. These values include intergenerational use, skill-building for novice users, and a shared sense of place. A complementary "cultural equivalency" layer can document these services through a non-monetary service ledger that informs restoration design.

The cultural equivalency layer may include:

- Qualitative service targets tied to reef use and experience.
- Explicit recognition that cultural services must be restored to previously recorded levels, or at minimum to a non-zero level if only qualitative evidence of non-monetary value exists.
- Performance standards aligned with access, safety, and experiential quality.

Framed this way, reef restoration seeks to make the system whole not only ecologically, but also socially and culturally.

Future Valuation Efforts

Lessons Learned

A one-size-fits-all approach to coral reef ecosystem service values is insufficient for U.S. jurisdictions. Coral reef ecosystems support communities in fundamentally different ways across U.S. jurisdictions, reflecting variation in geography, culture, and economic reliance on reef-related activities. For example, values associated with coral reefs in the Pacific are shaped by more recent historical relationships than their Atlantic/Caribbean counterparts. Applying a uniform valuation approach risks obscuring these differences and producing results that are poorly aligned with local decision-making needs. Specific jurisdictional contexts also need to be balanced with appropriate application of national-scale ecosystem services for explicitly national-scale interests, such as in National Marine Sanctuaries like the FGBNMS.

Monetary values cannot fully capture the worth of coral reefs. While monetary ecosystem service valuation can estimate certain reef impacts and benefits—such as tourism revenue or avoided storm damages—many dimensions of coral reef value cannot be understood using the monetary toolkit. Cultural identity, intergenerational knowledge, and spiritual connections to places are often central to how communities understand coral reefs, yet these values are difficult if not inappropriate to express in dollar terms without loss of meaning. Relying solely on monetary metrics can therefore underrepresent the full contribution of coral reefs to human well-being.

Non-monetary valuation can enrich ecosystem service valuation efforts, but the capacity of the research effort must match the context. Non-monetary approaches—including qualitative indicators, interviews, and threshold or equivalency analyses—offer a systematic wat to account for values that cannot be monetized. However, these methods require time, expertise, and sustained engagement, and they may not be appropriate or feasible for every ecosystem service valuation effort. Selecting valuation approaches that align with available resources, capacity, and decision timelines is essential to producing credible and usable results.

Engaging stakeholders in a more place-based and on-the-ground manner would improve trust and result in more examples of culturally relevant ecosystem service values. Meaningful stakeholder engagement grounded in local contexts can strengthen both the legitimacy and relevance of ecosystem service assessments. Directly interacting with community members, practitioners, and cultural leaders helps highlight locally specific values and narratives that are often missed in remote analyses. Such engagement not only improves trust in the valuation process, it also generates richer, more actionable examples of how coral reefs matter to people in place.

Building on This Work

The lessons learned from this assessment can inform future assessments in critical ways. Planning for a plural valuation approach and the capacity needed to engage stakeholders can address many of the challenges encountered over the duration of this project.

Collaborative and Deliberative Interactions

Overall, an emphasis on improved engagement should guide future work, and a key component of improved engagement involves performing this work in-person. The project team often heard “You should be here” from stakeholders during online workshops and interviews. When possible, in-person interactions to conduct workshops and interviews would not only improve the quality of those experiences and data, it could also foster a more transparent and trust-based relationship between stakeholders and the project team, including NOAA.

Working with trusted local partners can go a long way with establishing relationships and building trust between stakeholders and the project team. Local partners can be especially important when project team members are unable to attend engagement events in person. The project team recommends continuing to use local facilitators and liaisons to vet engagement approaches, help recruit participants, and facilitate engagement efforts.

Any future effort would also need to pursue and expand stakeholder interviews to learn about coral reef ecosystem services from individuals who presently or historically have had personal, working, or cultural relationships with coral reefs. Interviews provide a way to gather information that is often beyond the reach of desk-researchers, and they act as a trust building exercise between parties.

Future work should also consider the importance of data governance. The project team recommends establishing community data governance agreements before any data collection, applying CARE-constrained (Collective Benefit, Authority to Control, Responsibility, Ethics) FAIR (Findable, Accessible, Interoperable, Reusable) (Gudde et al.., 2026) to community-specific qualitative data (e.g., limiting data accessibility to conditions set by community consent), and including Indigenous data sovereignty practitioners as co-investigators from the design stage, not as liaisons engaged after the data governance methodology is set.

A collaborative and deliberative orientation to future work would be critical not only for including the best information in an assessment, but also maintaining relationships with communities that engage coral reef resources in general. Any efforts to engage local stakeholders should leverage the expertise of social scientists across NOAA line offices and at partner institutions to ensure the parameters for engagements are appropriately scoped and reviewed.

Encourage local governments in U.S. jurisdictions to systematically and consistently collect visitation data for both commercial and nonmarket reef-related activities (e.g., snorkeling, reef-specific fishing) that are often missing from existing datasets, or that are ambiguous in their connection to coral reefs. This effort would include tracking not only participation but also the duration and frequency of visits, which are essential inputs for robust monetary valuation. Pairing these data with site-specific value estimates would improve the accuracy of total economic value calculations. Expanding data collection in this way would also support more comprehensive assessments of ecosystem use and serve to clearly connect non-monetary data to monetary estimates.

Ecosystem Service Valuation Sources and Data

This effort heavily relied on existing primary data collection and valuation studies. **Encouraging partners to undertake more primary data collection efforts to fill data gaps and update older studies will ensure a future valuation effort has a robust and up-to-date set of source data.** Below are several key considerations for primary research on coral reef ecosystem services:

- Future studies should address well-documented quality limitations in coral reef nonmarket valuation by adopting representative sampling strategies, clearly defined ecological baselines, validated survey instruments, and improved handling of multi-destination travel behavior. These actions will increase the credibility, comparability, and policy utility of valuation estimates.
- Future research should address the temporal limitations of existing primary valuations by explicitly accounting for changes in coral reef ecological conditions and social contexts between the time of study and present day. This research would include documenting baseline conditions, assigning updated condition indicators, and using non-monetary measures—such as ecological status, access, and cultural use—as validity checks on the continued credibility of monetary estimates. Incorporating simple scenario-based analyses to estimate how the monetary estimates might respond to different trajectories of reef degradation or recovery would further strengthen the defensibility and policy relevance of valuation results.
- While this assessment included assigning assumed beneficiaries to ecosystem service values, future research could standardize categories and methods with the aim of conducting distributional analysis to identify who benefits from ecosystem services and who bears the costs of degradation and conservation actions. Tasks could include distinguishing between local and non-resident beneficiaries, differentiating between reef users who are active (e.g., divers) and passive (e.g., coastal property owners), and assessing how benefits and burdens are distributed across communities.

On the non-monetary side, collecting and organizing metrics and qualitative data associated with coral reef use and perceptions is more difficult. Federal agencies and academic researchers can improve reporting mechanisms to collate quantitative information across agencies and locations. Future ecosystem service assessments could also benefit from alignment with priorities set by local partners and stakeholders through additional outreach driven by the collaborative and deliberative actions described above. Key considerations of non-monetary research on coral reef ecosystem services include:

- Future research should develop and standardize a core set of reporting metrics for non-monetary valuation studies to improve their interpretability and transferability across contexts. These metrics should include sample characteristics (e.g., size, representativeness, relevance to the resource), as well as contextual factors such as stakeholder–resource relationships, levels of trust, and community embeddedness. Establishing such criteria would make it easier to consistently compare metrics across studies and support the responsible application of findings in different settings.
- Future research could build on this work and further standardize a set of higher-level conceptual categories for non-monetary values—such as "culturally important species," "food systems," and "heritage practices"—that can be consistently applied across jurisdictions. While locally specific indicators may vary, aligning them under shared concepts would enable comparison across contexts without losing place-based meaning.

Enhancing the Usability of Findings

Much of this project has involved attempting to give equal weight to both monetary and non-monetary indicators of coral reef ecosystem service values. At times, these approaches have been treated in parallel, and at other times partially synthesized. While challenging, this work has produced a substantial body of baseline data across jurisdictions for both monetary and non-monetary indicators. A next step could include integrating these datasets within a relational database structure that links, rather than forces equivalence between, distinct value types. For example, each valuation output could be assigned a unique identifier and connected through shared keys such as location, ecosystem service category, and use type—allowing monetary estimates (e.g., recreation value) to be explicitly tied to supporting non-monetary data such as visitation patterns or reported user experiences.

This structure would also allow qualitative indicators—such as perceptions of reef degradation linked to tourism—to be systematically associated with corresponding monetary estimates within the same jurisdiction and service category. By preserving the distinct nature of each data type while enabling structured relationships between them, a relational database would clarify how monetary and non-monetary values interact and co-produce overall value. Importantly, such a database could provide a mechanism for critically assessing if monetary estimates are valid and applicable to context specific decision making.

Future coral reef ecosystem service valuation efforts should explicitly align results with established wealth accounting frameworks, such as the System of Environmental-Economic Accounting—Ecosystem Accounting (United Nations, n.d.) and Hawai'i's Genuine Progress Indicator (State of Hawai'i, Department of Business, Economic Development & Tourism, n.d.)**.** Rather than producing a standalone valuation snapshot, future work should be designed to contribute to ongoing, policy-relevant accounting of reef assets over time, including developing stock-and-flow accounts, condition-adjusted asset values, and supply–use relationships. The project's existing non-monetary indicators provide a strong foundation for

this type of wealth accounting, and they can serve as an entry point for integration. Strengthening these connections would significantly enhance the policy utility, interoperability, and long-term relevance of the project's outputs.

Future research could integrate non-monetary coral reef ecosystem service indicators into the NOAA National Coral Reef Monitoring Program socioeconomic monitoring component (NOAA, n.d.-c) to leverage its existing framework for tracking reef use, perceptions, and community impacts over time. The National Coral Reef Monitoring Program already provides a consistent, long-term system for collecting comparable socioeconomic data across NOAA jurisdictions, making it a natural fit for aligning non-monetary values with existing indicators. Doing so would improve cross-site comparability and the policy relevance of non-monetary valuation efforts.

Monetary and non-monetary ecosystem service values can be more effectively incorporated into decision-making frameworks. To maximize the usefulness and policy relevance of these efforts, future valuation work should be explicitly tailored to its intended application, with a clear articulation of who will use the results and how they will be applied in decision-making contexts. Embedding this clarity in the statement of purpose and project objectives will enable project teams to select appropriate valuation approaches and produce more actionable and decision-relevant characterizations of ecosystem service value.

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Data Availability

The data that support the findings of this project were derived from previous studies listed in the references. Databases, prior reports, and other project materials are available upon reasonable request.

Appendix A. Non-Monetary Database Methods

The Non-Monetary Ecosystem Service Indicators Database includes quantitative and qualitative indicators collected from the academic and gray literature, online oral histories, interviews, and nonprofit Form 990 documents—a reporting mechanism whereby nonprofits fill out how many employees and volunteers they support annually.

Four review and meta-analysis articles served as the basis for the project team's initial non-monetary cultural ecosystem services literature review: Gould et al. (2019), Martin et al. (2016), Cheng et al. (2019), and Pratson et al. (2023).

The project team included additional sources via the following search criteria in Web of Science:

> (ALL=((“coastal and marine ecosystems” OR "coral reef*" OR "coastal and marine") AND (“intangible values” OR "relational values" OR "nonmaterial values" OR "non-economic values” OR “non-monetary values” OR “immaterial values” OR “non-material values” OR “social values” OR “cultural values” OR “cultural ecosystem service*” OR “spiritual values” OR “cultural identity” OR “community values” OR “ancestral values" OR “aesthetic values” OR “artistic values” OR “mental health” OR "community identity" OR "sense of place" OR "mental health")))

The Non-Monetary Ecosystem Service Indicators Database evolved from the initial non-monetary cultural ecosystem services literature review. The project team organized indicators based on jurisdiction, year of publication, region, and data type (e.g., number of people, percent of catch). The project team also coded each indicator into use versus non-use, extractive versus non-extractive, ecosystem service, IPBES valuation family, and IPBES-specific value, as shown in Table 3 and Table 4 in the Non-Monetary Valuation Methods section.