THE ECONOMIC BENEFITS OF THE PROPOSED ST. GEORGE UNANGAN HERITAGE NATIONAL MARINE SANCTUARY

EARTH ECONOMICS

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The authors are responsible for the content of this report.

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Executive Summary

This study presents an economic assessment of a potential national marine sanctuary around St. George Island, Alaska. St. George, the southern-most Pribilof Island, lies in the middle of the Bering Sea approximately 225 miles northwest of Unalaska in the Aleutian Islands. The area around St. George is extremely biologically productive, supporting vast amounts of fish, marine mammals, and birds.

Due to a variety of causes, the natural resources important to the Native Unangan people of St. George have been steadily declining. These resources are essential for residents' well-being, livelihood, and culture. One way to protect these resources is by implementing a national marine sanctuary to forge a path forward that safeguards critical natural resources while allowing sustainable uses. This report presents an assessment of the economic impacts and benefits of implementing a national marine sanctuary around St. George Island.

A National Marine Sanctuary (NMS) is a U.S. federal designation that protects a unique marine environment. To be designated as an NMS, a marine area must have ecological, scientific, cultural, historical, or educational significance. NMSs are managed to protect resources, and each has its own distinct management plan.

We assessed both market and non-market impacts of a potential national marine sanctuary using the benefit transfer method (i.e., in which existing data or information is used in settings other than that for what it was originally collected) and data on local markets. The following market impacts were assessed: employment, local spending, and commercial fisheries. Non-market impacts included subsistence harvests and other community assets, also known as ecosystem services.

Implementing a national marine sanctuary around St. George Island may have substantial effects on the local community, Alaska at large, and regions beyond Alaska. A national marine sanctuary could bring benefits such as:

- At least four full-time jobs
- $200,000 in annual government spending to support a sanctuary office
- $140,000 to $1 million in expenditures due to research grants
- $55,000 to $240,000 in annual recreation expenditures
- $22,000 to $44,000 in estimated subsistence harvest annually
- $2.8 billion to $3.3 billion in annual non-market ecosystem service benefits

Although this analysis pertains only to St. George Island, extending the sanctuary zone north to include St. Paul Island could create beneficial economic partnerships between the two communities. Finally, capitalizing on the tourism that may result from designating a sanctuary around the island could bring in big gains to the local economy. In light of this analysis, it is clear that additional monitoring, observation, and research should be implemented within the sanctuary zone.

St. George is a small community, and the natural resources its people depend on for survival are slowly disappearing. A sanctuary that aids in maintaining the resilience of the area would not only benefit St. George, but people throughout America. People are willing to pay for the knowledge that healthy and resilient ecosystems exist, an economic benefit called existence value. Ecosystems in Alaska have been shown to have immense existence value to Americans, and a sanctuary around such an enormously productive area would certainly provide existence benefits to people throughout the U.S. and even beyond.

Introduction

History of St. George Island

St. George Island is the southern-most of the Pribilof Islands, located off the west coast of Alaska in the Bering Sea. Formerly known as the Fur Seal Islands, the Pribilof Islands became well known to Russian fur traders after 1786, when Gabril Pribylov, a Russian sea captain, visited and discovered they were breeding grounds for northern fur seals.

By 1867, the Pribilof Islands were under United States control as part of the Alaska Purchase.[1] Fur seal harvesting continued, but 1869 marked the first resolution to declare protections for the fur seals on St. George and nearby St. Paul Island. By 1874, legislation establishing harvest times and quotas was in place.[2] In the coming years, sealing rights passed to various private entities: first, to the Alaska Commercial Company (1870), later to the North American Commercial Company (1890). By 1910, the U.S. Bureau of Fisheries controlled sealing, and leasing of harvesting rights to private entities had ended.[1]

Another shift in the fur seal industry occurred in 1959 with Alaska Statehood. Following statehood, 70 percent of revenue from commercial fur seal hunting shifted to the State of Alaska, thus, decreasing federal revenue from the harvests.[3] With this decline, the federal government started transitioning away from sealing at St. George Island. Nonetheless, sealing remained the island's dominant industry until the U.S. ended the commercial seal harvest in 1983 with the passage of the Fur Seal Act Amendments, which transferred control of the fur seal industry to local entities.[3,4] Since then, fur seal harvesting has been limited to subsistence or native handiwork purposes, in accordance with the 1972 Marine Mammal Protection Act.[3] After 1983, the island shifted to commercial fisheries primarily for Pollock and snow crab.

Current State of St. George Island

Ecosystems

St. George Island is surrounded by highly productive waters – what researchers call the Bering Sea's "green belt". Upwelled nutrients provide a rich habitat for plankton and support plankton productivities between 200 to 250 g C m^{-2} y^{-1} (grams of carbon per square meter per year).[5] As most ocean areas support productivities of only 50 to 100 g C m^{-2} y^{-1}, the waters surrounding St. George Island are thus extraordinarily productive. A unique circular current around St. George Island and St. Paul Island retains the water, nutrients, and plankton within approximately 30 miles of the Pribilof Islands and serves as the boundary of a zone called the "Pribilof Domain," which provides a stable basis for large populations of wildlife.[6]

The high plankton productivity sustains large fish populations, which in turn sustain marine mammals and seabirds. Over 210 species of birds make their homes in the island's cliffs,[4] 75 percent of the world's red-legged kittiwake (a threatened bird species) live on the island, and upwards of three million total seabirds are supported by ecosystems on and around St. George Island. [7] Several hundred thousand mammals spend the summer season on St. George breeding and raising young.[8] Unfortunately, several stressors threaten the long-term health of the island's ecosystems and the species that depend on them for survival.

Current Marine Management

The North Pacific Fishery Management Council (NPFMC) is one of eight U.S. councils whose purpose is to manage fisheries. NPFMC manages fisheries around St. George, the Bering Sea, and other parts of Alaska. NPFMC primarily manages groundfish, being in charge of several fisheries management plans and bycatch controls. NPFMC, together with the International Pacific Halibut Commission, also makes allocation decisions for halibut. Other Alaskan fisheries such as salmon, crab, and scallops are managed cooperatively by NPFMC and the State of Alaska.

The Western Alaska Community Development Quota (CDQ) Program was created by NPFMC to provide western Alaskan communities a venue to participate in fisheries which they could not take part of. The program allocates a portion of all quotas for groundfish, halibut, crab, and prohibited species to eligible communities. The goal of this program is to provide fisheries opportunities to communities, encourage economic development, increase social benefits for residents, and encourage sustainable and diversified economic development. St. George lies within the Aleutian Pribilof Island Community Development Association (APICDA) CDQ area.

Socio-Demographic Characteristics

The socio-demographics of St. George Island differ from other regions of Alaska in several important ways. St. George's residents are primarily Native Unangan people, making the island an important cultural stronghold, given that St. George is 1 of only 12 Aleut communities in Alaska.[9] Seals are of major significance to the local culture – approximately five hundred are harvested each year – as are other local foods such as reindeer, halibut, shellfish, and various plants.[10]

The population as a whole is in decline, and wages are significantly beneath Alaskan averages. The median age (39.5 in St. George vs. 33.8 in Alaska) is several years older than that for Alaska as a whole.[11] As seen in Table 1, employment is heavily weighted towards local government, though there are efforts to further develop commercial fishing and tourism.[10]

Totaling the number of workers in Table 1, and with approximately 80 residents (approximately 10 of which are children) on the island (Personal communication, George Pletnikoff, island native), the employment rate among adults is 77 percent, including both full-time and part-time employment.[12,13] Note, however, that the Alaska Department of Labor and Workforce Development does not factor in the duration of employment: a person is counted as a worker if they earn any wages covered under the state's unemployment system. Thus, although the official employment rate may be 77 percent, the actual employment rate is likely to be far lower, given the scarcity of full-time jobs on the island.

Figure 1. St. George Island Population (2001 - 2016) [12]

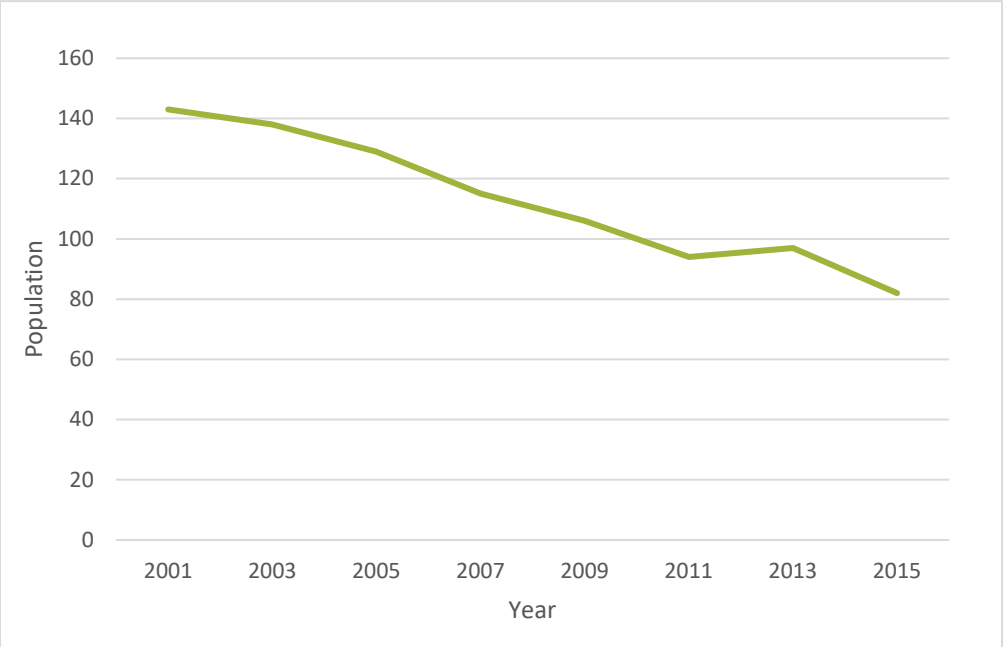


Table 1. Resident Workers by Industry (2014)[12]

Sector	Number of workers	Percent of total employment
Construction	1	1.7
Trade, Transportation and Utilities	5	8.3
Information	1	1.7
Financial Activities	3	5
Professional and Business Services	1	1.7
Educational and Health Services	5	8.3
Local Government	38	63.3
Commercial Fishing	6	10

St. George Island Community Vision

St. George's historically abundant natural resources are an integral part of the culture and way of life of the island's residents. As these resources have faced increased pressures, the island's

population has declined to the point that the school may be shut down. For those who remain, fisheries are seen both as essential to the island's economic future and as integral to the subsistence lifeway that binds their cultural heritage and community ties.[14,15]

The lifeway of St. George residents centers on a particular style of fishing known as day fishery. Unlike multi-day fisheries, day fishing crews go out to sea each day, but return home at night to be with their families and stay in their own homes. Local sentiment is that fish stocks have declined and moved farther out to sea, with the result that day fishing has become increasingly challenging for residents.[15]

If these trends continue, their cumulative impacts will have grave consequences for local culture and livelihoods. The St. George community wants to protect their community's existence, culture, and the ecosystems that sustain them. One way to do that is by bringing together native communities and other stakeholders to discuss and plan a sustainable future for St. George Island and the ecosystem on which it depends.

On July 1, 2016, the City Council of St. George unanimously passed a resolution stating that, "Urgent action is being taken and will be taken to save our Community and the resources we depend upon, and that we will immediately begin to pursue all appropriate measures, including, the creation of a National Marine Sanctuary, to protect our Home."

Why Create a National Marine Sanctuary Around St. George Island?

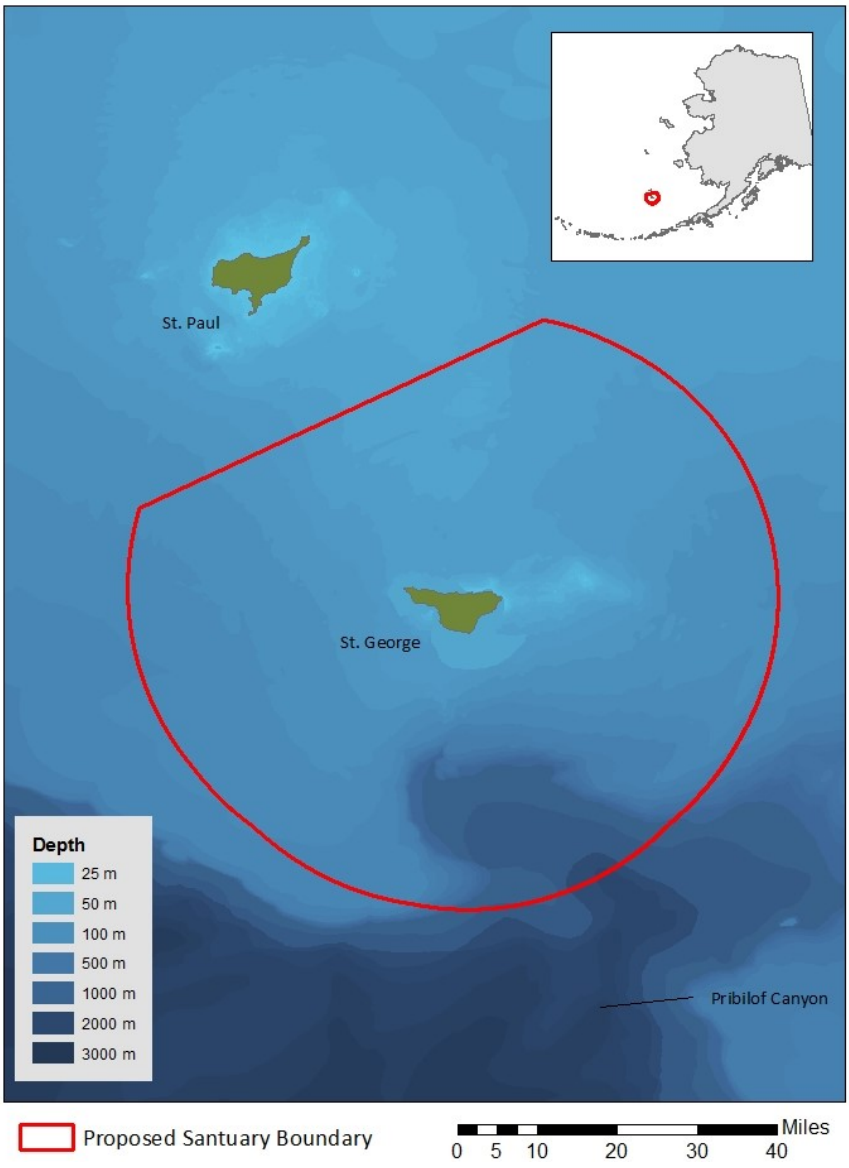
A National Marine Sanctuary (NMS) is a federal designation under the National Atmospheric and Oceanic Administration (NOAA) that provides protection to a marine area with unique conservation, ecological, recreational, historical, cultural, educational, aesthetic, or scientific quality. The goal of a NMS is to help protect marine ecosystems from the impacts of climate change, ocean acidification, and human activities. Sanctuaries also promote public education and awareness about their marine ecosystems.[16] Currently, there are 13 NMSs across the United States that cover more than 170,000 square miles of waters.[17]

The National Marine Sanctuary (NMS) nomination process enables communities to submit NMS nominations. NOAA designates sanctuaries only after conducting detailed consultations with all relevant stakeholders (government, industry, research institutions, etc.). The proposed St. George sanctuary, just like other NMSs, would have its own superintendent, advisory council, and staff, which see to creating and updating a balanced sanctuary management plan which takes into account existing regulations and management tools, monitoring, research, and education specific to the needs of the area.[16] Fisheries management decisions would remain under the authority of the NPFMC. No activities would be automatically prohibited.

This would also be the first national marine sanctuary in Alaska. Introducing a national marine sanctuary around St. George Island would enable integrated management of the extremely ecologically important area around St. George, providing benefits to the community, greater Alaska, and regions beyond.

The boundaries for the proposed NMS encompass a 30-mile radius around the island, with the exception of the north end, which would be limited to a 20-mile distance from St. George Island. Figure 2 shows the boundary of this hypothetical sanctuary zone.

Figure 2. Proposed St. George Island National Marine Sanctuary Map



Economic Contribution of a National Marine Sanctuary

Implementation of an NMS around St. George Island would provide economic benefits to the island community. Spending introduces direct effects on a local economy. Direct effects from initial spending (e.g., lodging expenses) create additional activity (also known as indirect effects) within the local economy in the form of income for workers, additional jobs, and further contributions. Due to data limitations, only the direct effects (i.e., those from initial spending) of implementing a National Marine Sanctuary will be considered in this report.

Government Expenditures

If an NMS were established around St. George, then a local sanctuary office would also need to be established to manage the sanctuary. The government revenue brought in for management purposes would generate a direct impact on St. George's economy. Because St. George Island is such a small community and the proposed sanctuary coverage is relatively small, we selected the three smallest sanctuary offices for comparison: Monitor National Marine Sanctuary, National Marine Sanctuary of American Samoa, and Cordell Bank National Marine Sanctuary.

The annual operating budgets of Monitor and Cordell Bank NMSs are approximately $600,000 to $700,000.[18] The operating budget of the NMS of American Samoa began at approximately $200,000 annually,[19] and increased steadily to a current budget of about $1.2 million annually.[i]

The NMS of American Samoa is the most remote of these three sanctuaries. Because St. George is also quite remote, it is reasonable to suggest that the initial annual budget of a sanctuary at St. George may be around $200,000, with increases in that amount over time as the office becomes more established. Such an increase in federal expenditures would bring in skilled labor, increase the population, increase expenditures at local businesses, and likely reduce the home vacancy rate, which is currently above 50 percent.[12]

Employment

Creating an NMS around St. George Island would be likely to result in additional jobs on the island. NOAA would establish a local sanctuary office for management purposes. To estimate the resulting employment impact, we collected information on NMS employment from public information in NOAA and Sanctuary Management Plans.

Monitor and Cordell Bank employ six and five full-time staff, respectively. However, it should be noted that Cordell Bank had no dedicated staff in the first six years after its designation, and

[i] Oral input from William Douros, West Coast Region Director, ONMS, NOAA.

was funded by the Gulf of Farallones National Marine Sanctuary until it received its own budget.[18] The most remote sanctuary, NMS of American Samoa, supports four staff members.[19]

Given these examples, it is reasonable to suggest that creating a sanctuary around St. George Island may produce at least four jobs at the sanctuary office within five years of establishment. If filled by St. George residents, these positions would have maximal direct benefit on the economy of the island. Nonetheless, these jobs would bring more spending into the local economy, which would generate indirect benefits, the estimation of which is beyond the scope of this report.

Fundraising and Grant Income

A potential source of additional funding could arise from scientific projects conducted within the sanctuary. St. George Island and the surrounding waters have a long history of hosting important scientific studies by researchers from around the world. It is difficult to determine the extent to which sanctuary designation could generate additional scientific funding. Following the methodology produced by Scorse and Kildow (2014) [20], total awards could be anywhere from about $140,000 to a little more than $1 million, with an average of about $585,000.

Commercial Fisheries

The area around St. George Island generates a great deal of revenue for commercial fisheries as the waters provide important habitat for the largest fishery by volume in the U.S.: walleye pollock.[21] Fishing-related income for St. George residents, however, is small.[14] As of 2015, only six people from St. George were participating in commercial fishing, with average gross earnings of about $36,000 per person.[22]

Island residents have had difficulties generating revenue from the bountiful harvests extracted from the island's surroundings. The harbor is challenging for commercial vessels to navigate. Combined with unreliable processing services and poor shipping infrastructure, commercial fishing has proven to be a difficult way for St. George residents to make a living.[14] However, supporting other commercial fishing vessels in the region did provide considerable employment for a period of time.

In the 1990s, processing snow crab and supporting fishing vessels was lucrative for the island's residents. However, snow crab fishing subsequently crashed, reducing the demand for processing and support services. Subsequent heavy damage to the harbor prevented the remaining processor from docking on the island and halted St. George's meaningful participation in the commercial fishing value chain.[14] Therefore, St. George sees very little of

the revenue generated from the bountiful commercial fish harvests from the island's surrounding waters. However, St. George receives from benefits from the APICDA CDQ.

Recreation Expenditures

St. George Island provides exceptional opportunities for recreational birding as it hosts essential breeding habitat for millions of seabirds. The National Audubon Society has designated two Important Bird Areas (IBA) on the island and its surrounding waters: The St. George Island Colony IBA and St. George Island Marine IBA.[23]

The designation of a national marine sanctuary at St. George Island is likely to boost local tourism, as this designation signals to the public that the site has unique natural resources. There is also evidence that tourism can increase if marketing and branding are developed after a site is designated as a protected area.[20]

To determine the potential effect of increased tourism on the St. George Island economy, we sought to analyze current recreational expenditures. People who come to St. George Island for birdwatching or other recreational or tourism purposes spend money that circulates through the local economy. To estimate recreationists' average expenditures during trips to St. George Island, we collected data from The McDowell Group's statewide analyses for Alaska's tourism economy. One component of their work is a statewide survey on visitor expenditures.[24] No visitors to St. George Island were surveyed. However, visitor expenditures for Dutch Harbor and St. Paul Island were available. We averaged expenditures for categories other than transportation, as most transportation expenditures would not find their way into the St. George economy. Another estimate of visitor expenditures was obtained from George Pletnikoff, island native (personal communication). This expenditure data was combined with visitor estimates from the eBird database to estimate the total expenditures from tourists in the study area.

Visitors to St. George Island spend approximately $550 to $1,200 per trip in lodging, entertainment, gifts, and food expenses.[24] Assuming that 100-200 people were to travel to St. George for recreation in a year, a reasonable assumption given the significance of a National Marine Sanctuary designation, recreationists annually would expend about $55,000 to $240,000 directly into the local economy. It should be noted that these recreationists come from all over the U.S. and other countries. Attracting tourists world-wide would produce massive benefits for St. George and benefit other countries by providing unparalleled recreational activities.

Summary

In summary, operating funding for a sanctuary office, fundraising and grant income for the purpose of sanctuary research, and increased recreational expenditures by tourists could create economic contributions to the St. George Island community of $395,000 to $1,440,000 annually.

Economic Benefits of a National Marine Sanctuary

St. George's economy operates within and relies on the natural capital of the island and its surrounding marine waters. The healthier these ecosystems are, the more likely it is that St. George's economy will thrive. Though it has long been recognized that environmental degradation can cause economies to falter, natural capital has generally been overlooked in economic accounting. Natural capital provides immense value to communities and the economy in the form of ecosystem goods and services. This chapter introduces the concepts of natural capital and ecosystem goods and services and analyzes the economic benefits of the natural capital of St. George Island and its surrounding waters in the context of implementing a national marine sanctuary.

Introduction to Natural Capital and Ecosystem Services

Natural capital is the foundation for all other forms of capital and for economies. A robust and resilient economy requires that natural capital and other forms of capital are healthy and work productively and synergistically. As the foundation for all other types of capital, natural capital is particularly important, yet frequently overlooked. It consists of any "minerals, energy, plants, animals, ecosystems, [climatic processes, nutrient cycles, and other natural structures and systems] found on Earth that provide a flow of natural goods and services."[25]

Like any form of capital, natural capital provides flows of goods and services. The infrastructure and assets of any given ecosystem perform functions that provide goods and services that humans need to survive. For example, natural capital assets of an ocean (e.g., water, fish, continental shelf) perform critical functions such as nutrient cycling, maintenance of coastal currents, and provide essential spaces for habitat. These processes support goods and services such as food, navigation, and healthy ocean habitats, which all provide benefits to people.

Figure 3 illustrates the relationship between natural capital assets, ecosystem functions, and the production of ecosystem goods and services.

Figure 3. Goods and Services Flow from Natural Capital

Ecosystem goods and services are the benefits people derive from ecosystems. Beneficiaries of ecosystem services can be both local and global. For example, subsistence harvests are an ecosystem good that benefits local populations participating in the activity. Climate stability provides benefits that affect communities all over the world. Additionally, people place value

on the fact that ecosystems, biodiversity, or specific species simply exist, even though they may never see it or use it.[26] Most of nature's goods and services are largely taken for granted. Navigable waters, nourishing food, and stable atmospheric conditions are all prime examples of underappreciated ecosystem goods and services.

A Framework for Assessing Ecosystem Services

Over the last 15 years, considerable progress has been made in systematically linking functioning ecosystems with human well-being. Early work on understanding the interactions between ecological and social systems laid the groundwork for a conceptual framework for valuing natural capital and ecosystem goods and services.[27]

Earth Economics' approach to valuation is adapted from this effort. The framework that we use clearly articulates and values the vast array of critical services and benefits that natural capital provides. Under this framework, the four categories of ecosystem goods and services, which are now commonly used in the field of ecological economics, are as follows:

- ***Provisioning goods and services*** provide physical materials and energy for society that vary according to the ecosystems in which they are found. Forests produce lumber, agricultural lands supply food, and rivers provide drinking water.

- ***Regulating services*** are benefits obtained from the natural control of ecosystem processes. Intact ecosystems keep disease-causing organisms in check, maintain water quality, control soil erosion or accumulation, and regulate climate.

- ***Supporting services*** include primary productivity (natural plant growth) and nutrient cycling (nitrogen, phosphorus, and carbon cycles). These services are the basis of the vast majority of food webs and life on the planet.

- ***Information services*** are functions that allow humans to interact meaningfully with nature. These services include providing spiritually significant species and natural areas, natural places for recreation, and opportunities for scientific research and education.

Table 2 defines the four categories and 21 distinct ecosystem services of Earth Economics' framework.

Table 2. Earth Economics' Ecosystem Services Classification

Service	Economic Benefit To People	Example in a Marine Context
Provisioning		
Energy and Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy	Sand, salt, or algae used for non-food purposes
Food	Producing crops, fish, game, and fruits	Fish, shellfish, and seaweed used for the specific purpose of human consumption as food
Medicinal Resources	Providing traditional medicines, pharmaceuticals, and assay organisms	Marine-derived pharmaceuticals
Ornamental Resources	Providing resources for clothing, jewelry, handicraft, worship, and decoration	Shells, pearls, aquarium fish, or coral
Water Storage	Providing long-term reserves of usable water via storage in lakes, ponds, aquifers, and soil moisture[28]	Long term storage of water in icebergs, glaciers, and shorefast ice sheets.
Regulating		
Air Quality	Providing clean, breathable air	Removal of air pollutants such as particulate matter by coastal and marine ecosystems
Biological Control	Providing pest, weed, and disease control	The role of larger predators in limiting the populations of opportunistic species like jellyfish or squid
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes	The consumption of greenhouse gasses such as carbon dioxide by marine phytoplankton and algae and the sequestration of carbon in mangroves, seagrass beds, and deep ocean sediments
Disaster Risk Reduction	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts	The reduction of damages caused by storms by coral reefs, seagrass beds and mangroves
Pollination and Seed Dispersal	Pollinating wild and domestic plant species via wind, insects, birds, or other animals	The dispersal of spawned gametes or larvae by midwater or surface currents to suitable ecosystems
Soil Formation	Accumulating soils (e.g.,. via plant matter decomposition or sediment deposition in riparian/coastal systems) for agricultural and ecosystem integrity	The natural erosion and flow of sediment which creates sand bars
Soil Quality	Maintaining soil fertility and capacity to process waste inputs (bioremediation)	The role of nutrient cycling within the ocean to enrich ocean bottom sediments
Soil Retention	Retaining arable land, slope stability, and coastal integrity	Near-shore macro-algae forests result in the reduction of scouring potential
Water Quality	Removing water pollutants via soil filtration and transformation by vegetation and microbial communities[29]	Filtering coastal water by shellfish and the role of nutrient cycling within ocean waters to produce healthy marine habitats
Water Capture, Conveyance, and Supply	Regulating the rate of water flow through an environment and ensuring adequate water availability for all water users[29]	The effect of marine vegetation on localized currents
Navigation	Maintaining adequate depth in a water body to sustain traffic from recreational and commercial vessels	Providing space and deep channels used for shipping
Supporting		
Habitat	Providing shelter, promoting growth of species, and maintaining biological diversity	Breeding habitat used by valuable species such as halibut

Information		
Aesthetic Information	Enjoying and appreciating the scenery, sounds, and smells of nature	Visual features of open water or beaches that appeal to individual observers
Cultural Value	Providing opportunities for communities to use lands with spiritual, religious, and historic importance[30]	The contribution of marine ecosystems to cultural traditions such as subsistence uses for fish or marine mammals
Science and Education	Using natural systems for education and scientific research	Utilization of marine animal swimming mechanisms in engineering design
Recreation and Tourism	Experiencing the natural world and enjoying outdoor activities	Bird or whale watching, SCUBA diving, sailing, etc.

Source: Compiled from Daly and Farley 2004, de Groot 2002, and Boehnke-Henrichs et al. 2013.[31, 32, 33]

The Importance of Valuing Ecosystem Services and Accounting for Natural Capital

Understanding and accounting for the value of natural capital assets and the ecosystem services they provide can reveal the economic benefits of investment in natural capital. Natural systems have only recently begun to be viewed as economic assets that provide economically valuable goods and services. Yet when these valuable goods and services are lost, people face increased risks and costly expenditures. In some cases, lost ecosystem goods and services are irreplaceable. This is particularly true when natural resources have historical and spiritual ties, as is true for the Unangan of St. George.

Throughout economic history, developing new means of measuring factors relevant to the status of economies has been necessary. In 1930, nations lacked measures of gross domestic product (GDP), unemployment, inflation, consumer spending, and money supply. Additionally, only after the 1930s were benefit-cost analysis and rate of return calculations invented to compare government investments in built capital assets such as roads, power plants, factories, and dams. Without these now standard economic tools and measures, both private and public decision makers were once investment-blind.

Today, a new type of economic assessment is necessary for effective investment planning: valuation of natural capital assets and ecosystem services. This concept has recently been recognized at a federal level. In 2015, the White House issued a memorandum that directed federal agencies to include the value of natural capital, ecosystem services, and green infrastructure into their decision making and planning. This is a major step towards taking nature into account in standard decision-making tools at all scales.

Today, there are economic methods available for valuing natural capital and many non-market ecosystem services.[ii] When valued in dollars, these services can be incorporated into economic tools such as benefit-cost analysis, accounting, environmental impact statements, asset management plans, conservation prioritization, and return on investment calculations. Inclusion of these values ultimately strengthens decision-making. When natural capital assets and ecosystem services are not considered in economic analysis, they are effectively valued at zero. Failure to consider natural capital can lead to inefficient capital investments, higher incurred costs, and poor asset management.[34,iii]

Natural capital sustains communities and economies. Without healthy natural capital, many of the services that we receive for free could not exist. Once lost, these services must be replaced with costly built capital solutions, which are often less resilient and shorter-lived. For example, the push to build desalination plants in California to replace water resources lost to drought. When we lose natural capital, we also lose the economic goods and services it provides.

Subsistence Lifeways on St. George Island (Cultural Value)

The subsistence lifeway is an essential part of the culture and society on St. George Island. Huntington et al. defines subsistence as "the taking of fish, wildlife or other wild resources for the sustenance of families, communities and cultures."[35] Not only does the subsistence harvest fulfill the majority of dietary requirements for residents, but it is essential to the St. George community's Unangan culture and social fabric.[6]

The significance of subsistence harvest on St. George Island is evident from the Alaska Department of Fish and Game's (ADFG) harvest records (Table 3). Approximately 5,000 pounds are harvested annually for subsistence purposes, including fish, marine mammals, birds, and eggs. This amounts to approximately 63 pounds per person each year, based on an assumption of a population size of 80 people.

We stress that the values below do not represent the full benefits that residents of St. George Island receive from participating in subsistence activities. Recent research on the island suggests that residence on St. George Island is a non-economic decision.[35] That said, the ability

[ii] Ecosystem services includes market goods such as fish and timber which are traded in markets. They also include non-market services, or goods not traded in markets, such as clean air and water, flood risk regulation, and climate stability which are not traded in economic markets. The only way to show their value is to rely on non-market valuation methods such as contingent valuation (e.g. surveys).

[iii] The same is true when *built* assets are not considered in economic analysis or asset management. See for example Grubisic, M., Nusinovic, M., Roje, G., 2009. Towards efficient public sector asset management. Financial Theory and Practice 33, 329-362. Available at: http://www.fintp.hr/en/archive/towards-efficient-public-sector-asset-management_283/

of the island and its surrounding waters to provide subsistence foods to the whole St. George community is inextricably linked to the continued existence of the island's native Unangan culture.

The market value of subsistence harvests is a simple way of demonstrating the importance of this community asset. If communities are not able to rely on subsistence harvest to provide sustenance, substitutes would have to be purchased from elsewhere. Thus, a simple estimate of the value of subsistence harvests is to assume a replacement cost. To estimate the annual amounts of subsistence harvests for halibut, fur seal, and a number of other marine species, birds, and plants, we gathered data from the ADFG's subsistence dataset, Short (2016), and personal communication with St. George residents. Table 3 shows the results listed in estimated total pounds of each resource gathered. To estimate the replacement cost of this harvest, we assumed a replacement cost of $4 dollars per pound to $8 dollars per pound based on previous studies on subsistence in Alaska.[36] The resulting estimate is $21,000 to $42,000 annually in subsistence harvests.

Table 3. Subsistence Harvest and Replacement Value on St. George Island

Subsistence Resource	Lbs Harvested	Low Value (at $4/lb)	High Value (at $8/lb)
Halibut	490	1,960	3,920
Fur Seal	1,800	7,200	14,400
Steller Sea Lion	1,800	7,200	14,400
Pink Salmon	550	2,200	4,400
Pacific Cod (gray)	200	800	1,600
Hair Crab	80	320	640
Red Legged Kittiwake	70	280	560
Unknown Sculpin	65	260	520
Common Murre	50	200	400
Tanner Crab, Bairdi	35	140	280
Red-Faced Cormorant	30	120	240
Emperor Geese	15	60	120
Black Legged Kittiwake	15	60	120
Unknown King Crab	15	60	120
King Eider	10	40	80
Sea Urchin	5	20	40
Harlequin Duck	5	20	40
Common Murre Eggs	5	20	40
Grouse	3	12	24
Least Auklet Eggs	1	4	8
Blue Mussels	1	4	8
Total	***5,245***	***20,980***	***41,960***

Research shows that ecosystem restoration increases ecosystem functions and service provisioning. [37] Research suggests provisioning services can increase by four percent.[37] In this

case, the value of subsistence harvest in a protected sanctuary zone may increase to almost $22,000 to $44,000 annually.

Attaching a dollar value to subsistence harvests is difficult since these products do not enter markets. The numbers we provide in this section are simply the replacement cost of the subsistence harvest from St. George and do not necessarily reflect the actual value of subsistence to the community. For example, replacement cost does not include the cultural value people place on participating in subsistence activities or the importance of subsistence in the community's traditions and history. Placing economic value on important cultural activities such as this can be difficult and controversial.

Food

Ecosystems also support food production for commercial purposes. The waters near St. George Island provide critical habitat for several important commercial fish species, including walleye pollock, which supports the largest fishery in the U.S. by volume.[21] Hence, the waters within the proposed sanctuary zone have national, if not global, significance. They are also home to Pacific cod, halibut, other groundfish, and snow crab, all of which are also commercially important. Working in cooperation with the NPFMC, the NMS would enhance opportunities for monitoring, observation and research that would benefit the management of the fisheries, as well as other aspects of the ecosystem, particularly in the face of climate change.

Other Ecosystem Services

This report also estimates the economic benefits from other ecosystem services not easily traded in markets. These services include medicinal resources, biological control, habitat, climate stability and nutrient cycling.

Methods and BTM

The benefit transfer method (BTM) is broadly defined as "...the use of existing data or information in settings other than for what it was originally collected".[38] Within the field of ecological economics, this method is a validated, well-established approach for indirectly estimating the value of ecological goods or services. BTM can generate reasonable ecosystem services estimates quickly and at a fraction of the cost of conducting primary analysis. Frequently, BTM is the most practical option for producing reasonable estimates in an ecosystem services valuation.[39]

The BTM process involves taking ecosystem service values from comparable ecosystems as found in peer-reviewed journals and transferring them to a study site, in this case, St. George Island.[40] The BTM process is similar to a home appraisal, in which the value and features of

comparable, neighboring homes (e.g., two bedrooms, a garage, one acre, recently remodeled) are used to estimate the value of another home. As with home appraisals, BTM results include a degree of uncertainty, but the process quickly generates reasonable values appropriate for policy and project analysis.

The first step in the process is to identify ecosystems present in the study area. We calculated the acreages of three marine ecosystem types in the area based on bathymetry and ocean cover: continental shelf, open ocean, and deep sea. The area within the proposed sanctuary boundary is approximately 4,220 square miles.

Next, we selected primary studies with comparable climatic and marine ecosystem classifications as those within the study area. Any primary studies deemed to have incompatible assumptions or ecosystem types are excluded. Individual primary study values are adjusted and standardized for units of measure, inflation, and ecosystem classification type to ensure an "apples-to-apples" comparison.

Earth Economics maintains a comprehensive database of published, peer-reviewed primary valuation studies and scientific literature for use in benefit transfer analysis.[iv] Each study in the database uses techniques developed and vetted within environmental and natural resource economics communities over the last four decades. Earth Economics used several criteria to select appropriate primary study values for St. George Island, including geographic location, latitude, demographic characteristics, and ecological characteristics of the primary study site.

All values included in this analysis were sourced from studies conducted in marine ecosystems. Where available, ecosystem valuation studies based in latitudes above the Tropic of Cancer (~23^{o} N) were given preference. Where local studies were not available, ecosystem services valuations conducted within the greater United States were then prioritized. In the cases where no local or national figures were available, suitable studies from countries outside the United States or global estimates were used. This careful filtering process ensures that estimates from areas with considerably different ecologies or demographics were excluded.

Once compiled, all ecosystem service values were then standardized to 2015 United States dollars using Bureau of Labor Statistics Consumer Price Index inflation factors.

The annual flow of value can be used to determine the proposed sanctuary's asset value into the future. Provided the natural capital of the St. George region is not degraded or depleted, the annual flow of ecosystem services will continue into the future. Just as with built capital, we can calculate the asset value of natural capital in the proposed sanctuary.

[iv] Earth Economics Ecosystem Valuation Toolkit (EVT). More information available at www.esvaluation.org.

Asset values provide a measure of the expected benefits flowing from natural capital over time. The net present value allows a comparison of benefits that are produced at various points in time. To calculate the net present value, a discount rate must be used.

Discounting allows sums of money from different time periods to be compared by expressing the values in present terms. In other words, discounting shows how much future sums of money are worth today. Discounting is designed to take two major factors into account:

- Time preference: people tend to prefer consumption now over consumption in the future, meaning a dollar today is worth more than a dollar received in the future.
- Opportunity cost of investment: investment in capital today provides a positive return in the future.

However, experts disagree on the appropriate discount rate for natural capital benefits.[41, 42] For example, the Federal Office of Management and Budget uses a standard rate of 7%. High discount rates such as this causes benefits far in the future to be highly discounted and can tremendously affect projects that consider costs and benefits over long time periods. Other federal agencies such as U.S. Army corps and NOAA use discount rates around 3 or 4 percent.[43, 44] As natural capital can produce benefits for hundreds of years, this issue is particularly relevant to this work. We chose to present the asset value using a range of discount rates to reflect these effects.

Net present values can be calculated over different timeframes depending on the purpose of the analysis and the nature of the project. In the case of natural capital valuations, ecosystems are self-maintaining, stable over long periods, and continuously productive as long as they remain unimpaired. Although arbitrary, we chose a timeframe of 100 years for the NPV calculation. It is, however, worth noting that, if kept healthy, the natural capital of the proposed sanctuary will continue to provide benefits well beyond 100 years into the future.

The asset value calculated in this report is based on a snapshot of the current ecosystems, consumer preferences, population base, and productive capacities. As such, it does not consider the possibility of future environmental degradation or change in value due to scarcity. Rather, it assumes that the ecosystems near St. George will remain the same over 100 years.

Valuation Results

Although there are a total of 21 ecosystem services in existence (see Table 4), this section focuses solely on those services for which values are available in the literature. Oceanic ecosystem services have not been studied with as much depth as terrestrial ecosystems. The waters surrounding St. George Island certainly have research value, given the number of academic studies of the area. However, no academic papers have provided information that

can be translated into a per acre value, making value transfer for this service an intractable problem. Given the data gaps for this ecosystem services valuation (ESV) it is expected that the valuation provided here is an underestimate of the full value of the ecosystem.

Table 4. Ecosystem Services and Marine Ecosystem Types which were Valued in this Report

	Continental Shelf	Deep Sea	Open Ocean
Provisioning			
Energy & Raw Materials			
Food			
Medicinal Resources			X
Ornamental Resources			
Water Storage			
Regulating			
Air Quality			
Biological Control	X		X
Climate Stability	X		X
Disaster Risk Reduction			
Pollination & Seed Dispersal			
Soil Formation			
Soil Quality (Nutrient Cycling)	X		
Soil Retention			
Water Quality (Nutrient Cycling)			X
Water Capture, Conveyance, & Supply			
Navigation			
Supporting			
Habitat & Nursery	X	X	X
Information			
Aesthetic Information			
Cultural Value			
Science & Education			
Recreation & Tourism			

Key	
Ecosystem Service Exists on Marine Ecosystem Type	
Ecosystem Service Exists and is Valued for a Marine Ecosystem Type	X

In the literature review, values for nutrient cycling were selected for the ESV. These fell under both the soil quality and water quality categories, as the studies valued the quality of different parts of marine ecosystems. Ocean water quality is important to keep pelagic species healthy, but soil quality of ocean sediments is also important to marine life. Benthic, or bottom-living, species have some of the highest biodiversity of species groups in the ocean.[45] Especially in deep-sea habitats, where food is scarce, availability of nutrients is essential to support this biodiversity. For clarity, we separate nutrient cycling into these two ecosystem services, as seen in Table 5.

Due to lack of Alaska-specific studies, we took the minimum value in each ecosystem service and marine ecosystem category as a value estimate. This approach provides conservative estimates of ecosystem services in the study area.

Annual Value

Given the declines in some of the key food web components in the area, we assumed that sanctuary status would promote recovery of the ecosystem and the services it provides. Research on post-restoration ecosystem service provision indicates that habitat values can increase by 28 percent following restoration. Biological control, soil quality, water quality, and carbon sequestration services increase by 20 percent, and medicinal resource services increase by approximately 4 percent.[37]

Table 5. Baseline Annual Ecosystem Services by Ecosystem Type ($/Acre/Year)

Ecosystem Service	Continental Shelf	Deep Seabed	Ocean/Sea
Habitat		$ 38	$ 58
Biological Control	$ 23		$ 3
Soil Quality (Nutrient Cycling)	$ 879		
Water Quality (Nutrient Cycling)			$ 70
Medicinal Resources			$1
Carbon Sequestration	$ 10		$ 0.01
Total	**$ 913**	**$ 38**	**$ 131**

Table 6. Restoration Adjusted Annual Ecosystem Service Values by Ecosystem Type ($/Acre/Year)

Ecosystem Service	Continental Shelf	Deep Seabed	Ocean/Sea
Habitat		$49	$75
Biological Control	$28		$4
Soil Quality (Nutrient Cycling)	$1,054		
Water Quality (Nutrient Cycling)			$84
Medicinal Resources			$1
Carbon Sequestration	$12		$0.01
Total	**$1,082**	**$49**	**$164**

Table 7. Ecosystem Services in the Study Area by Ecosystem Type

Marine Ecosystem Type	Acres	Baseline (USD/acre/year)	Restored (USD/acre/year)	Total Baseline (USD/year)	Total Restored (USD/year)
Continental Shelf	2,657,489	913	1,082	2,426,287,457	2,875,403,098
Deep Seabed	43,878	38	49	1,667,364	2,150,022
Ocean / Sea	2,701,367	131	164	353,879,077	443,024,188
Totals				**2,781,833,898**	**3,320,577,308**

Table 8. Ecosystem Services (USD/Year) in the Study Area by Service

Ecosystem Service	Baseline	Restored
Habitat	$158,346,650	$204,752,547
Biological Control	$69,145,307	$85,215,160
Soil Quality (Nutrient Cycling)	$2,335,932,831	$2,800,993,406
Water Quality (Nutrient Cycling)	$189,095,690	$226,914,828
Medicinal Resources	$2,923,238	$2,701,367
Carbon Sequestration	$26,601,904	$31,916,882

Asset Value

Natural capital assets within the study area, such as the continental shelf and deep seabed provide an enormous amount of value to the surrounding region. The asset value over 100 years was calculated for both the restored scenario and the baseline scenario within the proposed sanctuary. If the proposed sanctuary promotes restoration and resilience within its boundary, the asset value of ecosystem services may increase by roughly 19%.

Table 9. Total Asset Value of the Proposed St. George National Marine Sanctuary ($ Billions)

Discount Rate	Baseline Scenario	Restored Scenario
0%	$278 B	$332 B
3%	$ 86 B	$ 102 B
4.25%	$ 62 B	$ 74 B

Conclusion & Recommendations

Summary and Implications

Designation of a marine sanctuary around St. George Island could have great contributions on the community and the local economy. The creation of a sanctuary could bring in at least four direct jobs, and potentially $395,000 to $1,440,000 annually in expenditures into the local economy. These contributions would induce further local economic activity, but estimating indirect and induced effects was beyond the scope of this report.

The sanctuary zone also provides economic benefits not recorded in markets. Subsistence harvests, a huge part of local culture, provide non-market benefits to the community estimated at $21,000 to $42,000 annually. This could potentially increase to upwards of $22,000 to $44,000 with the implementation of a sanctuary. In addition, marine ecosystems within the sanctuary zone currently provide economic benefits of $2.8 billion to $3.3 billion annually. For a community of roughly 80-100 people, these effects are very significant.

Recommendations

1. **Promote integrated management:** The proposed sanctuary will provide an important opportunity for St. George to work with the U.S. government, the State government and other stakeholders to analyze the full scope of current and future threats to the St. George marine environment and cultural heritage, and to increase monitoring, observation, and research as well as necessary adaptive management measures to establish climate resilience and a holistic strategy that balances conservation with sustainable use of resources.

2. **Marketing for tourism:** Research suggests that, if local communities taking marine protection measures increase capacity for marketing or advertisement, there is potential to increase tourism in the area.[20] To fully capitalize on the successful designation of its waters as a NMS, St. George should try to establish partnerships that would help to market the island, attract tourists, and increase tourism spending.

3. **Pursue research and monitoring opportunities:** As was shown earlier in this report, sanctuary-related research could have the potential to produce significant economic activity in St. George. If a sanctuary designation was awarded, it would be wise to work with universities and researchers to fully develop the research potential around St. George.

4. **Fill the gaps:** Fill in key gaps by conducting primary valuations for important ecosystems and services not yet documented. There are many ecosystem service and marine ecosystem combinations that were not able to be included in the analysis due to lack of data. Table 4 shows data gaps from this analysis.

5. **Primary valuation:** Conduct a more thorough analysis of the subsistence as well as contingent values. We recommend a primary contingent valuation of existence values for St. George Island to the greater American population.

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