

Executive Summary

Investment in and maintenance of public resources is a prime function of government. Artificial and natural reefs are public resources that provide recreational benefits to reef users and income to local economies. This study determined, in a comprehensive manner, the net economic value of southeast Florida's natural and artificial reef resources to the local economies and the reef users. Southeast Florida is defined as the counties of Palm Beach, Broward, Miami-Dade and Monroe. This study area includes, from north to south, the cities of West Palm Beach, Fort Lauderdale, and Miami, and the Florida Keys.

This study employed extensive survey research to measure the economic contribution and the use values of artificial and natural reefs over the twelve-month period of June 2000 to May 2001. The reef users surveyed were boaters who are recreational fishers (commercial fishers were not included), reef divers, reef snorkelers and/or visitors viewing the reefs on glass-bottom boats. This study estimated the following values:

- Use of artificial and natural reefs by residents and visitors in each of the four counties over a twelve-month period as measured in terms of person-days
- Economic contribution of the artificial reefs as residents and visitors spend money in each of the four counties to participate in reef-related recreation
- Economic contribution of the natural reefs as residents and visitors spend money in each of the four counties to participate in reef-related recreation
- Willingness of reef users to pay to maintain the natural reefs of southeast Florida in their existing conditions
- Willingness of reef users to pay to maintain the artificial reefs of southeast Florida in their existing conditions
- Willingness of reef users to pay for investment in and maintenance of additional artificial reefs in southeast Florida
- Socioeconomic characteristics of reef users

Economic contribution is measured by total sales, income, employment and tax revenues generated within each county. In addition, the opinions of resident reef-using boat owners regarding the existence or establishment of "no-take" zones as a tool to protect existing artificial and natural reefs are presented.

This study was funded by each of the four counties, the Florida Fish and Wildlife Conservation Commission through the use of Federal Aid in Sport Fish Restoration funds, and the National Oceanic and Atmospheric Administration through the Socioeconomic Monitoring Program for the Florida Keys National Marine Sanctuary.

Study Methods. This study conducted four surveys as follows:

- Resident boaters – mail survey conducted in the Fall of 2000
- General visitors – intercept survey conducted in the Summer of 2000 and the Winter of 2001
- Visitor boaters – intercept survey conducted in the Summer of 2000 and the Winter of 2001
- Charter / Party boats – mail survey conducted in the Spring of 2001

Visitors are defined as nonresidents of the county that they are visiting. Residents are those who live within the county.

The purpose of the resident boater survey and the visitor boater survey was to collect information to estimate the following characteristics:

- Percentage of all boaters who fish, dive and / or snorkel on the reefs;
- Itemized expenditures in the county related to using the reefs (lodging, food, gas, equipment, etc.);
- Number of person-trips and person-days of reef use by type of reef and activity;
- Willingness of reef users to pay to protect southeast Florida's natural and artificial reefs in their existing condition;
- Willingness of reef users to pay for additional artificial reefs in southeast Florida; and,
- Socioeconomic characteristics of reef users.

In addition, at the request of the counties, the resident survey also included questions regarding "no-take" zones in southeast Florida and in their counties of residence.

The purpose of the general visitor survey was to obtain estimates of the total number of visitors to each county and the percentage of visitors who boat. This information was necessary to estimate reef use.

The charter/party boat survey was a survey of for-hire operations that take out passengers for recreational fishing, snorkeling, scuba diving and glass-bottom boat rides in saltwater off the coasts of the four counties. The primary purpose of this survey was to estimate the proportion of charter / party service activity that takes place on the artificial versus the natural reefs in each county. The results of this survey were used to allocate charter/party boat fishing days between artificial and natural reefs.

The results of this study are based on the responses to these surveys. The resident mail survey resulted in 2,543 completed surveys. The general visitor intercept survey resulted in 3,855 completed surveys. The visitor boater intercept survey resulted in 2,473 completed surveys. These completed surveys provided sufficient information to estimate the economic value of the reefs to reef users and the economies of each of the southeast Florida counties.

Definitions. Certain terminology is used in this report to represent units of recreational activity. These terms are person-trip and person-day. A person-trip is defined as one person making one trip to a county. That trip may last one day to many days. On any given day, the number of visitor person-trips and the number of visitors are the same. For resident boaters, a person-trip is one day's outing on a boat to participate in saltwater recreation activities. A person-day is defined as one person participating in an activity for a portion or all of a day.

Number of Days People Participated in Recreational Use of the Reefs. The number of person-days of reef use by county and by reef type is presented in Table ES-1. Visitors and residents spent 28.3 million person-days using artificial and natural reefs in southeast Florida during the 12-month period from June 2000 to May 2001. Reef users spent about 10 million person-days using artificial reefs and 18.4 million person-days using natural reefs.

The breakdown of reef use by residents and visitors is provided in Table ES-2. Overall, residents and visitors each spent about 14 million person-days using the reefs of southeast Florida but the proportions vary by county.

A summary of reef use by type of activity is provided in Table ES-3. Overall, fishing activity on the reefs appears to dominate when snorkeling and scuba diving are compared separately. When snorkeling and scuba diving are considered together as diving activities, diving and fishing contribute about equally to total reef use in southeast Florida. In Palm Beach County, diving and fishing are equally popular activities, while in Miami-Dade County fishing is significantly more prevalent than diving. In Broward and Monroe counties, the levels of fishing activities appear to be more prevalent.

Table ES-1
Number of Person-Days Spent on Artificial and Natural Reefs in
Southeast Florida
Residents and Visitors by County
June 2000 to May 2001

County	Number of Person-Days (in millions)		
	Artificial Reefs	Natural Reefs	All Reefs
Palm Beach	1.41	2.83	4.24
Broward	3.97	5.47	9.44
Miami-Dade	2.95	6.22	9.17
Monroe	1.58	3.88	5.46
Total	9.91	18.39	28.30

Table ES-2
Number of Person-Days Spent on All Reefs
Comparison of Visitor Versus Resident Use in Southeast Florida
June 2000 to May 2001

County	Number of Person-Days (in millions)		
	Residents	Visitors	All Users
Palm Beach	2.98	1.26	4.24
Broward	3.72	5.72	9.44
Miami-Dade	4.51	4.66	9.17
Monroe	3.38	2.08	5.46
Total	14.58	13.72	28.30

Table ES-3
Number of Person-Days on All Reefs by Recreational Activity
June 2000 to May 2001 – Residents and Visitors (in millions)

Activity	Palm Beach County	Broward County	Miami-Dade County	Monroe County	Total – Southeast Florida
Snorkeling	0.74	1.09	2.11	1.87	5.81
Scuba Diving	1.73	3.85	1.14	0.89	7.61
Fishing	1.76	4.45	5.90	2.62	14.74
Glass Bottom Boats	0	0.05	0.02	0.07	0.15
Total	4.23	9.44	9.17	5.46	28.30

a Residents were not asked about their participation in glass bottom boat sightseeing. Therefore, glass bottom boats include only visitors.

Glass bottom boat sightseeing is available in Broward, Miami-Dade and Monroe counties. The reported number of person-days associated with viewing the reefs using glass bottom boats applies to visitors, not residents. Resident boaters were not asked for their level of activity on glass bottom boats. Visitors spent about 160,000 person days on glass bottom boats in southeast Florida.

Contribution of Reef-Related Spending to the County Economies. The total economic contribution of the reefs to each county is the contribution of reef-related expenditures to county sales, income and employment. As residents and visitors spend money in the county to participate in reef-related recreation, income and jobs are created within the county as a result. Economic contribution includes the direct, indirect and induced effects of visitor spending and the direct effects of resident spending.

The economic contributions of the reefs to each of the counties are provided in Table ES-4. The sales contribution is defined as the value of the additional output produced in the county due to the reef-related expenditures. The total income contribution is defined as the sum of employee compensation, proprietor's income, interest, rents, and profits generated as a result of the reef-related expenditures. Income is the amount of money that remains in the economy. The employment contribution is the number of full-time and part-time jobs created due to the reef-related expenditures.

Table ES-4
Economic Contribution of Reef-Related Expenditures to Each County¹
June 2000 to May 2001 – Residents and Visitors

Type of Economic Contribution	Palm Beach County	Broward County	Miami-Dade County	Monroe County
Sales – All Reefs (in millions of 2000 dollars)	\$505	\$2,070	\$1,297	\$504
Artificial Reefs	\$151	\$962	\$419	\$131
Natural Reefs	\$354	\$1,108	\$877	\$373
Income – All Reefs (in millions of 2000 dollars)	\$194	\$1,049	\$614	\$140
Artificial Reefs	\$52	\$502	\$195	\$33
Natural Reefs	\$142	\$547	\$419	\$107
Employment – All Reefs (number of full- and part-time jobs)	6,300	35,500	18,600	10,000
Artificial Reefs	1,800	16,800	6,000	2,400
Natural Reefs	4,500	18,700	12,600	7,600

Reef-related expenditures generated \$505 million in sales in Palm Beach County, \$2.1 billion in sales in Broward County, \$1.3 billion in sales in Miami-Dade County and \$504 million in sales in Monroe County during the 12-month period from June 2000 to May 2001. These sales resulted in \$194 million in income to Palm Beach County residents, \$1.1 billion in income to Broward County residents, \$614 million in income to Miami-Dade County residents and \$140 million in income to Monroe County residents during the same time period. Reef-related

¹ *The economic contributions cannot be summed over the four counties to get the total economic contribution of the reefs to southeast Florida. This is because the concept of economic contribution looks at the economy of the individual geographic area as a separate entity from its neighbors. In this study, visitors were asked how much they spent in the county they were visiting. They were not asked how much they spent in the other three counties. Also, visitors to a county can come from one of the other three southeast Florida counties. When looking at southeast Florida as a whole, only the indirect and induced contribution of visitors from outside the four counties can be considered as 100 percent reef-related. To get the economic contribution of the reefs to all of southeast Florida, the southeast Florida expenditures of visitor reef users to southeast Florida would have to be estimated wherein a visitor lives outside the four county area.*

expenditures provided 6,300 jobs in Palm Beach County, 35,500 jobs in Broward County, 18,600 jobs in Miami-Dade County and 10,000 jobs in Monroe County.

In Palm Beach and Miami-Dade counties, artificial reef-related expenditures comprised about a third and natural reef-related expenditures comprised about two-thirds of the economic contribution associated with the reef system. In Broward County, artificial and natural reef-related expenditures added equally to the economic contribution of the reef system. In Monroe County, artificial reef-related expenditures comprised about 26 percent of the economic contribution associated with the reef system.

Value that Reef Users Place on the Reefs. In this study, four types of use values were estimated: (1) the value to natural reef users of maintaining the natural reefs in their existing condition; (2) the value to artificial reef users of maintaining the artificial reefs in their existing condition; (3) the value to artificial and natural reef users of maintaining both the artificial and natural reefs in their existing condition; and (4) the value of adding and maintaining additional artificial reefs. In general, use value is the maximum amount of money that reef users are willing to pay to maintain the reefs in their existing condition and to add more artificial reefs to the system. Use value was measured in terms of per party per trip for existing natural and artificial reefs and per party per year for new artificial reefs. For presentation, values were normalized to values per person-day of reef-related activity so that the use values can be compared to use values estimated in other studies. Use value is also presented in aggregate for all users of the reef system.

The reef user values associated with maintaining the reefs in their existing conditions for each county are provided in Table ES-5. Use value per person-day means the value per person-day of artificial, natural or all reef use, as specified in the table. Values for all reefs were taken from statistical analysis of responses to Question 38 of the Visitor Boater Survey: "Suppose that both of the above plans to maintain the natural and artificial reefs in southeast Florida were put together into a combined program...If your total costs for this trip would have been \$___ higher, would you have been willing to pay this amount to maintain the artificial and natural reefs?" The dollar values provided to the respondents were rotated from respondent to respondent and were \$20, \$100, \$200, \$400, \$1,000 and \$2,000. The responses were then statistically analyzed to calculate average values. Values for artificial reefs were taken from statistical analysis of responses to Question 36 pertaining only to a program to maintain the existing artificial reefs in their current condition. Values for natural reefs were taken from statistical analysis of responses to Question 34 pertaining only to a program to maintain the natural reefs in their current condition. For the individual reef types (artificial or natural), the dollar values provided to the respondents were rotated and were \$10, \$50, \$100, \$200, \$500, and \$1,000.

Table ES-5
Annual Use Value From June 2000 to May 2001 and Capitalized Value associated With Reef Use
Southeast Florida – Residents and Visitors

Item	Palm Beach County	Broward County	Miami-Dade County	Monroe County	Total ^a
All Reefs - Artificial and Natural					
Person-Days of Reef Use (in millions)	4.24	9.44	9.17	5.46	28.30
Use Value Per Person-Day	\$7.34	\$13.35	\$5.12	\$9.48	\$9.04
Annual Use Value in million dollars	\$31.11	\$126.00	\$46.92	\$51.78	\$255.81
Capitalized Value @ 3 percent Discount Rate in billion dollars	\$1.04	\$4.20	\$1.6	\$1.70	\$8.5
Artificial Reefs					
Person-Days of Reef Use (in millions)	1.41	3.97	2.95	1.58	9.91
Use Value Per Person-Day	\$6.47	\$14.07	\$3.50	\$6.18	\$8.58
Annual Use Value in million dollars	\$9.09	\$55.87	\$10.33	\$9.75	\$85.04
Capitalized Value @ 3 percent Discount Rate in billion dollars	\$0.30	\$1.86	\$0.34	\$0.33	\$2.83
Natural Reefs					
Person-Days of Reef Use (in millions)	2.83	5.47	6.22	3.88	18.39
Use Value Per Person-Day	\$14.86	\$15.16	\$7.54	\$14.82	\$12.47
Annual Use Value in million dollars	\$42.10	\$82.88	\$46.86	\$57.46	\$229.30
Capitalized Value @ 3 percent Discount Rate in billion dollars	\$1.40	\$2.76	\$1.56	\$1.92	\$7.64

^a Use Value per Person per Day is calculated by dividing Total Annual Use Value by Total Person-Days of Reef Use.
 Note: Use value per person day means per person day of artificial, natural or all reef use. Values for all reefs taken from statistical analysis of responses to Question 38 of Visitor Boater Survey: Suppose that both of the above plans to maintain the natural and artificial reefs in southeast Florida were put together into a combined program...If your total costs for this trip would have been \$ ___ higher, would you have been willing to pay this amount to maintain the artificial and natural reefs. Values for artificial reefs taken from statistical analysis of responses to Question 36 pertaining only to a program to maintain the existing artificial reefs in their current condition. Values for natural reefs taken from statistical analysis of responses to Question 34 pertaining only to a program to maintain the natural reefs in their current condition. Therefore, the sum of the values for the individual reef programs may be different from the value for both programs. These results were estimated using the Logit model. Alternate methods of estimation are provided in the Technical Appendix to this report.

Visitor and resident reef users in Palm Beach County are willing to pay \$31.1 million per year to maintain both the artificial reefs and the natural reefs in their current condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. When the projects to protect the artificial and natural reefs are considered separately, visitor and resident reef users are willing to pay \$9.1 million to protect the artificial reefs and \$42.1 million to protect the natural reefs.

Visitor and resident reef users in Broward County are willing to pay \$126 million per year to maintain both the artificial reefs and the natural reefs in their current condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. When the projects to protect the artificial and natural reefs are considered separately, visitor and resident reef users are willing to pay \$55.9 million to protect the artificial reefs and \$82.9 million to protect the natural reefs.

Visitor and resident reef users in Miami-Dade County are willing to pay \$46.9 million per year to maintain both the artificial reefs and the natural reefs in their current condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. When the projects to protect the artificial and natural reefs are considered separately, visitor and resident reef users are willing to pay \$10.3 million to protect the artificial reefs and \$46.9 million to protect the natural reefs.

Visitor and resident reef users in Monroe County are willing to pay \$51.8 million per year to maintain both the artificial reefs and the natural reefs in their current condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. When the projects to protect the artificial and natural reefs are considered separately, visitor and resident reef users are willing to pay \$9.8 million to protect the artificial reefs and \$57.4 million to protect the natural reefs.

Visitor and resident reef users in all four counties are willing to pay \$255.8 million per year to maintain both the artificial reefs and the natural reefs in southeast Florida in their current condition by maintaining water quality, limiting damage to reefs from anchoring, and preventing overuse of the reefs. When the projects to protect the artificial and natural reefs are considered separately, visitor and resident reef users in all four counties are willing to pay \$85.1 million per year to protect the artificial reefs and \$229.3 million per year to protect the natural reefs in southeast Florida.

The sum of the values for the individual reef programs can be different from the value for the combined programs. This result is not inconsistent with the literature on embedded values. Randall and Hoehn (1992) have shown that this type of result is consistent with economic theory. The combined programs have exceeded the income constraints of many respondents and/or many respondents had value for only one of the programs. So it is reasonable to conclude that the estimated values for the natural and artificial reefs valued separately and together are valid estimates. Bear in mind that willingness to pay for the combined programs is a different scenario from willingness to pay for the individual programs.

The capitalized value of the reef user values is equal to the present value of the annual values calculated at three percent discount rate. It represents the "stock" value analogous to land market values. The capitalized reef user value for all southeast Florida reefs is \$7.6 billion. Bear in mind that this value only includes the value that reef users place on the reefs and does not include the values that non-reef-users place on the reefs or the economic contribution of the reefs. The estimation of the value of the reefs to non-reef users was not part of this study.

Visitor and resident reef users' willingness to pay to invest in and maintain "new" artificial reefs is provided in Table ES-6. The use value per person-day is the value per day or a portion of a day of artificial reef use. In Palm Beach County, reef users are willing to pay \$4.7 million annually for this program in Palm Beach County. Broward County reef users are willing to pay \$15.7 million per year while Miami-Dade County reef users are willing to pay \$4.1 million per year. Monroe County reef users are willing to pay \$2.2 million annually per year to fund this program in Monroe County. These values are those that are appropriate to use in a benefit-cost analysis of providing new artificial reefs.

Table ES-6
Estimated Use Value of Investing in and Maintaining "New" Artificial Reefs
Southeast Florida – Residents and Visitors

Item	Palm Beach County	Broward County	Miami-Dade County	Monroe County	Total ^a
Person-Days of Artificial Reef Use (in millions)	1.41	3.97	2.95	1.58	9.91
Use Value Per Person-Day for "New" Artificial Reefs	\$3.37	\$3.95	\$1.38	\$1.38	\$2.69
Annual Use Values for "New" Artificial Reefs in million dollars	\$4.74	\$15.70	\$4.07	\$2.19	\$26.70
Capitalized Value @ 3 percent Discount Rate in million dollars	\$157.8	\$523.4	\$135.8	\$73.00	\$890.1

^a Use Value per Person per Day is the average among the counties.

Note: Use value per person-day is a day or portion of a day of artificial reef use.

Resident Opinions of "No Take" Zones. Both the economic contribution and the use value of the reef system are based upon its management or lack thereof. In each of the four counties, resident reef-users were asked questions regarding "no take" zones. A "no take" zone is a designated area of the reef system in which nothing is to be taken from this area including fish and shellfish.

Because the reefs play a vital role in the entire oceanic ecosystem by providing habitat and protection for young fish and other creatures, it is argued that "no-take" zones would actually increase recreational, commercial, and natural resource benefits even though takings would be banned in certain areas. No one knows exactly where and to what degree "no-take" zones must be employed to increase net benefits. As a result, "no-take" zones have become a controversial issue. Therefore, as part of this study, resident respondents were asked their opinions regarding the establishment of "no-take" zones as a management tool for artificial and natural reefs in southeast Florida.

These opinions are summarized in Table ES-7. It is apparent from this table that a majority of resident reef-users endorse the idea of "no-take" zones in their county and in the other southeast Florida counties. A majority of residents would support "no take" zones on 20 to 25 percent of the existing natural reefs. About 75 percent of respondents in all counties supported the existing "no take" zones in the Florida Keys. About 60 percent of respondents supported "no take" zones in their own counties and about the same percentage supported "no take" zones on some of the reefs in Palm Beach, Broward and Miami-Dade counties. Such a result provides public officials with information important to the management of the reef system from Palm Beach County to Monroe County.

Table ES-7
A Summary of the Opinion of Resident Reef-Users on
"No Take" Zones in Southeast Florida, 2000

Question: "Support Existing "No Take" Zones in the Florida Keys"			
County	Percentage of Respondents Answering "Yes"	Percentage of Respondents Answering "No"	Percentage of Respondents Answering "Don't Know"
Palm Beach	76%	15%	9%
Broward	75%	18%	7%
Miami-Dade	74%	19%	7%
Monroe	78%	18%	4%
Question: "Support "No Take" Zones on Some Reefs in Your County"			
County	Percentage of Respondents Answering "Yes"	Percentage of Respondents Answering "No"	Percentage of Respondents Answering "Don't Know"
Palm Beach	65%	23%	12%
Broward	63%	27%	10%
Miami-Dade	61%	28%	11%
Monroe ¹	57%	21%	22%
Question: "Support "No Take" Zones on Some Reefs off Palm Beach, Miami-Dade and Broward Counties"			
County	Percentage of Respondents Answering "Yes"	Percentage of Respondents Answering "No"	Percentage of Respondents Answering "Don't Know"
Palm Beach	65%	21%	14%
Broward	64%	24%	12%
Miami-Dade	61%	28%	11%
Monroe	44%	39%	17%
Question: "What Percentage of Coral or Natural Reefs in Your County Would Be Reasonable to Protect Using "No Take" Zones?"			
County	Average Percentage	Median Percentage	
Palm Beach	30%	20%	
Broward	35%	25%	
Miami-Dade	30%	20%	
Monroe	32%	20%	

¹ Since Monroe County already has "no take" zones, the word "additional" was inserted into this question for Monroe County surveys.

Demographic Characteristics of Reef Users. Demographic characteristics were obtained from the resident boater survey and the visitor boater survey. They are summarized in Tables ES-8 and ES-9. The typical reef user is a non-Hispanic white male, in his forties, with an annual household income from \$55,000 to \$90,000. However, the demographic picture provided in Table ES-8 also shows that females, non-whites and Hispanic persons also use the reefs. Visitor reef-users tend to be younger than resident reef users. Also, larger proportions of visitors than residents are women and/or non-white.

Table ES-8
Demographic Characteristics of Resident and Visitor Reef-Users in Southeast Florida, 2000

Median Age of Respondent	Resident Reef-Users			Visitor Reef-Users		
	Palm Beach	48			41	
Broward	48			39		
Miami-Dade	46			41		
Monroe	54			44		
Sex Of Respondent	Resident Reef-Users		Visitor Reef-Users			
	Male	Female	Male	Female		
Palm Beach	91%	9%	79%	21%		
Broward	92%	8%	77%	23%		
Miami-Dade	93%	7%	75%	25%		
Monroe	86%	14%	70%	30%		
Race Of Respondent	Resident Reef-Users			Visitor Reef-Users		
	White	Black	Other	White	Black	Other
Palm Beach	97%	0%	3%	94%	2%	4%
Broward	93%	2%	5%	89%	7%	4%
Miami-Dade	88%	1%	11%	83%	7%	10%
Monroe	94%	0.2%	5.8%	95%	2%	3%
Percent Hispanic/Latino	Resident Reef-Users			Visitor Reef-Users		
Palm Beach	4%			5%		
Broward	5%			13%		
Miami-Dade	33%			29%		
Monroe	7%			8%		
Median Household Income	Resident Reef-Users			Visitor Reef-Users		
Palm Beach	\$71,695			\$87,500		
Broward	\$72,310			\$87,500		
Miami-Dade	\$69,722			\$55,000		
Monroe	\$56,393			\$87,500		

From Table ES-9, it is clear that residents have been boating in southeast Florida for a significantly longer period of time than visitors – about 22 years versus 7 years. Overall, visitor and resident boat owners have similar sized boats and both resident and visitor reef users have about the same probability of belonging to a fishing or diving club.

Table ES-9
Boater Profile of Resident and Visitor Reef-Users in Southeast Florida, 2000

Average Years Boating in South Florida		
County	Residents	Visitors
Palm Beach	21	9
Broward	22	7
Miami-Dade	25	7
Monroe	22	7

Average Length of Boat Used for Salt Water Activities in Feet		
County	Residents	Visitors
Palm Beach	25	25
Broward	25	27
Miami-Dade	23	26
Monroe	24	22

Percentage of Respondents Who Belong to Fishing and/or Diving Clubs		
County	Residents	Visitors
Palm Beach	20%	24%
Broward	19%	12%
Miami-Dade	18%	6%
Monroe	15%	11%

The Economic Benefits Associated with Florida's Artificial Reefs¹

Chuck Adams, Bill Lindberg, and John Stevely²

Introduction

Florida reportedly has the most permitted artificial reefs in the nation. Approximately 2,700 artificial reef deployments are located off 34 coastal counties in Florida (Table 1). Although permitted by the United States Army Corps of Engineers and the Florida Department of Environmental Protection, artificial reefs are deployed under a set of guidelines established by the Florida Fish and Wildlife Conservation Commission. These guidelines are specified within the State of Florida Artificial Reef Strategic Plan (FFWCC 2003). Artificial reefs are utilized by recreational anglers, divers, and other user groups. The existence and use of artificial reefs sets in motion a variety of economic activities that result in significant economic benefit to the coastal communities in close proximity to the reefs. This document will provide an overview of these economic benefits and briefly discuss some recent studies that have attempted to measure them.

Benefits of Artificial Reefs

Artificial reefs may be constructed for a variety of purposes, each with a set of potential benefits associated with that intended purpose or goal. One purpose of artificial reefs might be to provide a source of biological replenishment to local populations of marine vertebrates and invertebrates. In that case, the benefit would be that a net biomass increase would result from deploying the reef. Artificial

reefs may also be used as a means of mitigating local habitat loss. Another purpose might be to simply provide a location where anglers and divers can utilize aggregated populations of marine species, either in a take (fishing) or no-take (viewing) fashion. The benefits in that case would be the increased economic activity (i.e., expenditures, incomes, jobs) associated with these activities. Each of these purposes may also generate non-market benefits (such as existence values), particularly to non-users of reefs. Such benefits reflect how individuals who may not directly utilize artificial reefs nonetheless value reef existence as being beneficial to the biological habitat of the region.

Aside from the purely biological benefits that might accrue from artificial reefs, many would argue that reefs are deployed to provide benefits to *human* users, whether commercial fishermen, recreational anglers, sport divers, or others. Milon, Holland, and Whitmarsh (2000) suggest that "a reef that is not useful to people is not a successful reef." If this is an acceptable tenet, assessments of the economic benefits accruing from artificial reefs to surrounding communities are necessary. Such information provides insight into the degree to which the public benefit is being served by reef deployment and the economic consequences associated with reef use. The actual or potential economic impact of reef development to the county or state can be measured, as well as determine to what extent artificial reef deployment is an efficient public investment. In turn, this information may help justify future public expenditures on

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artificial reefs and assist in developing adaptive strategies associated with reef deployment as a resource management tool. Of course, there are costs associated with artificial reef program implementation. These costs must be measured as well.

Measuring the Economic Costs and Benefits

The economic costs, activities, and benefits derived from artificial reef programs can be measured several ways. These are briefly reviewed below.

Economic Impact Analysis

This method can provide insight into how market-related activities associated with resident and non-resident expenditures change after reef deployment. An economic impact analysis will describe changes in economic activity within a given geographic region, such as expenditures, incomes, jobs, and business taxes.

Cost Effectiveness Analysis

This method can determine to what extent the estimated cost of deployment was realized in the actual reef deployment process. With limited local and state funds for reef development, ensuring that cost efficiency is maintained is vital to a sustainable county reef program. A cost effectiveness analysis will help ensure that reef programs are completed with a minimum of cost.

Benefit/Cost Analysis

This method takes into consideration the costs associated with the artificial reef site selection, permitting, deployment, monitoring, and other activities, and compares those costs to the suite of benefits that would be generated by the reef program. The benefits would include the total economic values associated with the overall public demand for the reef program. In this case, those benefit/cost analysis estimates would include values reflected in the market, as well as those values associated with user and non-user demand for reefs over and above that reflected by reef-related expenditures in local markets. These benefits are often referred to as consumer surplus. Foregone benefits of utilizing reef-related funds in the next best use within the region may be included as an opportunity cost. A benefit-to-cost ratio of greater than 1.0 suggests that the benefits associated with the program exceed the costs. This would be more desirable than a ratio less than 1.0, which would suggest that the costs derived from the reef program exceed

the benefits. In the former case, the program would yield positive overall (net) economic benefits.

The methods listed above are the primary means of determining the net economic benefits associated with artificial reefs. Several such studies have been completed regarding Florida's artificial reefs. These studies have addressed artificial reef-related changes in boater and angler use patterns and expenditures. They have examined the community/social impacts of artificial reef placement and the cost efficiency of reef projects, including the opportunity costs of utilizing scarce public funds for reef placement. Some studies have attempted to address the overall economic values associated with artificial reefs, such as existence values and consumer surplus. And some studies have attempted to utilize the information to determine if the costs associated with artificial reef programs are exceeded by the benefits. Not all studies address each of these issues. Some of the studies are dated and the results reflect the characteristics of the local economy and community structure at the time of the study. The key findings from these studies are briefly summarized below.

Florida Artificial Reef Study Summaries

Pinellas County

In one of the first such studies in Florida, Hanni and Mathews (1977) examined the costs associated with building an artificial reef system near Clearwater Beach. The intent of the study was to measure the potential economic benefits to anglers and divers who might utilize the reef. The study focused on the benefit-to-cost ratio of the reef program. The benefit-to-cost ratio for anglers was found to be greater than 1.0, while the benefit to cost ratio for divers was found to be less than 1.0.

In an attempt to examine the overall economic consequences of the artificial reef program in Pinellas County (which currently has the greatest number of permitted artificial reefs in Florida), Schug (1978) surveyed the users of the Pinellas County artificial reef system. The study found that the artificial reefs were not being utilized at the maximum use capacity. In fact, only 11 to 36 percent of the reef capacity was being utilized. In addition, 80 percent of the users were local. Thus, while the majority of users were contributing little economic impact to the region, they were enhancing the total economic activity due to their reef-related activities. Total annual expenditures by reef users were estimated to be \$181,000 to \$253,000. The

benefit-to-cost ratio of the artificial reef program in Pinellas County was estimated to be greater than 1.0.

Miami-Dade County

Miami-Dade County currently has the third largest complement of artificial reef deployments in Florida (Table 1). Milon (1988) attempted to measure the economic benefits associated with the artificial reef program by users and non-users. The technique utilized was a mail-out survey to local boaters and divers. Respondents were asked to provide their willingness to pay for an artificial reef program. Of the respondents, 29 percent were anglers who frequented artificial reefs and 13 percent were divers who frequented artificial reefs.

Both users and non-users expressed positive benefits associated with the artificial reefs of Miami-Dade County. The annual benefits associated with artificial reefs in Miami-Dade County were estimated to be as high as \$707,000. Interestingly, the largest component of that amount was associated with non-users. Thus, artificial reefs have high values associated with those individuals who simply value the existence of such reefs but may never directly utilize them. The present value associated with artificial reefs in Miami-Dade County ranged from \$18 million to \$128 million, based on estimation method.

Northwest Florida

The economic benefits associated with artificial reefs in northwest Florida were measured by Bell, Bonn, and Leeworthy (1998). The purpose of the study was to assess the economic impact, user valuation, and benefit-to-cost ratio associated with artificial reefs located in the waters adjacent to Escambia, Santa Rosa, Okaloosa, Walton, and Bay Counties.

A total of \$414 million in expenditures were associated with artificial reef use. Those expenditures supported 8,136 jobs and \$84 million in wages and salaries. Of the total expenditures, \$359 million and \$56 million were attributed to visitors and residents, respectively. Of the five counties studied, the total expenditures were distributed as follows: Bay (36%), Okaloosa (30%), Escambia (22%), Santa Rosa (7%), and Walton (5%). The willingness to pay for an artificial reef program was also measured for the region. The annual recreational use value was estimated to be \$19.7 million, with a discounted asset value of \$656 million for the reef program. The benefit-to-cost ratio of the artificial reefs within the northwest Florida region was estimated to be 131, a value indicating an extremely high, positive return to the cost of developing and implementing the artificial

reef programs within the five-county, northwest Florida region.

Southeast Florida

The economic impact and use values associated with artificial and natural reef systems in southeast Florida were analyzed by Johns, Leeworthy, Bell, and Bonn (2001). The methodology utilized was similar to that used in the study of the artificial reefs of northwest Florida. In addition, values associated with both the existing and potential new reef sites were assessed. The counties included in the study were Palm Beach, Broward, Miami-Dade, and Monroe.

The study found that non-residents and visitors annually spent \$1.7 billion on fishing and diving activities associated with artificial reefs. Of the total expenditures, Broward County contributed 53 percent, Miami-Dade County contributed 25 percent, and Palm Beach and Monroe Counties each contributed 11 percent. These expenditures generated approximately 27,000 jobs in the region and created \$782 million in wages and salaries. Interestingly, the expenditures associated with natural reef systems, in contrast to artificial reefs, generated \$2.7 billion in annual expenditures.

The annual recreational use value associated with existing artificial reefs in the region was estimated to be \$84.6 million. This annual value discounted into the future produced a discounted value of \$2.8 billion. The annual use value associated with any new artificial reefs was estimated to be \$27 million, with a discounted value of \$888 million. The annual willingness to pay for new artificial reefs was \$4 million. Interestingly, the annual recreational value associated with natural reefs was \$228 million, considerably more than that for artificial reefs.

Martin County

A study similar in methodology to the Palm Beach–Monroe Counties region was conducted for Martin County, Florida. The study examined the values associated with artificial and natural reef systems. Johns (2004) examined annual expenditures, jobs, and incomes, as well as annual use values. The annual expenditures associated with artificial reef use were \$7.2 million. The contribution associated with resident and non-resident expenditures were approximately equal. The incomes associated with artificial reefs were estimated to be \$3.2 million, with approximately 100 jobs created within Martin County. The values associated with natural reefs were slightly smaller in magnitude.

The annual use value associated with existing artificial reefs (by residents and non-residents) was estimated to be \$3.6 million. This value discounted into the future was estimated to be \$120 million. The annual value associated with any new artificial reefs was estimated to be \$1.1 million, which when discounted into the future yielded a value of \$37.5 million.

USS Spiegel Grove

The *USS Spiegel Grove* was a retired navy ship that was sunk off Key Largo, Florida in 2002. The primary purpose of the *Spiegel Grove* deployment as an artificial reef was to determine whether introducing an artificial reef in close proximity to a natural reef environment would reduce usage of the surrounding natural reefs. Thus, the primary objective was from a resource management perspective. However, economic implications were in question as well. A key question was whether the local economy would benefit from deploying artificial reefs whose primary purpose would be redirecting diver use away from natural reefs. A study was conducted on use patterns and local economic activity before and after the *Spiegel Grove* deployment (Leeworthy, Maher, and Stone 2005; Leeworthy, Maher, and Stone 2006). The study provided insight into how the *Spiegel Grove* performed as a substitute by divers and snorkelers for local natural reefs, as well as what benefits to the local economy occurred.

Regarding the resource management objective, the *Spiegel Grove* artificial reef was deemed a success. Following the deployment, the diver and snorkeler use of natural reefs within the study area declined by 13.7 percent. In addition, the number of dive charters specifically for natural reefs within the region declined by 16.7 percent. However, the total number of dive charters and other related dive/snorkel activity increased substantially. The net change in expenditures on diving and snorkeling activities increased \$2.6 million during the study period, with approximately 80 percent of that increase being attributed to non-residents. Incomes within the local economy increased by \$960,000, and an additional 68 jobs were created. Thus, the deployment of the *Spiegel Grove* was considered a win-win situation for both the natural reef environment and the local economy.

USS Oriskany

The decommissioned Essex Class attack aircraft carrier, the *USS Oriskany*, was sunk off the coast of Pensacola, Florida on May 17, 2006. The original 2004 deployment was delayed due to further PCB (polychlorinated biphenyl) abatement needs and hurricane events. Obtaining,

preparing, transporting, and sinking the vessel was due to the combined efforts of several county, state, and federal agencies. At the time of the sinking, the *Oriskany* was the largest artificial reef structure ever deployed. The *Oriskany* was sunk at a depth and distance from shore that would preclude most novice divers, with the top of the "island" being at 60 feet and the flight deck at 130 feet. Diving to the flight deck and hangar deck (150 feet) is better suited to those with technical diving skills (i.e., nitrox and trimix).

The primary purpose of the deployment was to enhance the coastal economic activity associated with the recreational dive industry located in the Baldwin County (Alabama) and Escambia County (Florida) regions. Analyses on both single- and two-county scenarios indicated significant economic activities and impacts were realized during the year immediately following the deployment of the *Oriskany* (Haas Center 2007). Approximately 4,200 chartered dive trips were taken to the *Oriskany* during the first year after the sinking. Average expenditures for dive trips originating from non-local destinations were estimated to be \$463, while an average local dive trip resulted in expenditures of \$352. Dive activities originating from Baldwin and Escambia Counties combined resulted in dive-trip related expenditures of \$2.2 million, with an economic impact of \$3.6 million, the creation of 67 jobs, and the generation of \$1.4 million in local incomes. Dive activities originating from Escambia County only resulted in dive-trip related expenditures of \$1.2 million, with an economic impact of \$2 million, the creation of 37 jobs, and the generation of \$740,000 in local incomes.

The *Oriskany* also provided the opportunity to examine the preferences of divers for existing and hypothetical dive opportunities. For example, the perceived value of the possibility of "bundling" (locating) a smaller sunken vessel in the proximity of the *Oriskany* but closer to shore, and thereby increasing the use opportunities of a hypothetical complement of artificial reefs, was examined (Morgan, Massey, and Huth 2009). Subsequent analyses have shown that the concept of bundling additional reef sites does increase the perceived use values associated with large ship artificial reef deployments.

USS Vandenberg

The 520-foot *USS Vandenberg* was a retired United States Air Force missile tracking ship that was sunk off Key West, Florida in May 2006. The vessel was placed within the Florida Keys National Marine Sanctuary. The primary purpose of the deployment was to enhance local economic development and tourism. The total cost of preparing and sinking

the vessel amounted to \$8.6 million. Subsequent studies have shown that the *Vandenberg* has increased activities within the local dive charter industry, as well as the local economy in general (Office of National Marine Sanctuaries 2011). Following the sinking of the *Vandenberg*, the local dive-related business increased by almost 190 percent. This resulted in an increase of \$6.5 million in expenditures, while annual state and local sales and lodging tax revenues increased by approximately \$620,000. An additional 105 jobs, with \$3.2 million in incomes, were generated by the deployment of the *Vandenberg* as an artificial reef.

Similar to the *USS Spiegel Grove* project, an additional objective of the *Vandenberg* artificial reef project was to assess the diversion of divers and snorkelers from natural reefs to the nearby artificial reef—the *Vandenberg*. As hypothesized, the total use of natural reefs by divers and snorkelers did decline, but the overall increase in activity due to the presence of the *Vandenberg* resulted in a net increase in the use of nearby natural reefs.

Southwest Florida

A study by the University of Florida focused on the economic impact that artificial reef deployments have on six counties in southwest Florida: Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, and Lee (Swett, Adams, Larkin, Hodges, and Stevens 2011). The study found that approximately 614,000 boating days and over 2 million person days were spent annually utilizing the artificial reefs within the six-county region, with 5,600 persons utilizing the reefs on a daily basis. The primary users of the artificial reefs were private boaters; however, the for-hire sector (guide, party, and charter clients) was also found to be an important user of the complement of artificial reefs in the region. In fact, this study was the first to provide clear insight into the role that the for-hire sector plays in the utilization of Florida's artificial reefs.

The use of artificial reefs in the six-county region resulted in annual expenditures of \$253 million, of which \$136 million was spent by residents in the region and \$117 million was spent by non-residents. Of the total expenditures, \$163 million was spent by private boaters, while \$90 million was spent by clients of the for-hire sector. The annual expenditures on artificial reefs generated economic impacts of \$227 million, along with \$122 million in incomes and \$17 million in business taxes, and created approximately 2,600 jobs. In addition, the study found strong public support for the use of public funds toward providing and maintaining artificial reefs in Florida waters.

Summary

Florida reportedly has the largest complement of permitted artificial reefs in the nation. These reefs have been shown to be beneficial to the local economies. The studies reviewed above show that artificial reefs do increase economic activity in surrounding communities. Because artificial reefs are valued by users and non-users alike and provide benefits that exceed costs, they may be an effective tool for redirecting use away from natural reefs if such a management objective is required. Overall, artificial reefs are a source of economic value that may justify additional deployments, even after taking into account the opportunity costs associated with scarce public funds.

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Table 1. Number of artificial reef deployments in Florida by county .

County	# of Reefs
Bay	220
Brevard	63
Broward	108
Charlotte	33
Citrus	25
Collier	80
Dade	191
Dixie	9
Duval	96
Escambia	182
Flagler	12
Franklin	47
Gulf	21
Hernando	22
Hillsborough	75
Indian River	10
Lee	116
Levy	31
Manatee	83
Martin	86
Monroe	62
Nassau	17
Okaloosa	181
Palm Beach	75
Pasco	37
Pinellas	401
Santa Rosa	15
Sarasota	156
St. Johns	40
St. Lucie	44
Taylor	17
Volusia	82
Wakulla	33
Walton	4
TOTAL	2,276

Source: Florida Fish and Wildlife Conservation Commission (2011) <http://myfwc.com/conservation/saltwater/artificial-reefs/>