

Comprehensive Report

Ecosystem Services Valuation of Guam and Florida Coral Reefs

NOAA National Ocean Service Office for Coastal Management

April 14, 2023

Ocean Associates, Incorporated

Eastern Research Group, Inc.



Written under contract for the

NOAA Office for Coastal Management

www.coast.noaa.gov



Eastern Research Group, Inc. (ERG)

Learn more at www.erg.com



Ocean Associates, Incorporated (OAI)

Learn more at www.oceanassoc.com

Acknowledgements: NOAA's Office for Coastal Management would like to thank the following people who collaborated on this project. **NOAA project team:** Jennifer Koss, Harriet Nash, Kate Quigley, Mary Allen, Lauren Knapp, Polina Dineva. **Contracting Team:** Charles Goodhue (ERG), Lou Nadeau (ERG), Hannah Stroud (ERG), Nathan Smith (OAI), Nejem Raheem (Emerson College), Rachelle Gould (University of Vermont), John Loomis (Colorado State University).

Table of Contents

Executive Summary	3
Purpose.....	3
Methods	3
Findings.....	3
Recommendations.....	4
I. Purpose and Background	5
Overall Project Purpose.....	5
Purpose of Deliverable	5
Background.....	5
Ecosystem Services of Coral Reefs	6
Economic Benefits and Impacts	7
Sensitivities of Ecosystem Services Valuation	8
II. Approach to Performing Work	8
Valuation Literature Review	8
Jurisdictional and Socioeconomic Workshops	9
Benefits Transfer	11
Cultural Literature Review and Analysis (Non-monetized values)	13
III. Results	15
Monetary Benefit Estimates.....	15
Table of values	15
Limitations	21
Ranges for Total Value - Guam	21
Ranges for Total Values - Florida	22
Monetary Economic Impact Estimates.....	22
Non-monetary Values	23
Guam.....	24
Florida	26
Methods Menu	29
IV. Synthesis of Results	30
Guam	30
Florida.....	31
V. Recommendations	32
Interviews	32
Primary studies / survey to improve data (both cultural and data to support monetization)	33
Visualizations.....	33
VI. References	34
VII. Appendices	36

Executive Summary

Purpose

This document summarizes the work performed in line with NOAA National Ocean Service (NOS), Office for Coastal Management (OCM), Coral Reef Conservation Program's (CRCP) mission to study the ecosystem goods and services—the benefits humans derive from ecosystems (coral reefs). The purpose of this report is to provide an update of work performed in option year one (April 2022-March 2023) of the project to comprehensively update ecosystem service values in the nine U.S. coral reef jurisdictions. This report serves as the first of a series of reports containing updated valuations for NOAA CRCP jurisdictions. Subsequent reports in the following years will build upon each other. A summary of methods, findings, and recommendations follow.

Methods

In option year 1, the NOAA, ERG, and OAI teams completed several objectives, described below, to move the project forward.

- Expanded the comprehensive review of the coral reef ecosystem service literature.
- Extracted source and valuation data as well as other metadata for analysis.
- Performed an updated gap analysis highlighting areas and services for future consideration.
- Evaluated literature review studies for benefit transfer potential.
- Incorporated non-monetary cultural ecosystem service values by conducting an additional cultural ecosystem services review.
- Engaged with local stakeholders and rights-holders in Guam and Florida, as well as socioeconomic experts (including cultural and anthropological experts) to guide the project in option year one and beyond.
- Provided monetary and non-monetary values for Guam and Florida.

Findings

Key findings at the end of option year one include:

- Task 4 called for an expansion of the initial Literature Review to include more international and cultural services. We added 111 sources to the Sources tab. Following full text review, 80 sources were retained, including 17 for U.S. states and territories and 63 from international sources. The initial Gap Analysis was updated to reflect addition of new subservices as defined in the literature. Notable gaps remain, but there are now more opportunities to fill gaps such as Aesthetic Value, Cultural Use, Artistic Inspiration, Non-Use Benefits, Biodiversity, and others across the jurisdictions.
- In terms of monetary values, the estimates can be divided between economic *benefits* and economic *impacts*. Economic benefits are the values that society places on ecosystem services.

Economists often measure these values using willingness to pay (WTP) methods (e.g., simulated markets or referendum surveys), but other approaches such as estimating avoided damages or replacement costs are also used. Economic benefits also include the value of goods and services that are not traded in markets such as aesthetic or existence values. Economic impacts estimate the economic activity (spending, taxes, jobs) in the study area that are related to ecosystem services. Economic impact estimates will often start with the spending associated with a natural resource (e.g., coral reef-related recreation) and then use multipliers to determine how that spending ripples through a regional economy to generate additional economic activity (including jobs). OAI/ERG was asked to focus on benefits, but the stakeholder meetings with jurisdictions revealed a strong interest in impacts as well. As such, we have presented both and keep them separate from one another.

- The monetary valuations of ecosystem service benefits provide a set of estimates reflecting the value that society places on those services in Guam and Florida. Given that some ecosystem services did not have available estimates from prior studies, the estimates we developed reflect a conservative estimate. Due to the potential for double-counting, summing over the values must be done with caution. OAI/ERG estimates that the economic benefit value for Guam coral reef ecosystem services is between \$63.4 and \$73.6 million annually. For Florida, we estimated a range of \$609.2 to \$1.3 billion annual economic benefits. We note that the upper bound for each may reflect some double-counting of benefits.
- The [Non-Monetary Cultural Ecosystem Services Literature Review](#) was a far reaching effort to expand the valuation efforts to better incorporate services that cannot or should not be valued monetarily. This effort included searching for both quantitative and qualitative assessments of value. Additionally, this review sought to determine the most common approaches and methods used to value non-monetary services, which would then guide efforts in future years to fill potential gaps. Top methods for non-monetary values include surveys, interviews, and field observations of reef users.
- Stakeholders are concerned about how to communicate the results of monetary valuations given the difference between benefits and impacts, and that decision makers often prefer impacts.

Recommendations

Based on an exploration of research gaps, four workshops with local experts, and two workshops with socioeconomic and cultural valuation specialists, we have proposed recommendations for primary data collection for both monetary services and non-monetary cultural services. Further detail is outlined in the “Recommendations” section of the full report below.

I. Purpose and Background

Overall Project Purpose

As part of the National Oceanic and Atmospheric Administration (NOAA) Coral Reef Conservation Program's (CRCP) Strategic Plan and Socioeconomics priority, Team OAI [Eastern Research Group, Inc. (ERG), and Ocean Associates, Inc. (OAI)] is providing technical assistance to update the ecosystem service values of the seven inhabited NOAA jurisdictions with coral reefs and to estimate the ecosystem service values of the Flower Garden Banks National Marine Sanctuary and the Pacific Remote Island Areas, so that ecosystem service values are estimated for all nine coral reef jurisdictions.

Thus far, the project has focused on preparing for jurisdictional valuations and conducting valuations for the first two jurisdictions, Guam and Florida. An outline of the completed and proposed timeline is below.

Year 1: Scoping year

Year 2: Guam and Florida, cultural services expansion

Year 3: Hawai'i, Puerto Rico, and the Pacific Remote Island Areas

Year 4: American Samoa and U.S. Virgin Islands

Year 5: The Commonwealth of the Northern Mariana Islands and Flower Garden Banks

Purpose of Deliverable

The purpose of this report is to summarize work performed in year two (i.e., the first option year, April 2022-March 2023) of the project. This report provides:

- Key findings from our expanded Literature Review and Gap Analysis.
- Key takeaways from local jurisdictional and socioeconomic expert workshops.
- An overview of valuation approaches for cultural/non-material ecosystem goods and services.
- Monetized value estimates for ecosystem service benefits and impacts provided by the reefs in Guam and Florida.
- Results of cultural valuation.

This report will be updated in future years to include the remaining seven coral reef jurisdictions. Additionally, as new research is published the project team will complete any necessary updates or additions to the Guam and Florida results.

Background

The NOAA National Ocean Service (NOS), Office for Coastal Management's (OCM) mission prioritizes the protection of natural and built environments and maintaining economic prosperity of coastal areas. In fulfilling their mission, the Coral Reef Conservation Program (CRCP) funds and equips reef restoration

activities by NOAA and its partners in the seven U.S. states and territories containing coral reefs, and supports monitoring in two uninhabited areas.

In support of this mission, the CRCP also studies ecosystem goods and services—the benefits humans derive from coral reefs—and evaluates the trade-offs between human use/benefits and the status of the ecosystem. Over an 11-year period (2001-2011), the CRCP conducted seven valuation studies in each of the inhabited coral reef jurisdictions: American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), Florida, Guam, Hawai'i, Puerto Rico, and the U.S. Virgin Islands (USVI). These valuation studies quantified benefits that society garners from the coral reefs in each jurisdiction. Despite coral reef monitoring in two uninhabited areas, the Flower Garden Banks National Marine Sanctuary and Pacific Remote Island Areas, the CRCP did not conduct valuation studies quantifying ecosystem goods and services provided in these areas.

Ecosystem Services of Coral Reefs

These efforts were guided by the original Millennium Ecosystem Service Assessment (MEA) categories, and have expanded to include a broader conception of how ecosystems and humans relate based on stakeholder feedback. The original MEA categories are:

- Provisioning: Any type of benefit that can be extracted from nature, e.g., food, building materials;
- Regulating: Benefit provided by ecosystem processes that moderate natural phenomena, e.g., carbon sequestration, storm protection;
- Cultural: Material and non-material benefits that contributes to the development and cultural advancement of people, e.g., recreation, spiritual uses;
- Habitat/Supporting: the processes that allow the Earth to sustain basic life forms, e.g., larval dispersal, nutrient cycling.

The Economics of Ecosystems and Biodiversity (TEEB) and The Common International Classification of Ecosystem Services (CICES) classifications were added retroactively for valuations from the initial Literature Review. These valuation systems and the columns added to the Literature Review allow for a systematic analysis of overlapping and parallel services. Further expansion to include non-monetary conception of ecosystem services was done through the Cultural Ecosystem Services review. Overall, the various frameworks and approaches used for determining what counts as an Ecosystem Service have allowed for a wide-ranging review for NOAA jurisdictions.

Coral reefs contribute a wide variety of important benefits and services such as food, coastal protection, recreation opportunities, habitat for a variety of species, tourism, cultural heritage, and identity through a sense of place. These benefits and services can be assessed via economic valuations and by exploring non-monetary values. However, threats to these ecosystems including increasing population growth rates along with economic and industrial development, unsustainable fishing, land-based pollution, global forces from climate change, coral bleaching, coral disease, among others, have resulted in

unprecedented pressure on coral reefs. Table 1 presents some examples, but not a comprehensive list, of ecosystem services and potential threats to those services.

Table 1. Examples of different types of services and threats

Service or Benefit	Example of Threats
Recreation and Tourism	Coastal development limits access to individuals seeking to use beaches for access to coral reef activities such as snorkeling.
Commercial Fishing	Through decreases in habitat area, coral bleaching and coral disease impacts food webs that may include commercially important species.
Cultural Heritage	Unsustainable fishing may result in declines in reef species that are important or even central to cultural beliefs or practices, such as in origin stories or traditional seasonal harvesting events.
Coastal Protection	Climate change, coral bleaching, and coral disease can decrease the strength and height of coral reefs, limiting their capacity to reduce wave energy, which can result in increases in coastal flooding during storm events.

Economic Benefits and Impacts

During the jurisdictional workshops, we heard a number of participants present information on monetary values in terms of what economists would describe as “economic impacts”. This project, on the other hand, has a focus on economic benefits. As such, we felt it was necessary to explicitly make a distinction between the two types of monetary values:

- Economic benefits are the values that society has for ecosystem services. Economists often measure this value using willingness to pay (WTP) using simulated markets or referendum surveys, but other approaches such as estimating avoided damages or replacement costs are also used. Economic benefits also 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 degradation of its associated habitat, then society is worse off by \$100 million annually.
- Economic impacts are the economic activity (spending, taxes, jobs) in the study area that are related to ecosystem services. Economic impact estimates will often start with the spending associated with something (e.g., coral reef-related recreation) and then use multipliers to determine how that spending ripples through a regional economy to generate additional economic activity (including jobs). Economic impacts are meant to measure how money associated with ecosystem services flows through the local economy and leads to additional

economic activity, as well as generating income and jobs in that economy. Of note, impacts are mostly considered transfers from one 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 that is generated from the spending and the 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 EPA use benefits as the measure of the value that society places on ecosystem services. Nevertheless, economic impact estimates are also important for understanding how coral reefs can contribute to the economic vibrancy of an area. Thus, in this analysis, we tabulate both economic benefits and economic impacts, but we also need to tabulate them as separate categories. Generally, economists and agencies do not add together the economic benefits and economic impacts, even though both are measured in dollars. This is because the dollars measure different economic concepts.

Sensitivities of Ecosystem Services Valuation

Ecosystem services valuations allow decision makers to weigh the costs and benefits of developments, programs, or policies that impact natural resources. While monetized valuations of ecosystem services allow easy incorporation into decision making frameworks, they often do not fully capture the value of a service, or in some cases are incapable of accurately valuing some services. Non-monetary ecosystem service valuations can assist in communicating ecosystem service valuation where monetization falls short, but do not always align with the needs of decision makers. This vein of research within the larger field of ecosystem services includes traditional concepts of cultural ecosystem services as well as relational values, which is based on research regarding topics such as Indigenous and Local Ecological Knowledge, sense of place, and human-nature connections.

II. Approach to Performing Work

Valuation Literature Review

Overview: In year 1 (i.e., the scoping study), the project team conducted a comprehensive [literature review](#) of the coral reef ecosystem service literature, extracted source and valuation data as well as other metadata for analysis, performed a gap analysis highlighting areas and services for future consideration, and engaged with local stakeholders, rights-holders, and socioeconomic experts (including cultural and anthropological experts) to guide the project in year two and beyond. Following the scoping year [Final](#)

[Report](#), NOAA requested an expansion of the Literature Review to include a wider array of international sources and to fill gaps in Cultural Services.

Approach: Team OAI performed a search of coral reef and ecosystem service databases, Google Scholar, incorporated studies provided by NOAA, and Technical Working Groups which totaled 61 publications 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. As a next step, Team OAI searched specialized databases including the [Blue Value Database](#) - an online, searchable ecosystem service tool, the [Ecosystem Service Valuation Database \(ESVD\)](#) - an expanded database from The Economics of Ecosystems & Biodiversity (TEEB) initiative managed by the Ecosystem Services Partnership, and the [Mapping Ocean Wealth Research Library](#) - a list of resources used for The Nature Conservancy's Mapping Ocean Wealth project. We also searched Google Scholar to further expand the search. Participants from stakeholder workshops also provided several resources that were added to the review. As a final step in the scoping year team OAI extracted the references cited within sources considered meta-analyses or systematic reviews were reviewed for additional valuations. Full details, including search terms, can be found in the Scoping Year Comprehensive Report, in the [Appendices](#).

To increase the number of potential studies for benefit transfer to fill remaining gaps, starting on May 5th, 2022 team OAI searched the original Literature Review databases but expanded the search to include a set of locations from which studies could be assessed for benefit transfer. After selecting for studies in the identified countries/regions, removing valuations from sources already included in the Literature Review, removing duplicate sources, and excluding the U.S. states and territories, a total of 471 valuations and 96 sources remained. These expanded search locations were chosen based on their biogeophysical, socioeconomic, and cultural similarities to NOAA jurisdictions.

Outcomes: Key findings at the end of year one include:

- Many jurisdictions and services are eligible for benefit-transfer based on primary valuations extracted during both phases of the Literature Review, however, considering the socio-cultural and bio-geophysical aspects of the policy and study sites is critical and may limit the transferability of some valuations to certain jurisdictions.
- Critical gaps remain for key services across several jurisdictions, due to both a lack of studies in general, or a lack of quality research. Examples include, Commercial Fishing values for uninhabited jurisdictions, and Artisanal Fishing values for most jurisdictions.

Jurisdictional and Socioeconomic Workshops

Overview: We held six workshops throughout this project year to support the valuation of the ecosystem goods and services in Guam and Florida. There were two workshops held in each jurisdiction and two workshops held with socioeconomic and cultural valuation experts. These workshops have informed our approaches to valuation and communication of results. Refer to Appendices C and H for more information about the individual workshops.

Approach: We held a workshop in each jurisdiction in October of 2022 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 and share draft values from benefit transfer. The feedback in the workshops was used to refine our approach to our benefits transfer. In November 2022, we held our first expert workshop to solicit expert economic and social science input on our approach for Guam and Florida. Our second round of jurisdictional workshops was held in late January and early February. These workshops provided local stakeholders and rights-holders an opportunity to review and comment on the draft results on ecosystem goods and service values for their jurisdiction. Our final socioeconomic workshop took place in late February. Experts reviewed sections of our draft report and the draft coral reef ecosystem services values for Guam and Florida as well as provided feedback on how we can communicate and potentially value cultural ecosystem services.

Outcomes: The first round of workshops with local stakeholders and rights-holders contributed to the project as follows:

Guam

- Determining that cultural values are perhaps the most important values for Guam residents, and also the most threatened, which is highlighted in this report and in our recommendations for future valuation efforts.
- Identifying that the services that can be monetized do not necessarily benefit Guam residents uniformly, and special consideration of these delineations can enrich valuation efforts.

Florida

- Expanding our set of ecosystem services to consider and improving our understanding of the nuances and differences of ecosystem service subcategories. We used this information to refine the list of ecosystem services we include in our assessment.
- Improving our understanding of when and how coral reefs function, and how conditions have changed over time (e.g., bleaching, disease, storms). For example, Florida participants identified 2014 as a critical year in changing reef conditions. Our defensibility scoring system took two events in 2014, bleaching and the introduction of Stony Coral Tissue Loss Disease, into account, but hearing from stakeholders on this issue corroborated that approach.¹
- Determining that overtourism needs to be explicitly addressed in a valuation of Florida's ecosystem services. Some services (e.g., tourism/rec, coastal protection) may be of high economic value, but have surpassed a threshold of social and ecological sustainability.

The first socioeconomic expert workshop provided valuable insights for including non-monetary cultural services and emphasizing their importance in the final report. Workshop participants pointed to evocative data visualization as a key component in effectively incorporating non-monetary cultural values into

¹ While we attempted to use more recent studies, studies from years before 2014 were not automatically disqualified. Rather, events like bleaching, storms, or biological threats gave rise to concerns, but we had to counterbalance that with valuation study availability.

valuation efforts as well as identifying which variables can be included in non-monetary valuation visualizations in order to effectively communicate to decision makers.

The second round of jurisdictional workshops provided new insights about how to best communicate findings and also added new sources to the cultural services review. Discussions in both Florida and Guam expressed concern about how the results were presented, and made recommendations about outreach and communication. Additional feedback on the values provided from both the monetary and non-monetary reviews will ensure the most important services and values are represented and the most appropriate approach is used when describing these services and values. Specifically, participants provided the following recommendations and requests.

Guam

- Better explanations about the process of benefit transfer might help to make those values more clear.
- Expanding non-monetary values could include incorporating facts and stories from important cultural sites, practices, and beliefs.

Florida

- Impact values are more salient for decision makers and stakeholders, so guidance is needed for communicating 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.

The second socioeconomic expert workshop reviewed our draft results and provided feedback that helped further refine and contextualize our results. Participants provided several data sources and suggestions for improving our estimates for research values. This workshop also had a robust discussion on the non-monetary valuations, where participants suggested ways to better visualize and communicate qualitative data and cultural services. Additionally, prior to the second socioeconomic workshop, ERG met with three experts individually who were part of the workshop as well. The experts provided ERG with a set of comments on draft materials that were incorporated into the workshop materials and were also discussed during the workshop.

Benefits Transfer

Overview: The study relies on benefit transfer to develop estimates of the value of coral reefs. Benefit transfer approaches involve taking estimates from previously performed studies and applying those estimates to another situation. In its simplest form, a benefit transfer will involve taking an economic value estimated from a study conducted at one specific site (the study site) and applying that estimate, with adjustment, to the site of interest (the policy site). The reason for using benefit transfer is that collecting primary data for a study such as this would be prohibitively expensive and time-consuming. Benefit transfers involve some inherent challenges. Errors from study site primary valuations can include

biased econometric estimators, while ecological and social discrepancies between the study site(s) and policy site can complicate the transfer process (Johnston et al., 2021).

Approach: There are generally three approaches to benefit transfer:

- Value transfer: An estimate from one or more study sites is/are taken and applied to a policy site after some adjustment reflecting conditions at the policy site (e.g., averaging over estimated values, adjusting for regional price differences).
- Functional transfer: An estimated statistical function from a study site is taken and 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 functional transfers since they rely on larger numbers of primary studies to identify relationships between estimated economic values and factors that influence those values. In this work, the OAI/ERG team was unable to find suitable meta-analyses to use. Additionally, given differences across policy and study sites, we were also not able to identify suitable studies for function transfers.² Therefore, our analysis has relied on a value transfer approach known as point transfer.

Point value transfer is the simplest benefit transfer method. It can be a beneficial way to estimate values where information is limited. To implement a point value transfer, we take the following steps:

- Identify relevant studies for each jurisdiction and/or each ecosystem service that meet defensibility criteria. This could involve using more than one study to form a range for the estimate. For a single point, we simply take a value from a study that is relevant and then adjust the value for inflation or price levels to apply it to the policy site. When taking multiple values, we need to ensure that two values are consistent with one another and that we can reasonably explain why differences exist. For the most part in this report, we use single point estimates based on our review of the available studies. In cases where we use more than one estimate, we discuss our reasoning in the discussion of results. See the [Task 5 Summary](#) in Appendix B for more details regarding the Defensibility Scoring criteria and Transferability results.
- Determine whether the studies being used have a similar scale (e.g., size of ecosystem service change, area) to the situation we are considering.³
- Adjust for inflation and possibly jurisdictional price levels.

² To effectively perform a function transfer, we would need to be sure that the function estimated at the study site could be applied at the policy site with updates to the data. For the most part, the estimated functions from study sites used data not readily available at the policy site (e.g., collected through a survey). Thus, it was necessary to rely on point transfers.

³ 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.

To apply this method, we used the literature review to identify studies for each jurisdiction that can form the basis of the value transfer. The focus was on studies using primary valuation methods.

As part of this project, the OAI/ERG team developed an initial list of studies to consider for use in the valuation and assessed those studies for defensibility. Defensibility was determined based on a score that took into account the overall quality of the research and methods used, as well as the number of events that could have impacted the coral reefs since the publication of the source. See the [Task 5 Summary \(Appendix C\)](#) for details concerning defensibility criteria. The set of studies for Guam can be found [here](#) and the ones for Florida [here](#). Once these studies were identified, OAI/ERG proceeded to develop estimates of the value of ecosystem services using these studies and other available information. This process led to OAI/ERG considering additional studies to fill gaps and, in some cases, using alternative studies that were better suited to the purposes of the work. The final set of studies we used reflects our literature review, the defensibility/validity assessment, and OAI/ERG's best professional judgment on the best studies/approaches to address the ecosystem services. *The documents for Guam and Florida linked above include reasons for excluding specific studies from use in our analysis.*⁴

Outcome: The use of benefit transfer in this project allowed for OAI/ERG to provide estimates of the ecosystem service benefits for coral reefs without performing primary data collection. Although primary data collection allows a study to be customized for a specific area, the time and cost associated with primary data collection can be prohibitive.

Cultural Literature Review and Analysis (Non-monetized values)

Overview: The goal of the [Non-Monetary Cultural Services Literature Review](#) was to provide recommendations to approaching cultural ecosystem service (CES) valuations, particularly for non-monetary values. In doing so, we've begun an extensive literature review of CES resources to discern the most commonly applied methods for CES and trends in the field. The scope of this review expands beyond coral reefs to coastal and marine contexts as well as some resources focused on terrestrial contexts. This allowed us to determine the primary methods being used for services across all ecosystem types, so, for services where there are gaps within the coral reef literature, we at least had an idea of what was being used elsewhere.

Approach: Resources were collected from several existing reviews and meta-analyses of CES. Additionally, an online academic search engine - Web of Science - was used to ensure that any recent studies would be included. These studies were then reorganized into a singular matrix to analyze information about each article and the methods and services in question. Following the reorganization, the data was cleaned and homogenized. The primary sources and search term, as well as a schematic of the data integration process are below.

⁴ Column G of each document contains a new field labeled "Non-use decision" that provides a statement on why a study was not used if it was not used. Studies that were used are labeled as such in that column as well.

1. Gould, Rachelle K., Joshua W. Morse, and Alison B. Adams. 2019. "Cultural Ecosystem Services and Decision-Making: How Researchers Describe the Applications of Their Work." *People and Nature* 1 (4). John Wiley & Sons, Ltd: 457–75. doi:[10.1002/pan3.10044](https://doi.org/10.1002/pan3.10044).: 232 sources
2. Martin, Carol L., Salim Momtaz, Troy Gaston, and Natalie A. Moltschanivskyj. 2016. "A Systematic Quantitative Review of Coastal and Marine Cultural Ecosystem Services: Current Status and Future Research." *Marine Policy* 74 (December): 25–32. doi:[10.1016/j.marpol.2016.09.004](https://doi.org/10.1016/j.marpol.2016.09.004).: 24 sources
3. Cheng, Xin, Sylvie Van Damme, Luyuan Li, and Pieter Uyttenhove. 2019. "Evaluation of Cultural Ecosystem Services: A Review of Methods." *Ecosystem Services* 37 (June): 100925. doi:[10.1016/j.ecoser.2019.100925](https://doi.org/10.1016/j.ecoser.2019.100925).: 292 sources
4. Pratson, 2022 (work in progress): 72 sources
5. Web of Science search
(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"))): 106 sources

We also requested resource recommendations from workshop participants. This proved to be very helpful and provided several new sources for services that were lacking in the academic literature review.

Outcomes: The Non-Monetary Cultural Ecosystem Services Literature Review added 903 resources to the project effort and several important values for services in Florida and Guam. The majority of studies pertained to terrestrial ecosystems (Figure 1). Workshop participants contributed a handful of studies related to marine or coral reef ecosystems. This effort provided a foundation from which non-monetary service values can be explored for other jurisdictions in future years. Along with an analysis of the service values, this review also took into account the methods used to value non-monetary services across a dataset representing ecosystem services research beyond just coral reefs and U.S. jurisdiction.

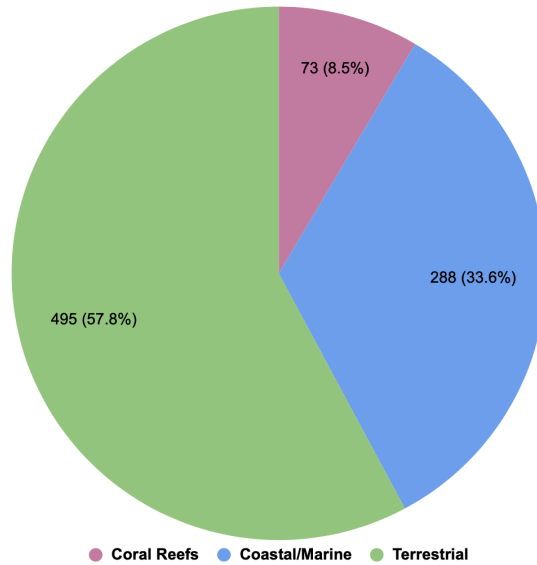


Figure 1. Studies by ecosystem type. Reviews or thought pieces which did not specify an ecosystem type (n=47) are excluded.

III. Results

Monetary Benefit Estimates

Table of values

This section summarizes the estimates of both economic benefits and impacts for Guam and Florida. Benefits are summarized in Tables 2 and 3 for Guam and Florida, respectively, and impact estimates are summarized in Tables 4 and 5 for Guam and Florida, respectively. We note that all values in the tables are phrased in terms of 2022 dollars. This was done by taking the estimates from the respective studies and adjusting based on appropriate price indices such as the Consumer Price Index.

For the benefit estimates in Tables 2 and 3, OAI/ERG extracted values from the studies identified in the tables and updated those values to 2022 dollars using appropriate price indices. For the most part, the values extracted from the studies reflect a rate (e.g., dollars per some unit). To develop a total value estimate based on those rates, OAI/ERG identified a total number of units from available data. In all cases, we present an annual value for the benefit and impact estimates. Finally, we present values rounded to the nearest \$100,000 phrased in terms of million.

Table 2. Summary of Guam Economic Benefits

Ecosystem Service	Study/Details	Rate (Value per unit; 2022 dollars)	Units	Total Value (Annual; 2022 dollars)
Coastal protection	<u>Storlazzi et al. (2019)</u> <ul style="list-style-type: none"> Study estimated the number of people protected and value of buildings protected by Reefs 	NA	NA	\$9.5M
Commercial fishing	<u>Western Pacific Regional Fishery Management Council (WPFMC) (2022) and Chan and Pan (2019)</u> <ul style="list-style-type: none"> Data on total landings taken from WPFMC; ERG then used NOAA NMFS sources to identify Guam reef fisheries and summed the total of those fish. Averaged over the last five years. Costs were estimated to be 36% of total revenues based on data from Chan and Pan (2019) for reef fisheries in Guam. 	NA	NA	<ul style="list-style-type: none"> \$0.26M/year in total catch
Traditional fishing	<u>Van Beukering et al. (2007)</u> <ul style="list-style-type: none"> Performed a choice experiment on Guam to estimate values for aspects of coral reefs. 	<ul style="list-style-type: none"> \$78.87 per household per year (value is based on the value of “having fish to share” from their model) 	43,381 households [a]	\$3.4M
Recreation – SCUBA diving and snorkeling	<u>Grafeld et al. (2016)</u> <ul style="list-style-type: none"> Choice experiment (CE) that estimated the value of potential improvements to coral reefs among divers. Value based on a specific set of improved conditions from the CE (medium biomass, medium diversity, few wrasse, and Sharks present). These represented value in the “middle” of what was possible. We will need an estimate of the number of dives in order to estimate the total dive value. 	<ul style="list-style-type: none"> \$38.79 per dive 	583,000 [b]	\$22.6M

Ecosystem Service	Study/Details	Rate (Value per unit; 2022 dollars)	Units	Total Value (Annual; 2022 dollars)
Recreation – non-diving/snorkeling	<p><u>Londono and Johnston, 2012</u></p> <ul style="list-style-type: none"> • Performed a meta-analysis of coral reef valuation studies related to recreation related to reefs. • Excludes “diving” in the meta-analysis from the estimated value since we have a better estimate from another study. • Will need an estimate of the number of person-days of use to estimate total non-diving/snorkeling value. • Note: the number of units reflects an assumption that all non-diving days for tourists are reef-related. 	<ul style="list-style-type: none"> • \$59.01 per person/per day 	630,000 non-diving days for visitors [d]	\$37.2M
Research	<p><u>Cesar & van Beukering 2004 (Hawaii) and van Beukering et al. 2006 (CNMI)</u></p> <ul style="list-style-type: none"> • Both studies estimated the value of research based on total grants being given to perform research on the reefs. Converted total to a per area value. • Values were updated to 2022 values and rounded to nearest hundred. No adjustment was made for purchasing power parity between Hawaii/CNMI and Guam. Both values were the same when these adjustments were made. 	<ul style="list-style-type: none"> • \$15,600 per square mile (Cesar & van Beukering 2004; Hawaii) • \$15,600 per square mile (van Beukering et al. 2006; CNMI) 	108 km ² (41.7 mi ² [c])	\$0.65M

NA: Not applicable; value was provided as a total.

[a] Based on 2020 Guam Census data: <https://bsp.guam.gov/census-of-guam/>.

[b] The number of dives (583,000) was derived by recreating the methods for estimating dives found in van Buekering et al. (2007).

[c] https://bsp.guam.gov/wp-bsp-content/uploads/2022/09/Guam-Shoreline-Atlas_Final.pdf

[d] This value was calculated by using data from the Guam Visitors Bureau and the methods from van Buekering et al (2007) used in calculating dives. We began by taking the number of visitor days to Guam and subtracting out the number of visitor diving days. The number of visitor diving days was calculated by taking the total number of visitors who dive and assuming 2-4 dive days per visitor (based on van Buekering et al. (2007)). We only focused on visitors since we do not have a reliable approach to estimate the same value for residents. The resulting estimate of 6,310,699 was then adjusted using the value from Spalding et al. (2017) which assumed that 10 percent of all tourism was reef-adjacent. We thus assumed that the reef-adjacent category from the Spalding et al. paper would apply to this category. We rounded the value to 630,000.

Table 3. Summary of Florida Economic Benefits

Ecosystem Service	Study/Details	Rate (Value per unit; 2022 dollars)	Units	Total Value (Annual; 2022 dollars)
Coastal protection	<p><u>Storlazzi et al. (2019)</u></p> <ul style="list-style-type: none"> Estimated the value of buildings protected by Reefs. 	NA	NA	<ul style="list-style-type: none"> Peninsula: \$431.2M/year Florida Keys: \$42.8M/year for areas outside the Florida Keys
Commercial fishing	<p><u>FL Fish and Wildlife Commission (FWC) (2021).</u></p> <ul style="list-style-type: none"> Tabulation by FWC for reef fish. Note: Value will need to be adjusted by a percentage to reflect costs incurred will generate an estimate of producer surplus. ERG assumed that 60 percent of the revenue represented costs. 	NA	NA	<ul style="list-style-type: none"> \$31.2M in total landings.
Recreational fishing	<p><u>Huth et al. (2014)</u></p> <ul style="list-style-type: none"> The study performed a contingent valuation (CV) survey to estimate WTP for developing artificial reefs that would support recreational fishing. Combined with data on the number of resident and non-resident recreational anglers, the values can be used to estimate the total value of reefs for recreational fishing. 	<ul style="list-style-type: none"> FL Residents: \$40.84/HH/year Non-FL residents: \$39.97/HH/year 	<p>FL residents: 1,058,846 [a]</p> <p>Non-FL residents: 673,907</p>	<p>FL residents: \$43.2M</p> <p>Non-FL residents: \$26.9M</p>

Ecosystem Service	Study/Details	Rate (Value per unit; 2022 dollars)	Units	Total Value (Annual; 2022 dollars)
Recreation – all types combined	<p><u>Wallmo and Allen (2021)</u></p> <ul style="list-style-type: none"> Estimated the WTP to access both natural and artificial coral reefs in Florida for three different groups, as well as estimating the value that people place in improvements to reef conditions. Values presented reflect willingness to pay to visit natural reefs. 	<ul style="list-style-type: none"> Southeast Florida County residents: \$11.11 per household per visit Other FL residents: \$10.98 per household per visit Non-FL residents: \$11.66 per household per visit 	<p>Florida (Southeast + other areas combined): 6.1 million household trips annually attributed to reef-related activities [c]</p> <p>Non-FL: 2.4 million household trips annually attributed to reef-related activities [c]</p>	<p>Florida (Southeast + other areas combined): \$67.1M</p> <p>Non-FL: \$27.5M</p>
Recreation – diving and snorkeling	<p><u>Bhat (2002) (adjusted using Loomis (2003))</u></p> <ul style="list-style-type: none"> Estimate of \$875/person trip provided in the study (value updated to 2022 dollars). Value was adjusted based on an avidity bias factor of 0.4 derived from Loomis (2003). [e] Note: the total value generated is not consistent with the value in Wallmo and Allen (2021) 	<ul style="list-style-type: none"> \$875/person-trip (or \$231/person-day) 	<p>1,650,109 person-trips [d]</p>	<p>\$578.8M</p>
Research	<p><u>Estudios Tecnicos, (2007)</u></p> <ul style="list-style-type: none"> The authors interviewed researchers to determine the number and value of recent (last three years) research projects involving coral reefs in Puerto Rico. The total value of the research projects was \$1.14M/year for the entire jurisdiction (2020 dollars). OAI/ERG converted to dollars per kilometer-squared and updated to 2022 dollars. 	<ul style="list-style-type: none"> \$8,411.6/km² 	<p>> 9,000 km² [b]</p>	<p>\$75.7M</p>

NA: Not applicable; value was provided as a total.

[a] The number of resident and non-resident anglers comes from NOAA's Marine Recreational Fisheries Statistics Survey 2016 data for East Florida

(https://www.st.nmfs.noaa.gov/SASStoredProcess/do?_program=%2F%2FFoundation%2FSTP%2Fmrip_series_participation&qyearfrom=2016&qyear=2016&qwave=-1&qstate=EAST+FLORIDA&qoutput_type=TABLE).

[b] <https://coastalscience.noaa.gov/project/benthic-habitat-mapping-florida-coral-reef-ecosystems/#:~:text=The%20Florida%20Keys%20are%20part,out%20to%20the%20Dry%20Tortugas.>

[c] These estimates were derived from data from Florida's [SCORP report, Appendix G](#). We used the number of participants in Saltwater Beach activities as a best estimate for a starting point. We then divided those numbers by average household size in Florida (2.57) and the United States (2.6; for tourists) to get a total number of households for each. Next, we used Spaulding et al. (2017)'s estimate that 10 percent of coastal tourism near coral reefs is "reef-adjacent" and (in Florida) four percent is on-reef for a total of 14 percent of visits being reef-related. Finally, we multiplied each by the relevant willingness to pay value. We do note that this assumes each household-day represents a unique visit, but we also expect this is consistent with the approach used in the SCORP report to estimate participants.

[d] Value reported in Wallmo et al., (2021) based on data reported by the Dive Equipment and Marketing Association for 2013.

[e] Avidity bias refers to the idea that those being surveyed in a study are more likely to place a larger value on the activity than those not being surveyed. Loomis estimated a value for river recreation of \$24 without adjusting for avidity bias and \$9.60 when adjusting for avidity bias. Thus, the ratio of adjusted to unadjusted was 0.4.

Limitations

The estimates presented above have a number of limitations, including:

- Our estimates are limited by available reliable studies. We can only provide estimates in cases where we feel the literature has provided a valid, reliable, and defensible value.
- Adding across the ecosystem services may result in double-counting. OAI/ERG developed the estimates by using a benefits transfer approach. As such, it is not clear sometimes when two (or more) studies are generating values that include overlapping elements. Nevertheless, we have provided ranges of total values based on summing over subsets of values where we think double-counting is least likely and then providing an indication of how the remaining values relate to the range.
- Matching rates to units is difficult. In cases where we had a rate (value per unit), we had to identify a relevant number of units to multiply by the rate to generate a total value. In most cases, this involved making some simplifying assumptions and performing a series of calculations. Each time we make an assumption or require a calculation to generate a unit, we run the risk of adding in some level of error to the estimates.

Ranges for Total Value - Guam

For Guam, OAI/ERG has determined that four of the six ecosystem service benefit estimates can be reasonably added together with minimal risk of double- or over-counting:

- Commercial fishing (\$0.26M annually)
- Traditional fishing (\$3.4M annually)
- Recreation, SCUBA diving and snorkeling (\$22.6M annually)
- Recreation, non-diving/non-snorkeling (\$37.2M annually)

These four represent distinct activities and there should be little overlap in the estimated values. This results in a total annual value of \$63.46 million for Guam.

As displayed in Table 2, research generates a value of \$0.65 million. Although research is a distinct activity from the other five categories, we hesitate to include it in the total since the data for that estimate is based on grant funding in CNMI and Hawaii. The value of those grants could be related to or influenced by the value of other ecosystem services.

The coastal protection value of \$9.5 million reflects the avoided damages to buildings and infrastructure due to the presence of coral reefs. Avoided damages estimates can be broad in scope and the source study (Storlazzi et al., 2019) does not provide details on aspects included or excluded from the estimates.

The lower bound of a total range can be estimated by assuming both research and coastal protection are subsumed in the other estimates and the upper bound would reflect a situation where both are not included in the other values. Thus, a plausible range would be between \$63.46M and \$73.61M.

Ranges for Total Values - Florida

Deriving a range for Florida is more complicated because there are three overlapping categories related to recreation. Nevertheless, we can derive a range using the following guidelines:

- Commercial fishing is additive to some combination of the three recreational categories.
- Coastal protection and research can be treated similarly to our approach for Guam.

These guidelines, unfortunately, do not lead to a clear-cut range as we had for Guam since it is unclear how the recreational categories can be combined. A lower bound, however, could be approximated by taking the largest recreation values (\$578M annually) and adding that to commercial fishing (\$31.2M annually) and then assuming coastal protection and research are subsumed in those values.⁵ This results in a value of \$609.2 million annually. The upper bound would then be the sum of all the values which would be \$1.3 billion annually.

Monetary Economic Impact Estimates

Tables 4 (Guam) and 5 (Florida) provide estimates of the economic impact from the studies we reviewed. Developing a total from adding these values together is challenging, however, since they tend to overlap significantly. For example, the values for coastal protection from Storlazzi et al. (2019) most likely include other values in other categories since the Storlazzi et al. values are based on protection of people, buildings, and infrastructure.

Nevertheless, for Guam we can assume the smaller value in the table is a lower bound and the larger value in the table is an upper bound. This leads to a range of \$14.1 million to \$332.6 million annually for Guam.

For Florida, we can assume the coastal protection value is a lower bound since it is smaller than the two comprehensive recreation-based values (i.e., excluding the one for Dry Tortugas National Park alone) and smaller than the tourism value. Given that some tourists would take part in fishing and diving/snorkeling, we can assume that the sum of the recreational fishing and diving/snorkeling values represents a conservative upper bound.⁶ This leads to a range of 424.8 million annually to \$1.5 billion annually.

⁵ We note that may not be a reasonable assumption, but we have little information to develop a percentage overlap assumption.

⁶ We call this a conservative upper bound since some of the tourism value does not include recreational fishing or diving/snorkeling. We are just not sure how much to attribute to an upper bound calculation.

Table 4. Summary of Guam Economic Impacts

Ecosystem service	Monetary Economic Impact
Coastal protection	<p><u>Storlazzi et al. (2019)</u></p> <ul style="list-style-type: none"> Estimated the economic activity associated with protecting people and buildings. \$14.1M /year (2022 dollars).
Tourism	<p><u>Tourism Economics (2021)</u></p> <ul style="list-style-type: none"> Based on input output modeling performed under contract to the Guam Visitors Bureau. Estimates reflect a significant reduction from pre-pandemic levels. \$332.6M in economic output (2021 dollars) 12,425 jobs

Table 5. Summary of Guam Economic Impacts

Ecosystem service	Monetary Economic Impact
Coastal protection	<p><u>Storlazzi et al. (2019)</u></p> <ul style="list-style-type: none"> Estimated the number of people protected and value of buildings protected by Reefs. Estimated the value of economic activity by using an estimate of the value of economic activity associated with people and buildings. Peninsula: \$367.6M/year (2022 dollars). Keys: \$57.2M/year for (2022 dollars).
Tourism	<p><u>Spalding et al. (2017)</u></p> <ul style="list-style-type: none"> Estimated the values of tourism expenditures for reef-adjacent and on-reef tourism. The reef-adjacent value can be used to add to a value of on-reef recreation from other sources. The method starts with a total tourism spending value and then develops percentages to distribute the total value to categories in the study. \$1,010.6M/year in reef-adjacent tourism expenditures (2022 dollars) \$363.8M/year in on-reef tourism expenditures (2022 dollars)
Recreational fishing	<p><u>Wallmo et al. (2021a)</u></p> <ul style="list-style-type: none"> \$456.2M/year in economic output (2022 dollars) 3,787 jobs
Recreation – all types combined	<p><u>Thomas et al. (2022)</u></p> <ul style="list-style-type: none"> Dry Tortugas National Park: \$6.5/year (2022 dollars) 61 jobs
Recreation – diving and snorkeling	<p><u>Wallmo et al. (2021a)</u></p> <ul style="list-style-type: none"> \$1,071.6M/year in economic output (2022 dollars) 8,668 jobs

Non-monetary Values

Approaches to demonstrating non-monetary values: Non-monetary values can be represented in many ways. Unlike monetary services which can all be represented in U.S. dollars, no single form of valuation was defined during the non-monetary review in order to cast the widest net and incorporate as many conceptions of coral reef values as possible. Some values are quantitative, such as the number of annual recreational fishing trips in Florida, while others are more qualitative, such as the cultural importance of coral reefs in providing a common theme for Chamoru diaspora and Guam residents to relate to.

Guam

Guam's cultural ecosystem services that can be valued in non-monetary terms include Recreation/Tourism, Cultural Heritage, Aesthetics, Identity, Knowledge Systems, Spirituality, Security, Learning/Education, Social Relations, Ecological Literacy, and Stewardship. These non-monetary values provide an enriched understanding of services for which previous work has defined monetized values, and also fill gaps where the monetary ecosystem service literature was lacking.

We found three sources particularly relevant to conveying non-monetary values of Guam's coral reefs.

- ([San Nicolas-Rocca and Parrish, 2014](#)) The purpose of this study was to understand if information and communication technologies, specifically social media, are used to capture and convey CHamoru cultural knowledge. Two data collection methods were used to understand the type(s) of CHamoru cultural knowledge that is valued, and what social media is used by the CHamoru people today to capture and convey cultural knowledge. The results indicate that the CHamoru people today share the core CHamoru cultural values, and do use information and communication technologies, including social media to capture and convey CHamoru cultural knowledge. Additionally, page 10 contains a table of survey respondents ranking of types of CHamoru Cultural Knowledge. CHamoru language, Food/recipes, Ways of Life, and Music ranked highly as very important cultural knowledge. See Figure 1 in the [Appendix](#) for more details. This approach allows for a more detailed look into knowledge types. Although this survey was not focused on associations between cultural values and natural resources, the authors point to the importance of both terrestrial and marine resources as central to CHamoru cultural and knowledge systems.
- ([Perez, 2020](#)) In an analysis of CHamoru writer Lehua Taitano's book of poetry, *A Bell Made of Stones* (2013), Perez explores the importance of cultural heritage, identity, and CHamoro aesthetics for CHamoru diaspora. CHamorus separated from their home islands are connected by a shared identity which they maintain through various means, but often via online communications and resources. Perez discusses how references to CHamoru knowledge systems, such as celestial and island navigation, are employed to help in connecting back to CHamoru heritage.
- ([Mushynsky, et al., 2022](#)) This anthropological exploration of island identity in Guam touches on several key services. Indigenous knowledge systems inform fishing, boating, and stewardship with the marine environment. Collaboration with Carolinian groups allows for both Carolinians and CHamorus to sustain their Indigenous fishing practices and navigation techniques.

Table 6. Non-Monetary cultural services in Guam

Ecosystem service	Summary of values from coral reefs in Guam	Summary of values from (or focused on) other ecosystems in Guam, may include corals
Rec & tourism	<ul style="list-style-type: none"> • Grafeld et al., 2016: 256,000–340,000 dives occur on Guam's reefs per year • NCRMP socioeconomic survey <ul style="list-style-type: none"> ○ 89% of respondents in Guam agreed that healthy coral reefs attract tourists to Guam 	<ul style="list-style-type: none"> • Guam Visitors Bureau: 328,000+ visitors in 2022
Cultural heritage/identity	<ul style="list-style-type: none"> • NCRMP socioeconomic survey <ul style="list-style-type: none"> ○ 97% of respondents in Guam considered coral reefs as important to Guam's culture 	<ul style="list-style-type: none"> • (San Nicolas-Rocca and Parrish, 2014): CHamoru language, Food/recipes, Ways of Life, and Music ranked highly as very important cultural knowledge. • (Perez, 2020): CHamorus separated from their home islands are connected by a shared identity which they maintain through various means, but often via online communications and resources. Perez discusses how references to CHamoru knowledge systems, such as celestial and island navigation, are employed to help in connecting back to CHamoru heritage.
Spiritual	<p>Jurisdictional workshop participants highlighted the importance of the reefs in relation to the story of Santa Marian Kamalen, the patron saint of Guam.</p>	<ul style="list-style-type: none"> • (San Nicolas-Rocca and Parrish, 2014): Spirituality is a key component of several services that were regarded as highly important by survey respondents. These include Folklore and Medicinal practices.
Security	<ul style="list-style-type: none"> • Priest, Halford, and McIlwain, 2012: Guam's coral reef ecosystems are uniquely situated to withstand pressures from climate change such as bleaching and increased sea surface temperatures, and are considered to be important repositories of global coral reef resilience. 	<ul style="list-style-type: none"> • NOAA CRCP: Tourism on Guam accounts for 21,000 jobs annually, and about 34% of total employment, thus providing income security for a significant portion of Guam's population.
Learning/education	<ul style="list-style-type: none"> • Web of Science search((ALL=(Guam)) AND TO=("coral reef" OR coral* OR reef* OR "reef fish" OR "reef species")): 531 peer reviewed publications about Guam's coral reefs resulting in 18,000+ citations • The University of Guam Biorepository: The biorepository at the University of Guam hosts 1,800 marine specimens that have been digitized for research and educational purposes. 	<p>None to report</p>
Knowledge systems	<p>None to report</p>	<ul style="list-style-type: none"> • (San Nicolas-Rocca and Parrish, 2014): Page 10 contains a table of survey respondents ranking of types of CHamoru Cultural Knowledge. CHamoru language, Food/recipes, Ways of Life, and Music ranked highly as very important cultural knowledge. This approach allows for a more detailed look into knowledge types. • (Perez, 2020): Perez discusses how references to CHamoru knowledge systems, such as celestial and island navigation, are employed to help in connecting back to CHamoru heritage. • United States 2020 Census: 21,390 Chamorro language speakers • (Mushynsky, et al., 2022) Indigenous knowledge systems inform fishing, boating, and stewardship with the marine environment. Collaboration with Carolinian groups allows for both Carolinians and CHamorus to sustain their Indigenous fishing practices and navigation techniques.
Identity	<p>Jurisdictional workshop participants repeatedly stressed the centrality of the coral reefs to CHamoru identity, especially in light of declining mental health for CHamorus.</p>	<ul style="list-style-type: none"> • (Perez, 2020): CHamorus separated from their home islands are connected by a shared identity defined by their relationship with the ocean, which they maintain through various means, but often via online communications and resources.

Ecosystem service	Summary of values from coral reefs in Guam	Summary of values from (or focused on) other ecosystems in Guam, may include corals
Aesthetics	None to report	<ul style="list-style-type: none"> • (Perez, 2020) Perez explores how the aesthetics of CHamoru tools, technologies, and navigational methods lend structure to Tiatano’s poems. Here the ecosystem service is in the form of a poetic device.
Social relations	Jurisdictional workshop participants discussed how the way that the coral reefs have always provided for CHamoru people has informed their sense of community, specifically in their feelings of ownership about resources. One participant described how these social relations allowed Guam residents to overcome in the aftermath of Typhoon Pongsona in 2002.	<ul style="list-style-type: none"> • (Mushynsky, et al., 2022): Collaboration with Carolinian groups allows for both Carolinians and CHamorus to sustain their Indigenous fishing practices and navigation techniques. This relationship has been categorized as an example of Social Relationships, but would benefit from stakeholder identification.
Stewardship/relational	<ul style="list-style-type: none"> • NCRMP socioeconomic survey <ul style="list-style-type: none"> ○ 29% of respondents in Guam indicated that they participate in organized pro-environmental behavior at least “several times a year.” 	<ul style="list-style-type: none"> • (Mushynsky, et al., 2022) Indigenous knowledge systems inform fishing, boating, and stewardship with the marine environment.
Ecological literacy	None to report	<ul style="list-style-type: none"> • (San Nicolas-Rocca and Parrish, 2014): Although this survey was not focused on associations between cultural values and natural resources, the authors point to the importance of both terrestrial and marine resources as central to CHamoru cultural and knowledge systems.
Other	<ul style="list-style-type: none"> • NCRMP socioeconomic survey - <ul style="list-style-type: none"> ○ 83% of Guam residents indicated that they consume seafood harvested from coral reefs, with 29% indicating that they consume seafood from coral reefs at least once a week. 	None to report

Florida

Florida’s non-monetary cultural ecosystem services include Recreation/Tourism, Cultural Heritage, Mental Health, Aesthetics, Identity, Knowledge Systems, Spirituality, Security, Learning/Education, Social Relations, Sense of place, Social Capital/Social Relationships, Ecological Literacy, Social responsibility, and Stewardship. These non-monetary values also provide an enriched understanding of services for which previous work has defined monetized values, and fill gaps where the monetary ecosystem service literature was lacking.

We found two sources particularly relevant to conveying non-monetary values of Florida’s coral reefs.

- [Michaelis et al., 2021](#): Although not specifically related to coral reefs, Michaelis et al., addresses many services that could be relevant to coral reef professionals, or to any professionals that work on the water. This paper surveyed participants in oyster aquaculture in several states in the Eastern US, and in the Gulf states, including Florida. Workers were asked if they could report on any values associated with working on the water, and specifically if there were any non-monetary benefits. The researchers used semi-structured interviews, as well as Photovoice interviews, a form of interview where participants provide photos that they associate with, in this case, the values or benefits they report.
- [Stolz, Shivilani, and Glazer, 2021](#): This study demonstrates the central importance of social capital and sense of place associated with reef-based fishing and trapping. Specifically, 73% of residents in one

community in the Keys (Conch Key) reported plans to stay in Conch Key despite the risks of sea level rise. These residents opted to stay in Conch Key, despite existential threats, due to the sense of place and social networks strongly associated with their engagement with the reef.

Table 7. Non-Monetary cultural services in Florida

Ecosystem service	Summary of values from coral reefs in Florida	Summary of values from (or focused on) other ecosystems in Florida
Rec & tourism	Wallmo et al., 2021 : In 2017, there were 4,983 jobs associated with recreational fishing in Southeast Florida. In 2016, 43.5% of all recreational fishing trips in Southeast Florida (Broward, Martin, Miami-Dade, Monroe, Palm Beach) targeted reef fish - a total of 4,829,302 trips.	None to report
Cultural heritage/identity	NCRMP Florida Socioeconomic Survey, 2019 : 76.9% of South Florida residents believed that coral reefs were important or very important to their family's cultural beliefs and practices	Michaelis et al., 2021 : Respondents discussed how aquaculture carries on the maritime legacies of fishing towns by maintaining the working waterfront and sustaining other services linked to cultural heritage such as identity and sense of place.
Mental health (includes things like autonomy, subjective well-being, fulfillment)	None to report	Michaelis et al., 2021 : Interviewees reported the mental health benefits of shellfish-based livelihoods by saying it provided a sense of relief or peace, and helped to relieve anxiety .
Spiritual	None to report	Michaelis et al., 2021 : Respondents discussed how farming oysters was spiritual in the sense that it connected them with the past to a time when oysters were more common in people's diets. In this way, shellfish-based livelihoods allow for a deep connection to history and the oysters themselves .
Security	None to report	Michaelis et al., 2021 : Security was a component of the shellfish industry in that there were plenty of job opportunities and training opportunities, so farmers felt secure in their occupational choice .
Learning/education	Hesley et al., 2017 : Coral reef restoration activities involving citizen science resulted in a significant increase in participant knowledge about coral reef ecology and restoration efforts . Additionally, this research showed that the mortality rate of outplanted corals by citizen scientists was comparable to that of experts.	Michaelis et al., 2021 : Respondents discussed the learning opportunities associated with shellfish-based livelihoods such as on the job training and intergenerational learning .
Identity	None to report	Michaelis et al., 2021 : Participants described how being a shellfish farmer informed their identity , noting that it felt good to be part of a novel or cutting edge industry. Additionally, for some participants, the fact that they were shellfish farmers became their identity .
Sense of place/belonging	Stolz, Shivlani, and Glazer, 2021 : This study of residents across a few communities endangered by sea level rise found that in Conch Key, a small fishing community in the Florida Keys, 73% of interviewed residents would stay in Conch Key despite the risks of sea level rise. The authors cite the strong networks associated with fishing and lobster trapping, and the social capital that these activities have helped to build . Ultimately, lobster trappers opted to stay in Conch Key, despite existential threats, due to the sense of place developed by their engagement with the reef.	Michaelis et al., 2021 : Aquaculture informed farmers' sense of place , and also helped to preserve sense of place in some cases. For example, one interviewee discusses how shellfish-based livelihoods allow for Cedar Key, FL to remain a fishing and working waterfront town.

Ecosystem service	Summary of values from coral reefs in Florida	Summary of values from (or focused on) other ecosystems in Florida
Aesthetics	None to report	Michaelis et al., 2021 : Aesthetics was one of the services that diminished under shellfish aquaculture . Participants reported that residents and stakeholders sometimes didn't like seeing the gear above water.
Social capital/social cohesion	Shivlani, 2013 : Fishers in Florida, and especially lobster trappers, have relied on forms of social capital including bonding, bridging, and linking capital to build trust, promote collective action, foster relationships with officials, and ultimately to decrease transaction costs associated with fishing . Shivlani describes how the creation of a lobster trap certificate management program actually decreased social capital amongst fishers in the Florida Keys.	Michaelis et al., 2021 : Participants noted the strong ties they had with others in the industry , with people in adjacent industries such as the culinary industry, and with their customers.
Social relations	Smith et al., 2023 : Social networks amongst divers and culinary professionals in Florida contribute to sustaining pressure on invasive lionfish abundance on coral reefs and in communicating coral reef conservation efforts to the public.	Michaelis et al., 2021 : Participants noted the strong ties they had with others in the industry , with people in adjacent industries such as the culinary industry, and with their customers.
Stewardship	<ul style="list-style-type: none"> • Coral Restoration Foundation 2021 Annual Report: 174,264 corals outplanted since 2007, covering an area of 25,000m² • Allen, Loomis, and Vaske, 2022: Research amongst snorkelers and divers in the Florida Keys related to normative behaviors while experiencing coral reefs suggests that these groups self regulate pro-conservation behaviors. These behaviors have several implications down-stream: they are often legitimized or eventually formalized through policy, they contribute to educating new snorkelers and divers about pro-conservation actions, and individuals who exhibit strong pro-conservation behaviors may be more inclined to participate in citizen science efforts. • Harper, 2015: Amongst Florida anglers, visiting coral reefs strongly predicted sustainable seafood purchasing behaviors, more than pro-environmental attitudes, income, and education level. • Hesley et al., 2017: Coral reef restoration activities involving citizen science resulted in a significant increase in participant knowledge about coral reef ecology and restoration efforts. Additionally, this research showed that the mortality rate of outplanted corals by citizen scientists was comparable to that of experts. 	Michaelis et al., 2021 : According to participants, stewardship and feelings of responsibility towards the environment was enhanced by shellfish-based livelihoods.
Social responsibility	Allen, Loomis, and Vaske, 2022 : Research amongst snorkelers and divers in the Florida Keys related to normative behaviors while experiencing coral reefs suggests that these groups self regulate pro-conservation behaviors . These behaviors have several implications down-stream: they are often legitimized or eventually formalized through policy, they contribute to educating new snorkelers and divers about pro-conservation actions, and individuals who exhibit strong pro-conservation behaviors may be more inclined to participate in citizen science efforts.	None to report

Methods Menu

Valuation efforts in future years may require primary research to fill gaps, e.g. places within Tables 6 and 6 where no values are reported, in the monetary and non-monetary literature. To the extent that these efforts pursue non-monetary values, NOAA has requested guidance on the best choices for approaching primary valuation of these services. The Non-Monetary Cultural Ecosystem Services Literature Review provides a robust dataset to analyze which methods have been used and which have not been used across a variety of services and ecosystem types.

The [Methods Menu](#), which can be found in the Task 7: CES Literature Review and Methods Guide Google Sheet, is a tool with which NOAA can plan for future years and prioritize resources if primary research is needed for non-monetary valuations. Several methods stand out due to their frequent use in valuing non-monetary services for coral reefs. Interviews and surveys, two common approaches across the social sciences, were the most commonly applied methods used for coral reef non-monetary cultural services. The most notable difference between the methods used across the whole dataset and coral reef studies in particular is the reliance on geographical information systems (GIS) for non-coral reef ecosystems. For some services and ecosystem types, GIS methods, which include GIS, Public participation in GIS, and Participatory GIS, were very commonly used. Cultural Heritage, one of the most frequently valued services across the whole data set (n=158), was valued using GIS in 20.8% of studies (n=33). Valuations of Mountain ecosystems utilized GIS methods to value 14 services across 7 studies, which made up more than a quarter of all studies focused on Mountain ecosystems. In contrast, GIS use for coral reef ecosystem services was minimal, with only 4 services valued with GIS across 3 studies, out of a total of 74 studies. This may represent an opportunity area for primary research, or warrant further research to discern the probable cause for the lack of geospatial analysis in coral reef non-monetary ecosystem service research.

The top methods used in studies valuing coral reef non-monetary ecosystem services include Surveys, Interviews, Observations (e.g. observing tourist behavior), Other methods (unconventional or uncategorized methods), and Document Review (historical documents, works of art, etc.). The most frequently valued services for coral reefs can be seen below (Figure 2), and include an array of methods. Many studies used multiple methods, and often valued multiple services. Co-occurrence analysis can further inform which methods are used in unison, and thus may provide additional guidance when planning primary research. Further details and analysis regarding the methods used across the dataset, including visualizations, can be found in the [Analysis](#) tab of the Non-Monetary Cultural Ecosystem Services Literature Review.

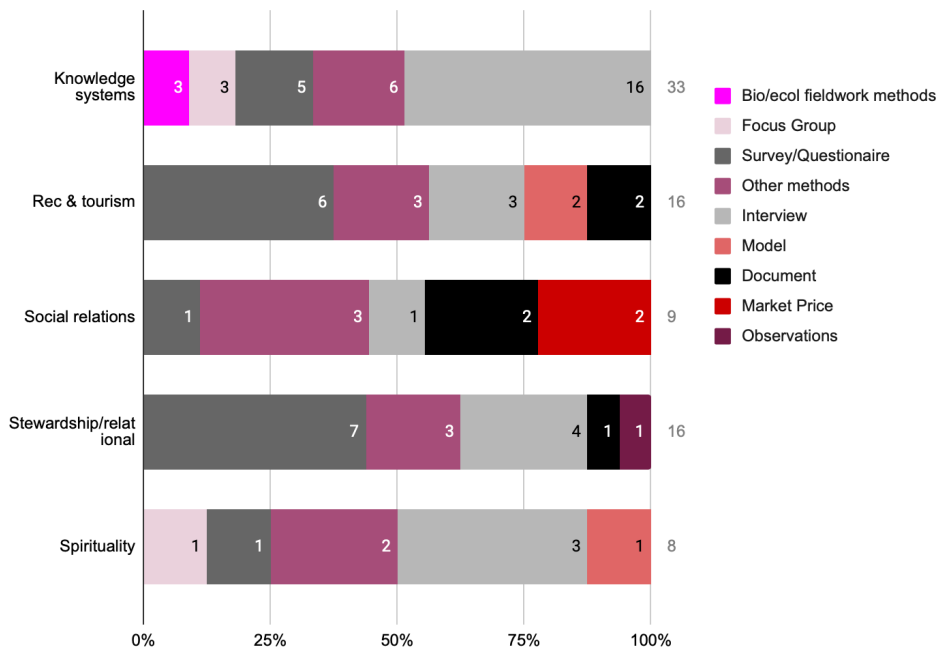


Figure 2. Top methods used to evaluate the five most frequently valued non-monetary cultural services across Coral Reef ecosystems

IV. Synthesis of Results

Comprehensively evaluating the ecosystem services requires going beyond strictly monetized valuation. While much of the coral reef ecosystem services literature has focused on applying a dollar value to services, efforts to expand the notion of value have grown in recent years and has found common ground with a number of adjacent fields such as anthropology, history, and sociology. Together, monetized and non-monetized values allow for enriched characterizations of ecosystem service values that represent and resonate with a wider audience. Work in option year one has been both instructive and constructive as future valuation in other jurisdictions will also benefit from a coupled approach to ecosystem services.

Guam

In Guam, the 2016 NCRMP Guam Socioeconomic survey found that 97% of a representative sample of residents consider coral reefs to be important to Guam’s culture, suggesting that no matter the monetized value associated with coastal protection, tourism, or fishing the services provided by the reefs will always be acknowledged. According to Storlazzi et al., (2019), the coral reefs provide an annual value of \$9.5M

to Guam in the form of coastal protection. In contrast, the University of Guam's 1,800 marine specimens, and recent research suggesting the genetic uniqueness of important fish species within Guam's coral ecosystems (Priest et al., 2012) as well as Guam's role as a stepping stone for larval transport in the wider South Pacific (Kendall, Poti, and Winship, 2019) mean that Guam's coral reefs may actually provide an incalculable value to the rest of the world by providing a unique vantage point from which to study the impacts of climate change and development on coral reefs. A per square mile Research Value of \$15,600 in nearby CNMI likely underestimates the importance of the resilience work done by Guam coral reef researchers.

Florida

The Florida Fish and Wildlife Conservation Commission (2021) reports that Florida had \$31.2M in commercial reef fishing landings for 2020. 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, Shivlani, and Glazer, 2021).

The recreation value for Southeast Florida residents' use of the coral reefs is \$67.1M (Wallmo and Allen, 2021). Non-monetary values for stewardship, a reciprocal cultural service, enrich this recreation value by informing stakeholders and decision makers about how they can be involved in sustaining coral reef recreation. For example, through a partnership with NOVA Southeastern University, the Coral Restoration Foundation (2021) reported that over 170,000 corals have been outplanted in Florida since 2007. 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 across variables including climate change perceptions, trust in food labels, seafood budget, and others, visiting coral reefs was the strongest predictor of sustainable seafood purchasing behavior amongst Florida anglers. 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 for corals in contrast to 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. A variety of threats including rising sea surface temperatures, disease, pollution, and even over-tourism, a concern highlighted by workshop participants, could reduce the value derived from corals if impacts are severe. These threats could certainly impact the monetary contribution from coral reefs if fewer people recreate, but the impacts to social networks associated with coral reef conservation would also suffer. While the latter may be more difficult to measure, it's clear that the reciprocal services delivered via these networks such as cultivating social responsibility towards marine resources (Allen, Loomis, & Vaske, 2022), or building social capital between lobster trappers (Shivlani, 2013) would be affected by declining reef health. 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 tradeoff considerations can lead to a more comprehensive understanding of the value of coral reefs in general.

Synthesizing monetary and non-monetary values for coral reefs can reveal stark contrasts between approaches and circular relationships between services. However, each valuation approach can elevate the overall value of coral reefs. Moreover, different valuation approaches and synthesized valuations for ecosystem services can resonate with a wider array of stakeholders, rights-holders, and decision makers.

V. Recommendations

Interviews

Florida and Guam have provided a baseline for synthesizing monetary and non-monetary values. Future years should explore the viability of informal or formal interviews or surveys with local stakeholders and rights-holders (e.g., tourism/recreation professionals, subsistence fishers, or snorkelers) to rank and/or characterize both monetary and non-monetary services. Additional detail such as the key locations or conditions/indicators for certain services could enrich valuations and tie them to spatially explicit areas. Interviews with key individuals within communities of coral reef users or beneficiaries could be conducted during the first few months of Option year 2. Objectives would include...

- represent holistic value and cultural benefits reefs have via key quotes or stories;
- elaborate the cultural services/benefits that were identified in literature and workshops, elaborating more on what those values are and *how* they're tied to coral reefs;
- capture how the cultural values differ between jurisdictions;
- determine whether there is a standard suite of indicators we could ask about in all jurisdictions.

Communicating non-monetary coral reef values includes a variety of approaches, some of which are included in the [Non-Monetary Valuation](#) section, e.g., the number of reef users, relationships between reef use and conservation behavior, and qualitative statements about coral reefs for key cultural groups. Incorporating quotes and stories adds to this list and also provides important context to understand these values in reef users' own terms. Such efforts not only align this valuation effort with local perspectives, but could also work to improve the understanding of economic valuation studies and their importance for decision makers and communities. The methods menu completed in this year and further analysis of best practices for non-monetary services could guide these efforts.

Primary studies / survey to improve data (both cultural and data to support monetization)

The monetary values we have developed are based on a benefit transfer approach. This has proved challenging since the studies we have used have taken place over time and have overlapping scopes. Thus, ERG recommends that NOAA explore the feasibility of developing a primary valuation study that can be implemented over all jurisdictions. Furthermore, we recommend that this study be in the form of a discrete choice experiment which will allow NOAA to assess trade-offs across ecosystem services and to allow for calculating a total value that avoids double-counting. Furthermore, the same survey (or something related) can also address cultural valuation issues by focusing on non-monetary values as well.

Visualizations

Combining data from interviews, primary studies, and benefit transfer should allow for a comprehensive view of coral reef ecosystem services within each jurisdiction. The relationships between different services, service indicators, and ecosystem components can be hard to communicate to stakeholders, rights-holders, and decision makers, so we advocate for the development of visualizations to illustrate the various pathways and ecosystem service flows. Figure 3 is the first iteration of a visualization template that can be used to represent the relationships and service flows within each jurisdiction. We recommend further discussion, exploration, and development of an evidence-based visualization tool to communicate and summarize coral reef ecosystem services following the completion of interviews, primary studies, and benefit transfer within each jurisdiction in future option years.

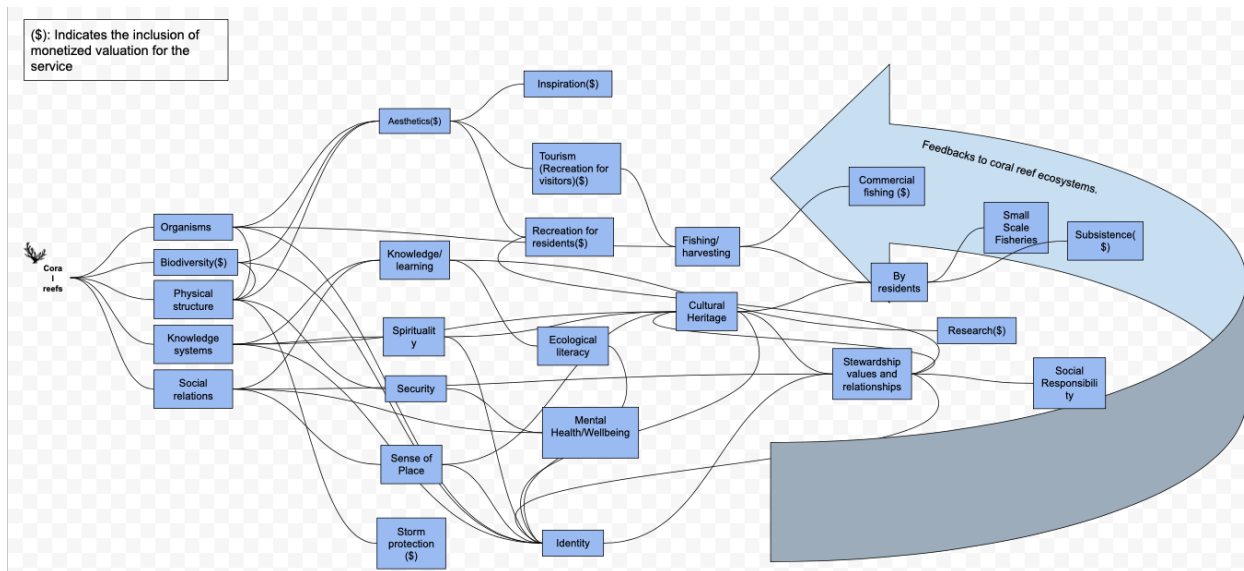


Figure 3. [Schematic of coral reef ecosystem service relationships.](#)

VI. References

- Allen, M. E., Loomis, D. K., & Vaske, J. J. (2022). Norm power of scuba diving and snorkeling behaviors in the Florida Keys. *Ocean & Coastal Management*, 228, 106300. <https://doi.org/10.1016/j.ocecoaman.2022.106300>
- Association, I., San Nicolas-Rocca, T., & Parrish, J. (2014). *Capturing and Conveying Chamorro Cultural Knowledge Using Social Media* (pp. 1489–1506). <https://doi.org/10.4018/978-1-4666-6114-1.ch074>
- Bhat, M.G., (2003). Application of non-market valuation to the Florida Keys marine reserve management. *Journal Environmental Management* 67 (4): 315-325
- Chan, Hing Ling, and Minling Pan. (2019). *Tracking Economic Performance Indicators for Small Boat Fisheries in American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands*, NOAA Technical Memorandum NMFS-PIFSC-79, <https://doi.org/10.25923/8etp-x479>.
- Cesar, H.J., and van Beukering, P. (2004) Economic Valuation of the Coral Reefs of Hawai'i.
- Estudios Técnicos. (2007). Economic Assessment of Eastern Puerto Rico's Coral Reefs and Associated Environments. San Juan, Puerto Rico
- Florida Wildlife Commission. 2021 Florida Commercial Reef Fish Data. (2021)
- Gorstein, M., Loerzel, J., Edwards, P., Levine, A., & Dillard, M. (2018). *National Coral Reef Monitoring Program Socioeconomic Monitoring Component: Summary Findings for Guam, 2016*. NOAA Coral Reef Conservation Program.
- Grafeld, S., Oleson, K., Barnes, M., Peng, M., Chan, C., & Weijerman, M. (2016). Divers' willingness to pay for improved coral reef conditions in Guam: An untapped source of funding for management and conservation? *Ecological Economics*, 128, 202–213. <https://doi.org/10.1016/j.ecolecon.2016.05.005>
- Guam Visitors Bureau. (2022). *Preliminary Visitor Arrival Statistics are compiled from the Guam Customs and Quarantine – Mandatory Customs Declaration forms*.
- Harper, J. W. (2015). The New Man and the Sea: Climate Change Perceptions and Sustainable Seafood Preferences of Florida Reef Anglers. *Journal of Marine Science and Engineering*, 3, 299–328. <https://doi.org/10.3390/jmse3020299>
- Hesley, D., Burdeno, D., Drury, C., Schopmeyer, S., & Lirman, D. (2017). Citizen science benefits coral reef restoration activities. *Journal for Nature Conservation*, 40, 94–99. <https://doi.org/10.1016/j.jnc.2017.09.001>
- Huth, W., Morgan, O.A., and Burkat, C. (2014). Measuring Florida Artificial Reef Economic Benefits: A Synthesis. Florida Fish and Wildlife Conservation Commission
- Johns, G.M., Leeworthy, V.R., Bell, F.W., and Bonn, M.A., (2001). Socioeconomic Study of Reefs in Southeast Florida.
- Johnston, R.J., Boyle, K.J., Loureiro, M.L. et al. Guidance to Enhance the Validity and Credibility of Environmental Benefit Transfers. *Environ Resource Econ* 79, 575–624 (2021). <https://doi.org/10.1007/s10640-021-00574-w>
- Kendall, M. S., Poti, M., & Winship, A. (2019). Is Guam a regional source, destination, or stepping-stone for larvae of three fisheries species? *Fisheries Oceanography*, 28(2), 159–170. <https://doi.org/10.1111/fog.12399>
- Londoño, Luz M. and Robert J. Johnston, Enhancing the reliability of benefit transfer over heterogeneous sites: A meta-analysis of international coral reef values, *Ecological Economics*, Volume 78, (2012).

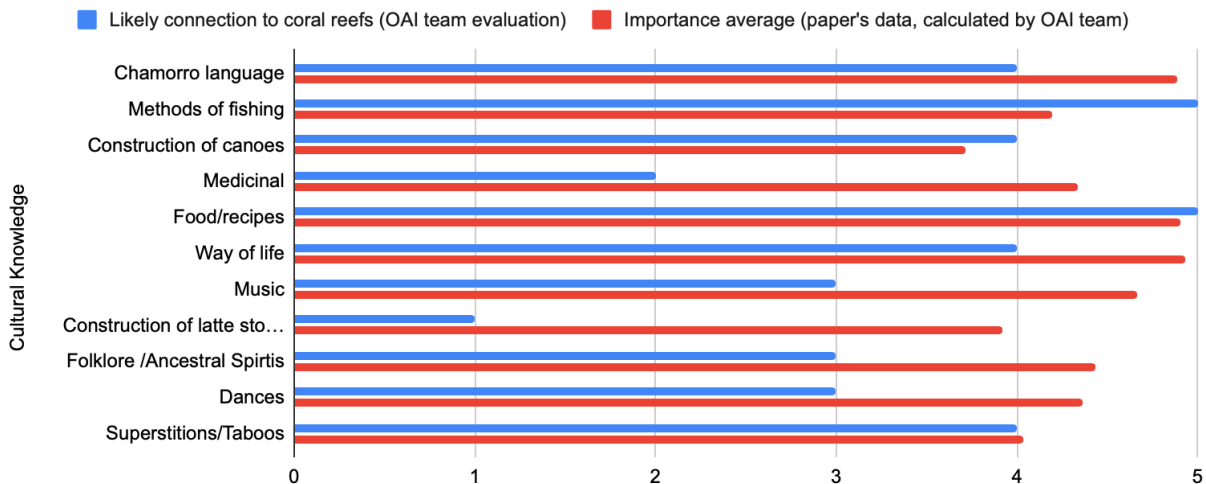
- MANOJ SHIVLANI. (2013). A Social History of Spiny Lobster Fishing and Management in the Florida Keys: Lessons for Sustainable Fishing Communities. *Proceedings of the 66th Gulf and Caribbean Fisheries Institute*.
- M.E. Allen, C.S. Fleming, B.M. Zito, S.B. Gonyo, S.D. Regan, & E.K. Towle. (2021). *National Coral Reef Monitoring Program Socioeconomic Monitoring Component: Summary Findings for South Florida, 2019*. NOAA Coral Reef Conservation Program.
- Michaelis, A. K., Walton, W. C., Webster, D. W., & Shaffer, L. J. (2021). Cultural ecosystem services enabled through work with shellfish. *Marine Policy*, 132, 104689. <https://doi.org/10.1016/j.marpol.2021.104689>
- Mushynsky, J., McKinnon, J., Cabrera, G., & Tudela, H. (2022). The foundation of island identity: Chamorro maritime practices and resistance in the Commonwealth of the Northern Mariana Islands. *AlterNative: An International Journal of Indigenous Peoples*, 18(2), 299–312. <https://doi.org/10.1177/11771801221084123>
- NOAA CRCP. (2018). *Coral reef condition: A status report for GUAM*.
- Perez, C. (2020). “The Ocean in Us”: Navigating the Blue Humanities and Diasporic Chamoru Poetry. *Humanities*, 9, 66. <https://doi.org/10.3390/h9030066>
- Pert, P. L., Thiault, L., Curnock, M. I., Becken, S., & Claudet, J. (2020). Beauty and the reef: Evaluating the use of non-expert ratings for monitoring aesthetic values of coral reefs. *Science of The Total Environment*, 730, 139156. <https://doi.org/10.1016/j.scitotenv.2020.139156>
- Priest, M. A., Halford, A. R., & McIlwain, J. L. (2012). Evidence of stable genetic structure across a remote island archipelago through self-recruitment in a widely dispersed coral reef fish. *Ecology and Evolution*, 2(12), 3195–3213. <https://doi.org/10.1002/ece3.260>
- Shivlani, M. (2013). *A Social History of Spiny Lobster Fishing and Management in the Florida Keys: Lessons for Sustainable Fishing Communities. Proceedings of the 66th Gulf and Caribbean Fisheries Institute*.
- Spalding, M., Burke, L., Wood, S.A., Ashpole, J., Hutchison, J., and zu Ermgassen, P. (2017) Mapping the global value and distribution of coral reef tourism. *Marine Policy*, 82 p.104-113
- Stoltz, A. D., Shivlani, M., & Glazer, R. (2021). Fishing Industry Perspectives on Sea-Level Rise Risk and Adaptation. *Water*, 13(8). <https://doi.org/10.3390/w13081124>
- Storlazzi, C.D., Reguero, B.G., Cole, A.D., Lowe, E., Shope, J.B., Gibbs, A.E., Nickel, B.A., McCall, R.T., van Dongeren, A.R., and Beck, W.M. (2019) Rigorously valuing the role of U.S. coral reefs in coastal hazard risk reduction: U.S. Geological Survey Open-File Report 2019-1027, 42 p.
- Tourism Economics, The Guam Traveler Economy, 2021 Results (2021), https://ghra.org/uploads/presentation/2022_GTTA_Presentation_MM.pdf
- University of Guam. (2021). *GUAM ECOSYSTEMS COLLABORATORIUM FOR CORALS AND OCEANS BIOREPOSITORY*. <https://guamepscor.uog.edu/guam-ecosystems-collaboratorium-biorepository-2/>
- US Census Bureau. (2020). *Decennial Census of Island Areas DP2SELECTED SOCIAL CHARACTERISTICS*. <https://data.census.gov/table?g=0400000US66&d=DECIA+Guam+Demographic+Profile&tid=DECENNIALDPGU2020.DP2>
- van Beukering, P., Haider, W., Longland, M., Cesar, H., Sablan, J., Shjegstad, S., Beardmore, B., Liu, Y., and Omega Garces, G. (2007) The Economic Value of Guam’s Coral Reefs.
- Wallmo, K., Lovell, S., Gregg, K., & Allen, M. (2021). *Economic Impact Analysis of Recreational Fishing on Florida Reefs*. NOAA Coral Reef Conservation Program.
- Wallmo, Kristy, and Mary Allen. Economic Valuation of Artificial and Natural Coral Reefs in Southeast Florida. Report submitted to Florida Fish and Wildlife Conservation Commission (2021)

- Wallmo, K., Edwards, P., Steinback, S., Wusinich-Mendez, D., and Allen, M. 2021. Economic Impact Analysis of Snorkeling and SCUBA Diving on Florida Reefs. NOAA National Ocean Service, National Coral Reef Conservation Program. NOAA Technical Memorandum CRCP 42. Silver Spring, MD. 48 pp. doi: <https://doi.org/10.25923/g8ex-r982>.
- WPRFMC, 2021. Annual Stock Assessment and Fishery Evaluation Report: Pacific Remote Island Areas Fishery Ecosystem Plan 2020. Remington, T., Sabater, M., and Ishizaki, A. (Eds.) Western Pacific Regional Fishery Management Council, Honolulu, Hawaii 96813 USA, 80 pp. + Appendices.

VII. Appendices

- A. [Completed literature review](#), Cultural services literature review, [gap analysis](#) and catalog of ecosystem services
- B. [Scoping Year Comprehensive Report](#)
- C. [Defensibility scoring reports](#)
- D. Local stakeholder workshops
 - a. [Guam Workshop 1](#)
 - b. [Florida Workshop 1](#)
 - c. Guam Workshop 2 (draft)
<https://docs.google.com/document/d/1pfNBP0RxxhohtwQ1axg5tdJnExF9Z7uyrGyisyMZv4c/edit?usp=sharing>
 - d. Florida Workshop 2 (draft)
https://docs.google.com/document/d/1JGWmHkiyJhJp4HAkMDf0s5F_r032zWzSb1Bult_Rxo/edit?usp=sharing
- E. [Interim report on cultural valuation methods](#)
- F. Cultural review service tables
 - a. [Guam](#)
 - i. Appendix Figure 1: The Importance of cultural knowledge in Guam, adapted from San Nicolas Rocca and Parrish, 2014.

Importance of cultural knowledge in Guam



- b. [Florida](#)
- G. [Cultural Methods Menu](#)(table)
 - a. [Analysis](#)
- H. [Benefits transfer memo and spreadsheet](#)
- I. Expert workshop reports and memo summarizing feedback
 - a. [November Workshop](#)
 - b. [February Workshop](#)