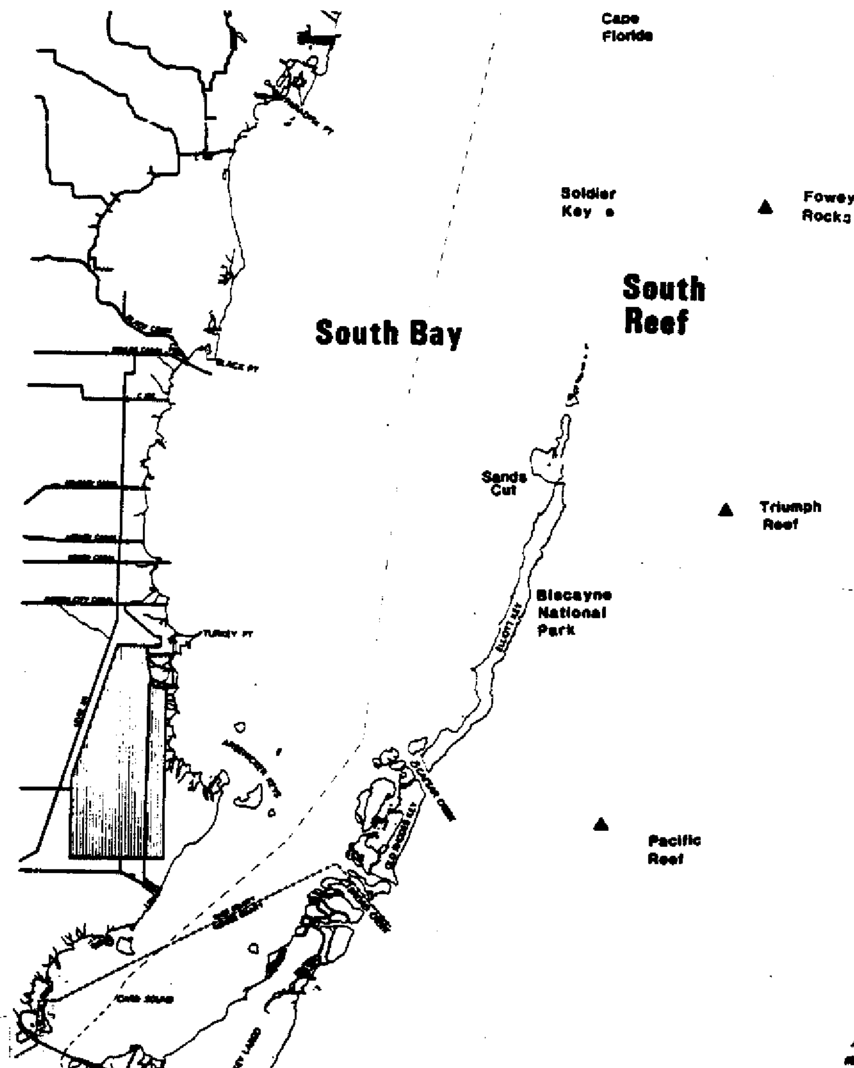
April 1988

FLSGP-T-87-005 C2

SGR-90

The Economic Benefits of Artificial Reefs: An Analysis of the Dade County, Florida Reef System

J. Walter Milon



THE ECONOMIC BENEFITS OF ARTIFICIAL REEFS: AN ANALYSIS OF THE DADE COUNTY, FLORIDA REEF SYSTEM

J. Walter Milon

Food and Resource Economics Department
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida 32611

Sea Grant Project No. R/LR-E-9-PD
Grant No. NA85AA-D-SG059

Report Number 90
Florida Sea Grant College
December 1987
Price $3.00

ABSTRACT

This report presents results from a research project to identify recreational uses of artificial reefs by private boat owners in Dade County, Florida and to evaluate the merits of alternative methods to measure the economic benefits of artificial reef development. Results from a mail survey of registered boat owners in 1985 showed that approximately 29 percent of respondents who fished during the survey period used at least one of the artificial reefs in Dade County. Catch rates at artificial reef sites were generally higher than at nonreef sites. Approximately 13 percent of respondents who participated in sport diving during the survey period used the artificial reefs. The percent of divers who spearfished at artificial reefs was about the same as at nonreef sites. Results from an experiment using three different contingent valuation formats indicated that both current users and nonusers had a positive willingness to pay for new artificial reef development; the valuation format had a significant influence on the mean valuation. Several different variations on the basic travel cost method were also used to assess the economic benefits of a new artificial reef; these modeling alternatives also yielded different estimates of users' economic benefits. Extensions of the sample benefit estimation methods to the population of Dade County private boaters provide a range of estimated economic present values for new and existing artificial reefs in Dade County. Recommendations for future research on modeling artificial reef participation and on economic benefit estimation are provided.

KEYWORDS: artificial marine habitat, socio-economic analysis, economic benefits, contingent valuation, multi-site travel cost models

ACKNOWLEDGEMENTS

Many individuals deserve credit for their contribution to this research project without being implicated for any of the author's results and conclusions. Bill Seaman and Jim Cato of the Florida Sea Grant College were instrumental in initiating this project and provided helpful technical assistance. Mr. Don Pybas, Dade County Marine Extension Agent, offered thoughtful counsel on the mail survey design and willingly shared his knowledge of local waters and sport fishing and diving practices. Mr. Ben Mostkoff, Director of the Dade County Artificial Reef Program, and the staff of the Department of Environmental Resources Management made invaluable contributions through their comments on survey design, technical assistance on artificial reef locations and map development, and through contacts with members of the local sport fishing and diving communities. Mail survey projects of this scale also benefit from many hours of dedicated graduate student assistance. Special thanks to Robert Zabawa who kept the project on track during the author's assignment in Washington, to Sharon Moon and Bill Malick for many boring hours of survey handling and coding, and to Carolyn Fonyo for data analysis assistance. Thanks also to Ron Ward and Mercedes Rosalsky of the Food and Resource Economics Department who provided many valuable tips on programming the data analysis and to Ann Fisher in the Office of Policy, Planning and Evaluation at the U.S. Environmental Protection Agency for helpful comments on the contingent valuation section of the survey. Helpful comments by four anonymous Sea Grant reviewers on an earlier draft are gratefully acknowledged. Remaining errors, omissions and opinions are solely those of the author. This report was developed under the auspices of the Florida Sea Grant College Program with support from the National Oceanic and Atmospheric Administration, Office of Sea Grant, U.S. Department of Commerce, Grant No. NA85AA-D-SG059.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

THE ECONOMIC BENEFITS OF ARTIFICIAL REEFS: AN ANALYSIS OF THE DADE COUNTY, FLORIDA REEF SYSTEM

EXECUTIVE SUMMARY

This report summarizes the results of a research project to determine the uses and economic benefits of artificial reefs in Dade County, Florida. The project was designed to: 1) identify artificial reef usage rates for private boat sport anglers and divers, 2) compare the estimated individual economic benefits from artificial reefs using contingent valuation and travel cost methods, and 3) provide an estimate of the aggregate economic value of the County reef system to resident private boaters. As part of the project, a mail survey of 3600 registered pleasure craft boat owners in Dade County was conducted in 1985. The survey response rate was 45 percent. The data collected in this survey were analyzed to provide information about the uses and benefits of the reef system. The major findings can be summarized as follows:

* Saltwater fishing was the most common boating activity with 75 percent of total boating days; cruising was the second most popular activity followed by diving and skiing.

* Approximately 29 percent of those anglers who fished during the survey period used an artificial reef. Reef users and nonusers tended to differ in the types of boating equipment they owned, their membership in fishing clubs, age, and other socioeconomic characteristics. The main reason cited by reef users for fishing artificial reefs was the chance to catch more fish. Many nonusers did not know about the artificial reef sites.

* A variety of fishing methods were employed by artificial reef users; bottom fishing was the most common but drift fishing and trolling were also popular.

* Catch rates at artificial reefs as measured by number and pounds per unit effort were generally higher than at nonreef sites. These measures are not an unambiguous indicator of better fishing at artificial reefs because reef users also generally had higher catch rates at nonreef sites than nonusers. Also, the survey did not collect species-specific catch data so the significance of the catch rate measures cannot be directly related to target species objectives.

* Approximately 13 percent of the sport divers who responded to the survey used the artificial reefs during the survey period. As with the anglers who used the artificial

reefs, divers using the artificial reefs had more boating equipment, more were members of fishing and diving clubs, and they were slightly younger than nonusers.

* The majority of divers using the reefs participated in sightseeing and/or photography as opposed to spearfishing; the percentage of users engaged in spearfishing at artificial reefs was about the same as the percentage of spearfishing by nonusers. Catch rates for spearfishing at the artificial reefs were generally much lower than catch rates by anglers at the reefs. However, sample sizes for spearfishing at specific reef sites were very low so these results should be interpreted with caution.

* The main reason cited by divers for using the artificial reefs was that the sites were easy to locate. Many nonusers did not know about the reefs or thought the sites were too hard to find.

* Results from a contingent valuation experiment using three different valuation formats indicated that current users of the reef system have a positive annual willingness to pay for a new reef site ranging on average from $18.04 to $26.57 per respondent across the different formats. Nonusers also had a positive willingness to pay ranging from $1.14 to $31.93; the wider range reflects the influence of the valuation formats.

* Five different model variations on the basic travel cost method were also estimated based on anglers' site usage patterns. Generally, the alternative models indicated that travel costs to a site, catch rates at the site, the angler's boating equipment, and certain socioeconomic characteristics were significant determinants of artificial reef use and site selection. Benefits estimated from the travel costs models for reef users ranged from $6.15 to $20.70 per respondent. Benefits estimated from a more encompassing nested choice model including both users and nonusers were $3.14.

* Extensions of the individual benefit estimates from the different valuation methods to the general Dade County boating population resulted in a range of total economic benefits for a new artificial reef site. Total annual benefits from the contingent valuation methods ranged from $121,937 to $706,974. These benefits are for users and nonusers and may include certain benefits not directly related to expected use of an artificial reef site. Total annual benefit estimates from the travel cost models apply only to expected use benefits for anglers; these estimates range from $30,387 to $102,279.

* Annual benefit estimates for a new artificial reef site were extrapolated to the existing Dade County reef system. Under certain assumptions about reef usage and the longevity of the reef system, the benefit capitalization approach was used to approximate the present value of the system. With a 3 percent capitalization rate and a "best estimate" of the annual benefits from the different estimation methods, the present value of the system ranged from $17,500,000 to $128,333,333. In light of the different uses and reasons for artificial reefs, it was difficult to define a narrower range of total economic value.

* Because this study was limited to private boater users of artificial reef sites and did not include charter boat fishing and diving users, these estimated economic benefits are only a partial measure of the total economic value of the Dade County artificial reefs.

THE ECONOMIC BENEFITS OF ARTIFICIAL REEFS: AN ANALYSIS OF THE DADE COUNTY, FLORIDA REEF SYSTEM

J. Walter Milon*

1.0 INTRODUCTION

Artificial reefs are man-made structures placed in coastal waters to enhance marine fishery resources and to provide recreational opportunities for sportfishing and diving. Local civic groups and government organizations have been involved in the construction of artificial reefs for several decades but only recently have artificial reefs been recognized as an important component of coastal resource management. The National Fishing Enhancement Act of 1984 (P.L. 98-623, Title II) established a planning process to coordinate efforts to develop artificial reefs. The subsequent National Artificial Reef Plan (U.S. Department of Commerce, 1985) provides a framework to develop site-specific plans sensitive to local resource use demands and marine environmental conditions.

An essential component of planning artificial reef construction is an understanding of the siting and design features that influence user perceptions of the reef and the economic benefits accruing to different user groups. Despite the growing awareness of and interest in artificial reefs, there has been relatively little formal research on user group perceptions of artificial reefs, the influence of siting and design features on user choice of reef sites versus natural habitat, and the economic benefits of reefs for user groups and the local community. Buchanan (1973) provided the first detailed study of artificial reef users in South Carolina. This study examined the species composition of catch at artificial reefs and the economic Similarly, Ditton et al. (1979), Ditton and Auyong (1984), and Liao and Cupka (1979) identified use patterns and recreatonal trip expenditures associated with artificial reefs in the Gulf of Mexico region and South Carolina, respectively. Thompson and Roberts (1982) provided the first assessment of direct use benefits from artificial reefs (oil platforms in offshore Louisiana) but the study was limited to a small group of sport divers. Bockstael et al. (1986) completed the first detailed study of fishing benefits from artificial reefs for the

*J. Walter Milon is an associate professor in the Food and Resource Economics Department, University of Florida, Gainesville, FL 32611.

expenditures of artificial reef anglers but no attempt was made to estimate use benefits.[1] South Carolina reef system. Their study utilized two different methodologies to estimate use benefits (the travel cost and contingent valuation methods) and provided a comprehensive evaluation of the factors contributing to user perceptions of artificial reefs and use benefits. Samples (1986) also examined the association between perceptions and user benefits although this study focused on floating fish aggregation devices.

This report describes the results of a research project to identify use patterns, user and nonuser perceptions, and use benefits for the artificial reef system in Dade County, Florida. The Dade County system is a well established network of 7 offshore artificial reefs that is managed by the Metro-Dade Department of Environmental Resources Management. Placement of material at these sites began in the early 1970s with efforts by local sportfishing groups and has increased rapidly in the last five years. The specific objectives of this research project were:

1) To document usage patterns of private boat sport anglers and divers at specific artificial reef sites and to identify differences in catch rates and site perceptions for both users and nonusers of artificial reefs;

2) To test and compare the results of alternative benefit estimation methods, specifically the contingent valuation and travel cost methods, for reef user and nonuser groups; and,

3) To use the results of the benefit estimation models to estimate the aggregate resident economic value of artificial reefs in the Dade County system.

This project focused exclusively on the use benefits of artificial reefs for Dade County boaters. In this context, the total expenditures of reef users and the economic impact of these expenditures are irrelevant since they do not cause a change in the total level of economic activity within the County. These use benefits are the economic measures of value that are most appropriate for benefit-cost analysis.

---

[1]The term "use benefits" refers to an economic measure of the amount of money individuals would be willing to pay for the use of a recreation site. Economists also refer to a second category called "nonuse" benefits that includes the willingness to pay for the option of using a site at some future time (option value), the willingness to pay for knowing that the site exists (existence value), and the willingness to pay to give the site to future generations (bequest value). While each of these components of individual benefits has a specific meaning, in practice it is difficult to distinguish each component. This is particularly true for local public goods such as artificial reefs which may have spillover benefits. Throughout this report a broad interpretation of the term use benefits will be considered that encompasses both categories of benefits. Several methods have been employed to estimate use benefits for recreation sites; a general description of use benefit estimation methods is provided in Milon and Johns (1982). Bockstael et al. (1985) provide a more detailed discussion of estimation methods with specific application to artificial reefs.

The report is organized in the following manner. Section 2.0 provides a description of the mail survey design used in this project and reports the overall response statistics. Section 3.0 reports the socioeconomic characteristics and the recreational boating activity profile of survey respondents. Section 4.0 evaluates reef site usage patterns, catch rates, and respondent perceptions for user and nonuser sport anglers. Section 5.0 provides a comparable analysis for user and nonuser sport divers. Section 6.0 reports on respondent attitudes about the existing system of artificial reefs and describes the benefit estimation methods used in this study. This section also reports the results of the alternative methods for user and nonuser groups and provides extensions of the benefit estimation results to estimate aggregate economic benefits from the Dade County reef system. Section 7.0 summarizes the major conclusions from this research effort and offers some recommendations for future research on the economic benefits of artificial reefs.

2.0 SURVEY DESIGN AND RESPONSE

The collection of participation, socioeconomic and valuation data for artificial reefs in Florida is difficult because no special license or permit is required to use the reefs, participation may involve both sport angling and diving, and the State of Florida has no general licensing requirement for either saltwater fishing or diving. In addition, the Dade County reef system is particularly complicated because boat launch access to the reef sites is possible from a large number of public and private launch areas. The sites are also widely distributed along the County's coastline. Because of these features of the research setting, interview surveys either on-site or at access points were not a realistic or reliable means of data collection. As an alternative, a mail survey sample was constructed from Dade County 1984-1985 boat registration files using general stratified sampling with proportional allocation by zip code. The zip code allocation rule was used because there was no prior information available about participation in fishing and diving activities for resident subgroups and because the boat registration file did not provide any information about the boat owner other than address. The sample was restricted to include only privately owned, recreational engine powered vessels over 16 feet in length since it is highly unlikely that smaller craft could travel offshore to use the artificial reefs. An attempt to include sport divers using local area commercial dive boats was abandoned due to a lack of cooperation from dive charter operators. The survey instrument was mailed in two separate waves of 1800 sample units in June and November of 1985. Two waves were used to minimize recall problems about specific fishing and diving activities, to provide a distribution of activity reporting over different seasons, and to provide a data set that could be readily generalized to an annual basis. To reduce response bias that may be attributable to respondent perceptions of the purpose of the survey, the survey was represented as a general boater survey designed to identify boater's use of facilities in the Dade County area and to elicit information about boating facility needs in the County. A postcard and two follow-up letters of reminder were used to augment the initial mailing. A complete copy of the survey instrument is provided in Appendix A.

Table 1 provides a summary of the response to the mail survey. For the two waves, the second produced the lower response rate due to a higher number of undeliverables that resulted from the aging of the boat registration file. The overall response rate of 44.9 percent is acceptable considering the transciency of the Miami-Dade County population, the length of the survey instrument, and the impersonal nature of a general boating related survey.

A comparison of boat length classifications for boats over 16 feet in length for the sample groups and the total County registered boat population is provided in Table 2. The table shows that the distribution of boat length in the survey response group very closely matches the population distribution. While there were some slight differences in the length distributions for the two samples, the average boat length for the samples is the same.

Table 1. Summary of responses to mail survey by sample group

	Sample 1	Sample 2	Total
Sample Size	1800	1800	3600
Returned as Undeliverable	276	335	611
Effective Sample Size	1524	1480	2989
Returned Complete	644	538	1182
Returned But Not Useable Due To:			
-Incomplete/Inconsistent Responses	6	7	13
-Boat Sold or Inoperable	45	45	90
-Use Boat Only Outside Area	30	26	56
Overall Response Rate Based on Effective Sample Size	47.6%	41.6%	44.9%
Completed Response Rate Based on Effective Sample Size	42.3%	36.4%	39.4%

Table 3 provides a comparison of the distribution of sample group responses across the County zip code strata with the registered boat population across the same zip code strata. The results show that the sample group response strata are very similar although there are some slight differences between the sample response strata and the population strata. Given

Table 2. Summary of responses by sample group and boat size and comparison to total Dade County registered pleasure craft over sixteen feet in length (1984)

	Boat Length								
	16 to 25 feet		26 to 39 feet		39 to 65 feet		Total		Average
Total Responses									
Sample 1	545	84.6%	92	14.3%	7	1.1%	644	100.0%	22.2
Sample 2	452	84.0%	73	13.6%	13	2.4%	538	100.0%	22.2
Total Sample	997	84.3%	165	14.0%	-20	1.7%	1182	100.0%	22.2
Total Pleasure Craft	24,639	84.7%	3,913	13.4%	550	1.9%	29,102	100.0%	NA

Table 3. Summary of responses by regional zip code stratification and sample group

Sample Strata and Zip Codes	Total Registered Boats (1984)		Sample Group 1		Sample Group 2		Total Sample	
1 Hialeah [33010-33019]	2,182	9.4%	41	6.4%	36	6.7%	77	6.5%
2 Hollywood [33020-33029]	637	2.8%	15	2.3%	11	2.1%	26	2.2%
3 Homestead and Key Largo [33030-33035,33037, 33039,33070]	1,926	8.3%	65	10.1%	56	10.4%	121	10.2%
4 Opalocka [33054-33056]	596	2.6%	14	2.2%	13	2.4%	27	2.3%
5 Miami [33101-33140]	4,136	17.9%	84	13.1%	73	13.6%	157	13.3%
6 Miami [33141-33199]	13,615	58.9%	418	64.9%	344	63.9%	762	64.5%
Other	--	--	7	1.0%	5	0.9%	12	1.0%
TOTAL	23,092	100.0%.	644	100.0%	538	100.0%	1,182	100.0%

the small differences between the sample results and the actual population, the sample design and execution resulted in a data sample that is representative of known population characteristics. The extent of nonresponse bias attributable to other population characteristics (e.g. income groups, education) is unknown and could not be ascertained given the sample frame available for this study.

3.0 RESPONDENT PROFILES

3.1 Socioeconomic Characteristics

A socioeconomic profile of the sample group respondents is presented in Table 4. As a general characterization, sample respondents could be described as white, middle aged males with at least some college education and above average household incomes. Although comparisons of the boat owner population with the general population are difficult, it would appear that the sample groups are not representative of the average Dade County resident. Female, Hispanic and lower income groups are proportionally lower in the samples than in the general population, but this does not indicate that the samples are not representative of the boating population. In addition, the relatively high number of years the average respondent has boated in Dade County suggests that the sample groups represent stable, long term residents of the community who are experienced and knowledgeable of local waters and resources.

3.2 Allocation of Boating Activity

In order to provide as representative a sample of the general boating population as possible, all respondents were asked to report their participation in boating related activities during the preceding six months. The six month period was used to minimize recall problems. The allocation of boating days across fishing, diving, skiing and pleasure cruising activities is reported in Table 5. Respondents were asked to count only the primary activity on a single day as participation in that activity. The results indicate that saltwater fishing is by far the most popular boating activity with the highest rate of participation and the largest number of activity days. Cruising was the second most popular activity with skin and scuba diving a close third. Although there are some small differences in the distribution of activity days between the two sample periods, in general the participation profiles are very similar. This can be attributed to the relatively constant weather conditions in the South Florida area that permits practically year-round participation in boating. The average respondent spent approximately 21 days engaged in boating related activities during each six month reporting period.

Table 4. Summary of respondents by socioeconomic characteristics and sample group

Item	Sample 1	Sample 2	Total
Age	43.7	45.0	44.3
Sex			
-Male	94.4%	94.0%	94.2%
-Female	5.6%	6.0%	5.8%
Race			
-Hispanic	19.9%	15.9%	18.1%
-Black	2.2%	1.5%	1.9%
-White	76.7%	81.9%	79.0%
-Other	1.3%	0.7%	1.0%
Education			
-Some high school	6.2%	4.5%	5.4%
-Completed high school	16.5%	11.3%	14.1%
-Some college	23.7%	22.0%	22.9%
-Completed two-year degree	15.9%	17.6%	16.7%
-Completed four-year degree	21.7%	25.1%	23.2%
-Completed graduate degree	16.0%	19.5%	17.6%
Years Boating in Dade County	16.5	18.0	17.2
Household Income	$44,975	$48,076	$45,781

Table 5. Allocation of boating activity days by sample group and total

Item	Mean	Minimum	Maximum*	Percent of Respondents Participating	Total Days
Sample 1					
-Fishing Days	10.8	0	99	73.9%	6,956
-Diving Days	3.0	0	69	40.4%	1,938
-Skiing Days	1.5	0	99	21.7%	978
-Cruising Days	5.5	0	99	57.6%	3,530
Sample 2					
-Fishing Days	9.2	0	99	77.1%	4,952
-Diving Days	3.9	0	80	48.7%	2,090
-Skiing Days	1.8	0	48	25.3%	991
-Cruising Days	6.0	0	99	62.3%	3,230
Total					
-Fishing Days	10.1	0	99	75.4%	11,908
-Diving Days	3.4	0	80	44.1%	4,028
-Skiing Days	1.7	0	99	23.4%	1,969
-Cruising Days	5.7	0	99	59.7%	6,760
TOTAL	20.9				24,665

*Maximum days in any one activity were truncated at 99 for reporting purposes.

4.0 FISHING ACTIVITY ANALYSIS

4.1 Trip Activity and Artificial Reef Use

All respondents who participated in saltwater fishing during the prior six month period were classified into two groups depending on whether they had fished at artificial reefs during the period. Because the Dade County reefs are not marked by buoys, reef users must depend on shore "line-ups" or specialized equipment readings to locate a site. To avoid confusion about the name and location of artificial reefs and natural habitat, respondents were provided with a map of the Dade County coastal area (Figure 1). The map divided the area into six zones with each artificial reef site highlighted and the names of wrecks or other material used to construct the reef listed for each site.

The number of respondents indicating they had fished at artificial reef sites during the prior six month sample period is reported in Table 6 for both sample groups. The percent of each sample that used the artificial reefs is very similar. Approximately 28 percent of the total sample who participated in saltwater fishing reported some activity at artificial reefs. Since most respondents who fished at artificial reefs also reported fishing at other non-reef sites, the reader should not conclude that these were single purpose trips. If artificial reef use is expressed as a percent of the total boat owner sample (not just those who participated in saltwater fishing), the percent of reef users would be 21.4 percent.

Table 6. Number of respondents fishing at artificial reefs by sample group and total*

	Sample 1		Sample 2		Total	
Fished at artificial reefs	138	29.0%	115	27.7%	253	28.4%
Did not fish at artificial reefs	338	71.0%	300	72.3%	638	71.6%
Total angler respondents	476	100.0%	415	100.0%	891	100.0%

*Percentages are for the respondent group that participated in some fishing activity during the sample period, not for the total sample.

Indications of the differences between artificial reef user and nonuser anglers are given by the socioeconomic and boat equipment data reported in Table 7. For the total sample, the angler reef user group was slightly younger with fewer years boating experience in Dade County than nonusers. Users were more likely to be members of a fishing or diving club but there was little difference whether boating trips occurred on weekends and holidays or during the week. In terms of boating equipment, reef users tended to have only slightly larger boats

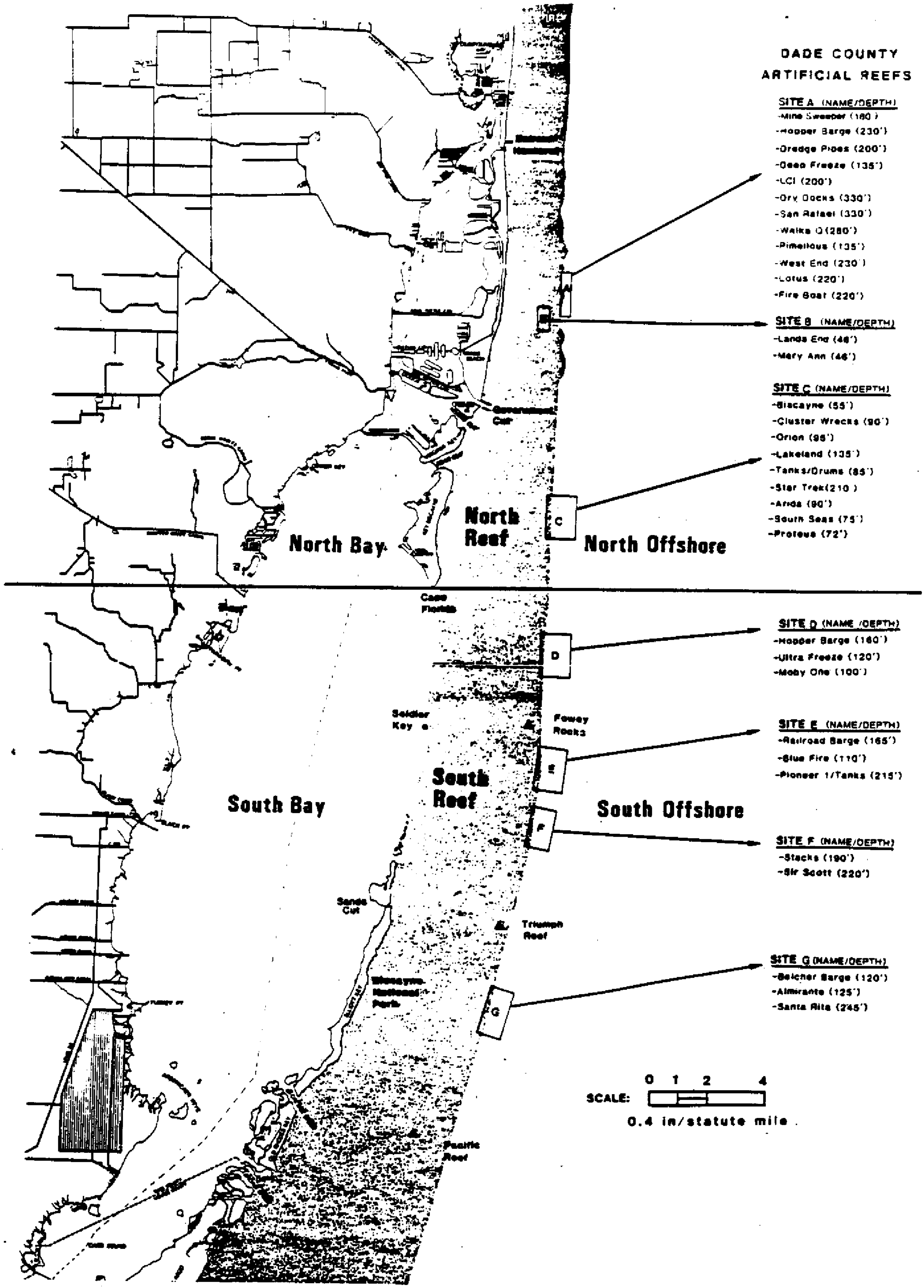


Figure 1. Map of Dade County coastal waters with zones and artificial reef sites.

and engines but there were significant differences in other specialized equipment. Reef users were more likely to own depth-finders, Lorans, and fish-finders; all are pieces of equipment that can be useful in locating an artificial reef. This equipment may also indicate a more serious committment to fishing activity.

Another dimension of the differences between reef users and nonusers is evident in the distribution of fishing trips across fishing zones reported in Table 8. In both sample groups reef users were on average more avid anglers with nearly double the number of fishing trips in the reporting period. In addition, reef users were more likely to fish in the reef or offshore zones (see Figure 1) than nonusers. While there are differences in the distribution of activity across zones in the two sample periods, the differences are relatively small suggesting that seasonal factors are not a major influence on angler site choice decisions in the Dade County area.

Artificial reef users also reported the number of fishing trips to the specific artificial reef sites identified in Figure 1. The results reported in Table 9 indicate that the average user visited an artificial reef site approximately 10 times during each six month period or on roughly 50 percent of the average users' total fishing trips during the period. While there are differences in the average number of site-specific trips between the sample groups, the total number of users for any single site is relatively small so that conclusions about seasonal use patterns cannot be drawn. Sites B and D were the least frequently used which is not

Table 7. Profile of artificial reef user and nonuser angler respondents by socioeconomic characteristics and boat equipment for total sample

Characteristic	Users	Nonusers
Age	42.7	44.7
Years boating in Dade County	17.2	18.4
Member of a fishing or diving club(%)	14.9%	9.7%
Boat only on weekends and holidays(%)	87.6%	89.5%
Boat length	22.2	21.8
Engine horsepower	199.0	186.7
<u>Special equipment (percent with)</u>		
-Depth-finder	77.8%	60.5%
-Loran	26.2%	13.3%
-Two-way radio	83.7%	69.6%
-Compass	96.4%	90.6%
-Radar	0.4%	1.4%
-Fish-finder	49.2%	26.5%

surprising given that these sites are in the shallowest water and are among the sites with the least amount of reef material. The other reef sites had definite differences in user visitation.

Respondent anglers who used the artificial reef sites were asked a series of detailed questions about their most recent trip to a reef site. These detailed questions focused on the most recent trip again in order to minimize recall problems. The distribution of the months in which these most recent trips occurred is reported in Table 10. Not surprisingly the distribution tends to cluster around the months of survey mailing, namely June and November. For the majority of user respondents the average recall period for the most recent trip was three months or less. This length of time is generally considered to be acceptable for respondent recall about fishing trip activities. Because of the focus on the most recent trip, user reef fishing activity during the winter season is not well represented in the data.

Respondent anglers who did not use the artificial reefs (nonusers) were also asked a series of detailed questions about their most recent fishing trip. Since the monthly distribution of trips closely parallels that reported for reef users in Table 10, the distribution is not presented here. Instead, a comparison of fishing methods employed by artificial reef users at reef sites and nonusers in specific fishing zones for the combined sample is presented in Table 11. Since anglers may use more than one method on a single trip and at a single site, the categories are not mutually exclusive. The results, however, show some consistent patterns. Nonusers' fishing in the Bay tends to concentrate on bottom fishing and/or surface casting; reef zone fishing also concentrates on bottom fishing but deep trolling and drift fishing are also popular; offshore fishing typically involves surface trolling but some bottom fishing, drift fishing, and deep trolling are also used. By contrast, fishing at artificial reefs is more eclectic. While bottom fishing is the most common method, drift fishing and surface trolling at the sites are also popular methods. Given the location of the reef sites, this diversity is not surprising. The Dade County reefs are located along the coastal "shelf" where water depth changes rapidly from 100 feet or less to 300 feet or more within a distance of approximately one nautical mile. In addition to the bottom dwelling species that are typically associated with artificial reefs, the Dade reefs may also serve as attractants for "open-water" species due to the high water column profile on many of the ships/vessels used for reef material. In light of the wide variety of resident and migratory species in the coastal Southeast Florida area, the concept of a well defined fishing method for a "target species" is not a very meaningful approach to characterize fishing effort by Dade County anglers.

Table 8. Distribution of fishing days across trips to fishing zones by user group and sample*

Destination	Used Artificial Reefs			Did Not Use Reefs		
	Sample 1 (N=138)	Sample 2 (N=115)	Total (N=253)	Sample 1 (N=338)	Sample 2 (N=300)	Total (N=638)
ZONES						
North						
-Bay	0.99	1.23	1.10	0.88	0.96	.92
-Reef	3.10	3.06	3.08	0.81	0.63	.73
-Offshore	3.75	3.66	3.71	1.49	1.18	1.34
South						
-Bay	1.53	1.51	1.52	1.82	2.06	1.93
-Reef	3.72	4.87	4.24	3.06	1.98	2.55
-Offshore	5.60	4.75	5.21	3.35	2.72	3.05
TOTAL	18.70	19.08	18.86	11.41	9.53	10.52

*Zone destinations are not mutually exclusive; a respondent may choose several destinations on a single trip.

Table 9. Distribution of fishing trips to artificial reef sites by sample*

Destination	Sample 1 (N=138)	Sample 2 (N=115)	Total (N=253)
ARTIFICIAL REEFS			
-A	1.97	1.39	1.71
-B	1.01	0.62	0.83
-C	1.49	1.46	1.47
-D	0.80	0.83	0.81
-E	1.78	1.74	1.76
-F	1.33	1.63	1.47
-G	1.88	1.64	1.77
TOTAL	10.25	9.32	9.82

*Site destinations are not mutually exclusive; a respondent may choose several sites on a single trip.

Table 10. Monthly distribution of artificial reef use based on last reported fishing trip by sample group and total

Month	Sample 1		Sample 2		Total	
	Number	%	Number	%	Number	%
January	-		-		-	
February	2	1.4	-		2	0.8
March	9	6.5	2	1.7	11	4.3
April	24	17.3	1	0.9	25	9.8
May	42	30.2	6	5.2	48	18.9
June	48	34.5	11	9.6	59	23.2
July	9	6.5	12	10.4	21	8.3
August	2	1.4	25	21.7	27	10.6
September	-		20	17.4	20	7.9
October	2	1.4	26	22.6	28	11.0
November	-		11	9.6	11	4.3
December	-		1	0.9	1	0.4
TOTAL	138	100.0%	115	100.0%	253	100.0%

4.2 Catch Rates by Zone and Site

Because of the diversity of species composition, an attempt to incorporate species specific catch reporting into the survey questionnaire was abandoned after an initial screening trial with local sportfishing club members. As an alternative, both reef users and nonusers were asked to report the total number and weight of fish caught (either kept or released) by the total fishing party on their most recent fishing trip. From this data, fishing success at artificial reef and nonreef sites was measured by the number and weight caught per unit effort. For this analysis per unit effort is defined as the total hours fished at a site times the number of persons in the fishing party. The per unit effort calculation is a means of "standardizing" fishing trips of different duration and party size. In situations where more than one fishing site was reported on the most recent trip, total catch was allocated to individual sites based on the number of fishing hours reported for each site. The resulting measures of reef user and nonuser success for the combined sample are reported in Table 12.

Different statistics for the angler success measures are reported in Table 12 because of the difficulty of characterizing angler objectives. The mean statistic is simply the average value of the measure for all anglers at a particular site. The median is the middle value of the measure's distribution. Both the mean and median represent "typical" catch (number or weight) for a unit of effort (one angler fishing for one hour). Neither statistic is very

Table 11. Distribution of fishing methods by zones and artificial reefs for users and nonusers for total sample

	Fishing Method*				
Site	Bottom Fishing	Deep Trolling	Surface Trolling	Drift Fishing	Surface Casting
			NONUSERS		
ZONES					
North					
-Bay	70.5	4.5	25.0	29.4	31.8
-Reef	77.4	3.2	41.9	32.3	25.8
-Offshore	23.8	25.4	79.4	25.4	15.9
South					
-Bay	69.8	2.3	24.4	26.7	40.7
-Reef	88.3	6.7	33.3	34.2	21.7
-Offshore	44.6	17.4	72.1	25.4	19.5
			USERS		
ARTIFICIAL REEFS					
-A	76.7	30.0	30.0	53.3	16.7
-B	92.3	15.4	30.8	61.5	15.4
-C	77.3	20.4	52.3	45.5	11.4
-D	61.5	30.8	46.2	15.4	23.1
-E	80.5	19.5	26.8	51.2	9.8
-F	58.0	19.4	45.2	64.5	12.9
-G	71.3	18.8	37.5	56.3	11.3

*Fishing method categories are not mutually exclusive.

Table 12. Alternative measures of angler success for fishing zones and artificial reefs for total sample by user and nonuser groups*

Fishing Site	Number/Unit Effort				Pounds/Unit Effort			
	Mean	Median	C.V.	Skewness	Mean	Median	C.V.	Skewness
NONUSERS								
ZONES								
North								
-Bay(57)	1.05	0.60	139.31	2.76	2.43	1.33	129.80	2.30
-Reef(57)	1.23	0.67	145.81	2.46	2.63	1.17	195.14	3.59
-Offshore(82)	0.76	0.36	157.56	2.77	2.86	1.67	149.15	3.50
South								
-Bay(111)	1.72	1.00	119.76	2.19	2.63	1.67	107.70	1.75
-Reef(155)	1.56	0.88	122.54	2.71	3.02	1.93	139.43	4.25
-Offshore(196)	1.16	0.44	230.08	9.10	4.54	2.50	216.06	8.31
TOTAL TRIP (508)**	1.68	0.83	162.23	5.01	4.29	2.30	184.56	7.60
USERS								
ARTIFICIAL REEFS								
-A(42)	0.85	0.50	137.53	2.46	8.57	3.75	194.65	4.36
-B(26)	1.27	0.96	95.51	1.01	6.47	3.75	133.52	2.43
-C(52)	1.68	0.40	236.93	4.63	5.76	2.25	270.49	6.24
-D(28)	1.15	0.37	214.74	3.89	6.66	3.17	188.04	4.36
-E(78)	0.95	0.35	204.15	5.31	4.43	2.38	197.18	5.33
-F(53)	0.93	0.33	272.12	6.26	5.72	2.50	223.06	5.00
-G(78)	1.16	0.39	194.77	4.14	5.82	2.00	171.27	3.66
TOTAL TRIP-REEF(234)**	1.72	0.61	199.37	4.16	9.03	2.67	216.18	5.76
TOTAL TRIP-OTHER SITES(180)***	2.28	1.00	153.70	3.42	10.02	3.75	233.96	7.24

*Numbers in parentheses indicate the number of respondents in group for each site.

**The Total Trip measure is the average catch across all sites for the total number of respondents in each group; it is not the average of catch rates for each site. The Total Trip measure is generally higher than the average across all sites because the number of respondents used for the total trip group does not account for the multiple site trips that are reflected in the individual site data.

indicative of "exceptional" or "low probability" catch that may attract anglers interested in experiencing a special fishing trip. As an alternative, the coefficient of variation (C.V.) is a unitless measure of relative variability in the distribution of a success measure. The C.V. is the ratio of the standard deviation to the mean and is expressed as a percentage (scale of 100.0). The C.V. is useful for comparing the relative variation in success for two or more sites. Another measure of variability in success is skewness. This statistic indicates the tendency of deviations from the mean to be larger in one direction than in the other (asymmetry). Skewness can also be used to evaluate the relative variability of sites.

The results in Table 12 indicate some distinct differences in angler success at artificial reefs versus nonreef sites. Looking first at number per unit effort (NUE), the range of mean and median statistics for nonuser fishing in the six zones and user fishing at the artificial reef sites is similar although the user reef site medians tend to be lower than the nonuser zone medians. The "total trip" measure for each grouping is an average measure of catch for the total time fished across zones or sites; it is not the average of the individual site catch measures. A comparison of total trip mean and median NUE for nonusers and users (Total Trip-Reef) also indicates similar success rates for the fishing time reef users spend at artificial reefs versus the fishing time nonusers spend in the nonreef zones. However, reef users also reported time and catch at other nonreef sites used on their most recent trip. This catch measure is reported on the line "Total Trip-Other Sites." These mean and median NUE indicate a higher average success rate for reef users at nonreef sites than at reef sites and a higher success rate than nonreef users fishing in the other zones. These results suggest that reef users who use both artificial reef and other nonreef sites may be "more skillful" anglers than the average nonreef angler.[2]

The measures of NUE variability in Table 12 indicate other differences between reef users and nonusers. The C.V. and skewness for reef sites tends to be larger for users at reef sites than for nonusers. The exception is for the south offshore zone. This suggests that some reef anglers are likely to have "unusual" success at reef sites. It is interesting to note however that the variability measures are smaller for reef users at other sites than at artificial reefs and for nonusers at nonreef sites. Again this may indicate that reef users who combine reef and nonreef site fishing may be more skillful anglers than nonusers.

---

[2]The notion of "more skillful" may also be interpreted as more avid. As noted above in Section 4.1, reef users tend to have more specialized equipment to find particular sites and/or fish and they tend to fish more frequently than nonreef users. In addition, reef users tend to fish more hours per trip than nonusers. The average nonreef user spent 3.36 hours fishing per trip. The average reef user who just fished at the artificial reefs spent 3.76 hours per trip. The average reef user who fished at both reef and nonreef sites spent 7.09 hours per trip, 3.28 hours at reef sites and 3.81 hours at nonreef sites.

The pounds per unit effort (PUE) measures in Table 12 also indicate differences in success rates between reef users and nonusers. On average, the mean and median PUE for reef users is consistently higher than the comparable measure for nonusers across the six fishing zones. The south offshore zone is again an exception. The variability measures also indicate that catch for reef users is more variable but skewed toward larger catch than for nonusers in other zones except for the south offshore zone. The total trip statistics for PUE support the notion that fishing effort at artificial reefs is more productive than for nonusers at other sites. User success at other sites besides the artificial reefs, however, is higher than at the reef sites suggesting that the differences between reef and nonreef success cannot be attributed only to differences in fish availability at different sites. Reef users may catch a different composition of species at artificial reefs and other sites than nonusers at other sites. These possible differences in catch between user and nonuser groups cannot be resolved with this data set and the reader should not conclude from these results that the Dade County artificial reefs are more productive or have a better "quality" of fishing than nonreef sites.

In summary, catch success as measured by NUE and PUE indicates that there is considerable variation in NUE and PUE across different artificial reef and nonreef sites. While NUE for reef users and nonusers tended to be similar for reef and nonreef trips, the PUE measures indicated that reefs generally yielded larger average catch and more "exceptional" catch than nonreef sites. There is considerable evidence, however, that reef users may be more "skillful" anglers than nonusers. These measures of angler success should not be interpreted as indicators of differences in fishery productivity for reef and nonreef habitat.

4.3 Anglers' Perceptions of Artificial Reefs

Artificial reef users were also asked to indicate the importance of different reasons for deciding to fish at the reef sites. Respondents could vary their response on a scale of 1 to 4 where 1 was "very important" and 4 was "not important at all." The percentile breakdown of responses is reported in Table 13 with an entropy measure of agreement among the respondents. The entropy statistic is a measure of consensus across different response categories and varies between 0 and 1. An entropy value close to 1 indicates little or no agreement; a value closer to 0 indicates strong or complete agreement. The entropy formula is: $\sum_i (p_i \cdot \ln(p_i))$ where p is the probability of the ith response category. The entropy statistic is given by the ratio of the actual to the maximum possible entropy.

The results in Table 13 indicate that the reason for fishing at an artificial reef with the highest level of agreement among reef users was a "better chance of catching fish." The perception of improved fishing success is clearly a very important factor even though not as

Table 13. Artificial reef users' reasons for fishing at artificial reefs for total sample*

Reason	Very Important	Somewhat Important	Not Very Important	Not Important at All	Entropy
	----------	----------	%	----------	
Better chance of catching fish	78.1	18.7	1.4	1.8	.51
Previous fishing success at sites	52.5	33.3	7.8	6.4	.78
Sites are close to shore	26.2	23.4	30.1	28.2	.98
Wanted to fish near other boats	5.2	7.1	14.5	72.1	.63
Other fishermen had recommended sites	15.9	42.5	22.4	18.6	.94
Sites are easy to locate	40.6	37.5	12.3	9.4	.87

*Responses may not sum to 100 percent because some respondents did not mark each reason.

many users agreed that previous success at reef sites was as important in their site choice decision. Other factors that were of some importance for deciding to fish at artificial reefs were the ability to easily locate the reef sites and recommendations from other anglers.

For comparison purposes, nonusers (only those who had fished in the last six months) were also asked their reasons for not fishing at artificial reefs. The results are presented in Table 14. The majority of nonusers indicated they simply did not know about the artificial reefs while approximately a third indicated the reefs were too hard to find.[3] Less than 20 percent of nonusers chose to fish at sites other than artificial reefs because they thought fishing was better elsewhere. Approximately 10 percent of the total nonuser group indicated they had fished at artificial reefs at some time in the past other than during the preceding six months. This would indicate that the actual artificial reef user group may be larger than that represented by those users surveyed in this study based on reef use during the preceding six months.

---

[3]The reader should recall that the Dade County reefs are not marked by buoys and users must depend on shore line-ups or electronic locating devices. Differences in the types of specialized equipment (see Table 7 above) between users and nonusers may account for the alternative perception of users that the reefs are easy to locate compared to some nonusers' perceptions.

Table 14. Reasons cited for not fishing at artificial reef sites for total sample

Reason	Percent (N=548)
Didn't know they were there	47.2
Too hard to find	30.2
Better fishing elsewhere	19.5
Other	3.1
No response	(42)
Fished at artificial reefs at some previous time	(73)

5.0 DIVING ACTIVITY ANALYSIS

5.1 Trip Activity and Artificial Reef Use

Sample respondents who participated in sport diving activity during the prior six month period were also classified into two groups depending on whether they had used artificial reefs during the sample period. Respondents for this section of the questionnaire were also asked to refer to the map of coastal zones and reef sites provided with the questionnaire (see Figure 1).

The number of respondents indicating they dove at artificial reef sites during the prior six month period is reported in Table 15 for both sample groups. As with the preceding fishing activity analysis, the percent of each sample using artificial reefs is very similar. However, a considerably smaller percent of the total diving group used artificial reefs as compared to the total fishing group (13.5 percent versus 28.4 percent, respectively). If reef use is expressed as a percent of the total boat owner sample (not only those who participated in sport diving), the percent of sport diver reef users would be 6.0 percent.

Differences in the socioeconomic characteristics and boating equipment between divers using artificial reefs and nonusers are presented in Table 16. As with the angler user and nonuser groups, there are some slight differences in age and experience and users were more likely to be members of a fishing or diving club. There was no difference in the boat length and engine horsepower of the two groups but users were again more likely to have specialized equipment that could be useful in locating a specific reef site. As with the angler user group,

Table 15. Number of respondents diving at artificial reefs by sample group and total*

	Sample 1		Sample 2		Total	
Sport diving at artificial reefs	38	14.4%	33	12.6%	71	13.5%
Did not sport dive at artificial reefs	226	85.6%	228	87.4%	454	86.5%
Total diver respondents	264	100.0%	261	100.0%	525	100.0%

*Percentages are for the respondent group that participated in some sport diving activity during the sample period, not for the total sample.

Table 16. Profile of artificial reef user and nonuser sport diver respondents by socioeconomic characteristics and boat equipment for total sample

Characteristics	Users	Nonusers
Age	39.1	41.0
Years boating in Dade County	15.5	17.7
Member of a fishing or diving club(%)	18.6%	11.6%
Boat only on weekends or holidays(%)	83.8%	90.5%
Boat length	22.5	22.6
Engine horsepower	198.3	199.6
Special equipment (percent with)		
-Depth-finder	73.2%	63.2%
-Loran	32.4%	18.1%
-Two-way radio	81.7%	75.8%
-Compass	97.2%	92.3%
-Radar	1.4%	1.3%
-Fish-finder	45.1%	29.1%

this additional investment in special equipment suggests that reef users may have a more serious commitment to diving activity.

Another aspect of the additional commitment of reef users is apparent in the differences between the number of days user and nonuser respondents participated in diving activities. As reported in Table 17, reef users on average took twice as many dive trips as nonusers during both six month sample periods. In addition to more trips, artificial reef divers were more likely to dive in the reef and offshore zones than nonusers. This may suggest that divers

Table 17. Distribution of diving days across trips to diving zones by user group and sample

Destination	Used Artificial Reefs			Did Not Use Reefs		
	Sample 1 (N=38)	Sample 2 (N=33)	Total (N=71)	Sample 1 (N=226)	Sample 2 (N=228)	Total (N=454)
ZONES						
North						
-Bay	0.34	0.52	0.42	0.19	0.20	0.20
-Reef	1.83	1.72	1.78	0.64	0.45	0.55
-Offshore	2.37	1.73	2.11	0.07	0.03	0.05
South						
-Bay	0.42	0.96	0.69	0.80	1.13	0.97
-Reef	4.30	3.48	3.90	3.24	3.09	3.16
-Offshore	2.24	1.49	1.87	0.25	0.33	0.29
TOTAL	11.50	9.90	10.77	5.19	5.23	5.22

using artificial reefs are oriented more to deep water diving than nonusers. Also the relatively high number of trips by nonusers to the south reef zone, an area that encompasses most of the natural reef habitat designated as the Biscayne National Park, may indicate that nonusers prefer relatively shallow (less than 35 feet) natural reef habitat over deeper, open water sites.

While divers using artificial reefs may be more oriented to deep water diving, it is apparent from the distribution of diving trips to specific artificial reefs reported in Table 18 that the water depth of some sites limits diver use. It is not surprising that Site C is the most popular site since it is the artificial reef with the most material (primarily ship wrecks) in water less than 100 feet. Most divers consider dives over 100 feet to be more dangerous because decompression is usually required. The other sites received relatively similar usage although Site B, the only site in relatively shallow water (less than 50 feet), and Site D were below average. Firm conclusions should not be drawn from these results, however, given the small sample sizes for each site.

Table 18. Distribution of diving trips to artificial reef sites by sample*

Destination	Sample 1 (N=38)	Sample 2 (N=33)	Total (N=71)
ARTIFICIAL REEFS			
-A	0.84	0.36	0.61
-B	0.27	0.42	0.35
-C	2.92	1.57	2.25
-D	0.73	0.00	0.39
-E	1.03	0.70	0.87
-F	0.89	0.79	0.84
-G	0.84	0.40	0.62
TOTAL	7.52	4.24	5.93

*Site destinations are not mutually exclusive; a respondent may choose several sites on a single trip.

Respondent divers were also asked a series of detailed questions about their most recent trip to a reef site. The distribution of the months in which these trips occurred is reported in Table 19. As with the angler monthly trip distribution, the diver monthly distribution is clustered around June and November, the months of survey mailing. The second period sample, however, is more dispersed across the full six month sample period suggesting that the frequency of dive trips may decline in the later months of the year. This pattern is also apparent in the nonuser monthly trip distribution profile (not reported here). Thus, there may be more seasonality in diving activity than in angling activity and artificial reef use by divers may be more seasonal than use by anglers.

Table 19. Monthly distribution of artificial reef use based on last reported diving trip by sample group and total

Month	Sample 1		Sample 2		Total	
	Number	%	Number	%	Number	%
January	-		-		-	
February	3	7.9	-		3	4.2
March	3	7.9	-		3	4.2
April	5	13.2	-		5	7.0
May	9	23.7	4	12.1	13	18.3
June	18	47.3	1	3.0	19	26.8
July	-	-	5	15.2	5	7.0
August	-	-	6	18.2	6	8.5
September	-	-	9	27.3	9	12.7
October	-	-	3	9.1	3	4.2
November	-	-	4	12.1	4	5.6
December	-	-	1	3.0	1	1.5
TOTAL	38	100.0%	33	100.0%	71	100.0%

5.2 Trip Purpose and Catch Rates by Zone and Site

In contrast to anglers who use artificial reefs, sport divers may be interested in more than the fishery resources available at the reef. Sport divers may be attracted by the novelty and adventure of wreck diving as well as the opportunity to photograph large schools of colorful tropical fish. Respondent divers were asked to indicate the purpose of their most recent dive trip whether to an artificial reef or to natural habitat. The responses reported in Table 20 indicate that the percent of divers participating in spearfishing was roughly the same for both artificial reef users and divers using only natural habitat. These percentages were relatively stable across the two sample periods (data not displayed here). Thus, the responses suggest that there are few differences in the types of diving activities engaged in by artificial reef users and nonusers.

To assess the magnitude of spearfishing activity by divers at artificial reefs, reef users who did spearfish on their most recent trip were asked to report the number and weight of their catch in exactly the same manner as anglers did in another section of the questionnaire. For comparison purposes, nonusers who engaged in spearfishing at natural habitat sites were also asked to report their catch. The results for both groups are reported in Table 21 for specific zones and reef sites. Success measures are calculated in an analagous manner to the angler success measures reported above in Table 12 based on the number of divers in the dive

Table 20. Dive trip purpose for total sample by user and nonuser groups*

Activity	Used Artificial Reefs		Did Not Use Artificial Reefs	
	Number	%	Number	%
Sightseeing/Photography	40	56.3	268	59.0
Spearfishing	31	43.7	186	41.0

*Percentages are for the respondent group that participated in some sport diving activity during the sample period, not for the total sample.

party and the time at the site. The results suggest that although there are differences in the success rates for the two groups, the differences are minor. Reef users tended to have a slightly smaller number per unit effort (NUE) but the pounds per unit effort (PUE) was larger. In addition, the dispersion measures (C.V. and skewness) indicate for both NUE and PUE that reef success was more variable but more skewed in the direction of larger catch. Thus, the results suggest that reef users are more likely to have the "unusual" catch but the small sample sizes limit any firm conclusions about differences for specific sites or zones. Since most divers who used artificial reefs only dove at the reef site, the success rates for reef users at other sites are not reported here.

It is interesting to note the differences in the success rates for divers (Table 21) and those for anglers (Table 12). On average, divers reported considerably lower success rates than anglers. Both reef user and nonuser divers had catches with fewer fish and smaller fish than angler users and nonusers. Because the survey did not distinguish between fish species, it cannot be determined from these data whether anglers and divers pursue the same fish species. The data suggest, however, that divers put less pressure on fish populations (as indicated by NUE and PUE) than anglers regardless of the type of habitat. Considering the percentage of the total sample indicating angling use of the artificial reefs as compared to the percent indicating spearfishing use, it is apparent that the total harvesting pressure on the Dade County artificial reefs by private boat anglers is considerably greater than the harvesting pressure exerted by private boat divers.

5.3 Divers' Perceptions of Artificial Reefs

Divers who used artificial reefs were asked to indicate the importance of different reasons for deciding to dive at artificial reefs. Responses could vary on a scale of 1 to 4 where 1 was "very important" and 4 was "not important at all." The results reported in Table 22 indicate considerable diversity of opinion among divers about their reasons for using reef

Table 21. Alternative measures of success by spearfishing for diving zones and artificial reefs for total sample by user and nonuser groups*

Fishing Site	Number/Unit Effort				Pounds/Unit Effort			
	Mean	Median	C.V.	Skewness	Mean	Median	C.V.	Skewness
NONUSERS								
ZONES								
North								
-Bay(1)	2.50	2.50	-	-	5.00	5.00	-	-
-Reef(9)	1.11	1.00	39.35	-0.17	2.88	2.50	68.44	0.86
-Offshore(3)	1.47	0.33	148.94	1.71	4.57	0.89	150.19	1.72
South								
-Bay(6)	1.24	0.83	89.28	1.79	3.61	3.75	52.27	-0.05
-Reef(111)	0.72	0.50	92.21	1.11	2.44	1.75	111.19	2.07
-Offshore(1)	0.06	0.06	-	-	0.17	0.17	-	-
AVERAGE	0.79	1.11	94.36	1.47	2.57	1.88	106.90	1.95
USERS								
ARTIFICIAL REEFS								
-A(2)	0.00	-	-	-	0.00	-	-	-
-B(1)	0.63	0.63	-	-	4.69	4.69	-	-
-C(17)	0.28	0.17	111.69	0.98	1.86	0.67	121.09	1.01
-D(3)	0.56	0.75	60.62	-1.73	5.09	2.25	127.20	1.59
-E(8)	0.62	0.47	129.08	2.33	2.30	1.99	96.60	0.71
-F(6)	0.56	0.38	118.71	2.12	2.64	1.39	113.08	1.04
-G(7)	0.63	0.44	90.28	2.33	3.47	2.78	60.22	1.49
AVERAGE	0.68	0.30	125.14	2.05	3.79	2.00	118.10	1.16

*Numbers in parentheses indicate the number of respondents in group for each site.

sites. While a majority indicated it was at least important that there was a better chance of spearing fish at artificial reefs, a large percent also indicated it was not important at all. This lack of agreement reflects the different activities engaged in by divers (Table 20). But, it sharply contrasts with the high level of agreement among anglers about the importance of better fishing in their decision to fish at artificial reefs (Table 13).

Table 22. Artificial reef users' reasons for diving at artificial reefs for total sample

Reason	Very Important	Somewhat Important	Not Very Important	Not Important at all	Entropy
	%				
Better chance of spearing fish	39.1	15.6	15.6	28.1	.94
Previous diving success at sites	59.7	29.0	6.5	4.8	.71
Sites are close to shore	53.0	25.8	12.1	9.1	.84
Wanted to dive near other boats	18.5	12.3	20.0	49.2	.89
Other divers had recommended sites	21.9	37.5	20.3	20.3	.97
Sites are easy to locate	69.2	13.8	10.8	6.2	.67

The two reasons with the highest importance ranking and the most agreement among divers were the ability to easily locate artificial reef sites and previous diving success at the sites. Both of these reasons suggest familiarity with artificial reef sites and indicate some concern for convenience as a reason for using artificial reefs. This convenience factor is also apparent in the importance of the reef sites' proximity to shore. The reader may wish to note again that this convenience factor is apparent also in the angler importance ratings (Table 13) but divers give a much higher rating to these reasons.

Sport divers who did not use the artificial reefs were also asked to indicate the most important reason for their decision. The results reported in Table 23 indicate a similar pattern as the results for angler nonusers reported earlier in Table 14. The majority on diver nonusers (40.2 percent) did not know about the artificial reefs while approximately one-fourth thought diving was better at natural habitat sites. Although it was not a response option on the questionnaire, approximately 11 percent of the respondents wrote in that they did not use the reefs because they were too deep. In addition, a relatively high number of respondents did not answer this question suggesting that the choices offered to respondents may not have been representative of their personal reasons. The fraction of reef nonusers indicating they had used the artificial reefs at some time in the past other than during the previous six month survey period was considerably smaller than for the angler sample group. This would indicate that the reef user group from the Dade County diver population identified in this survey is fairly representative of the reef user population.

Table 23. Reasons cited for not diving at artificial reef sites for total sample

Reason	Percent (N=361)
Didn't know they were there	40.2
Too hard to find	22.7
Better diving elsewhere	25.5
Reefs are too deep	11.4
No response	(93)
Dove at artificial reefs at some previous time	(27)

6.0 BENEFIT ESTIMATION FOR ARTIFICIAL REEFS

6.1 Introduction

Artificial reefs are different from other types of marine recreation facilities such as marinas and fishing piers because it is very difficult to measure use of the facility and add up the amount of money customers are willing to pay for the facility. In this sense, artificial reefs are "local public goods" because they benefit members of the local community. Yet, it is difficult or impossible to pay for the facility from user charges or entrance fees because it is not realistic to exclude those who will not pay for using the facility. As a result, artificial reefs are typically provided out of general public tax proceeds and the economic benefits of the reefs are not directly measurable.

The Dade County artificial reef system has operated in a local public good setting such as the above since its inception. Therefore, to estimate the economic benefits of the reef system, it was necessary to utilize survey methodologies that would yield information about public perceptions of the artificial reefs and economic values. This section describes the methods used and the results. This material is not intended as a general discussion of economic valuation methods; useful references to the literature are provided in the text for the reader who wishes further detail on the methods used. Section 6.2 reports on both reef user and nonuser attitudes about the artificial reef system. Section 6.3 describes the application of the contingent valuation method used in this project and reports the results. Section 6.4 describes the travel cost methods used and the results from this valuation methodology. Section 6.5 summarizes the results of the different valuation methods and provides total benefit estimates for the population based on extensions of the sample results. Since some of the discussion in Sections 6.3 and 6.4 involves the use of advanced statistical techniques, the reader who is only interested in the general results of this analysis may want to skip these sections and go directly to Section 6.5.

6.2 Respondent Attitudes About Artificial Reefs

Individual attitudes about and values for public investments are closely intertwined. To determine both user and nonuser attitudes about artificial reefs, a set of statements were presented to respondents and they were asked to indicate a range of responses from strong agreement (1) to strong disagreement (4) to each statement. For this attitude evaluation, nonusers are classified as boaters who had not used the artificial reefs for either fishing or diving. Respondents who had not participated in any fishing or diving activity during the past six months also responded to these statements and are included in the nonuser group.

Results from this attitude evaluation are presented in Table 24. Attitude scores are presented here as the mean response in order to provide a comparison between the three groups. Using the mean, a score less than 2.5 indicates general agreement with the response while a score greater than 2.5 indicates general disagreement. For the first statement concerning whether the existing artificial reefs are located too far from shore, the fishing user group tended to disagree with the statement while diving users and nonusers tended to agree. Considering the convenience issue for divers discussed earlier in Section 5.3, this response is quite consistent. The second statement about whether the reefs are too crowded elicited general disagreement from all three groups although the nonuser group had a high percentage indicating no opinion about the issue. The statement that artificial reefs are more productive than natural reefs drew general agreement from all three groups although it is interesting to note that this item drew the highest percentage of "No Opinion" for all the attitude statements in this section. While the exact reason for this lack of opinion cannot be determined, it may be due to confusion about the meaning of the term "more productive."

Table 24. Respondent attitudes about existing artificial reefs by fishing and diving user groups and nonusers for total sample

Statement	Fishing Users		Diving Users		Nonusers	
	Ranking[1]	No Opinion(%)	Ranking[1]	No Opinion(%)	Ranking[1]	No Opinion(%)
Artificial reefs are located too far from shore	2.62	10.5%	2.39	10.1%	2.35	27.6%
Artificial reefs are too crowded	2.56	13.0%	2.59	11.4%	2.73	53.7%
Artificial reefs are more productive than natural reef	2.26	25.9%	2.33	24.6%	2.35	54.5%
There are too many artificial reefs now	3.58	6.9%	3.72	7.2%	3.49	29.3%
Artificial reefs should only be in water less than 150 feet deep	2.30	10.5%	1.74	12.9%	1.97	23.0%

[1]The attitude ranking is the mean of group responses on the scale 1 to 4 where 1 is Strongly Agree, 2 is Agree, 3 is Disagree, and 4 is Strongly Disagree.

Respondents may have different interpretations of the purpose of artificial reefs and/or they may feel they do not have enough experience/knowledge to form an opinion.

On the issue of whether there are now too many artificial reefs in the Dade County area, users and nonusers all indicated strong disagreement with this statement. For the user groups this statement led to the lowest level of "No Opinion" responses and even the nonuser group had a relatively low level of nonresponse. This response pattern clearly suggests that artificial reefs are viewed as a positive contribution to the marine environment and the (boating) community has not yet reached their limit with respect to the number of artificial reefs.

The last statement about whether artificial reefs should only be sited in water depths less than 150 feet drew a surprising level of agreement from all three groups. This is a relevant issue for this area because the coastal shelf extends the length of Dade County and water depths change rapidly along this shelf. Divers of course most strongly agreed with the statement which would be expected given the difficulty and danger of diving below this depth. Nonusers also indicated considerable agreement suggesting that deep water sites may be too difficult for many anglers or divers to use given either the size of their boat, their degree of boating experience, or their preferences for fishing and diving activities. Anglers also generally agreed with the statement but with much less consistency. Given the angler usage rates for some of the deep water reef sites (see Table 9), some anglers clearly prefer this deep water habitat. However, it also seems apparent that many current users of the reefs would prefer sites in shallower water.

Another important attitude issue concerns community preferences for the location of a new artificial reef. Given the length of the Dade County coastline and the number of access points, locational preferences could be an important determinant of future use. However, because it would be impossible to specify all possible sites, respondents were asked to indicate their first priority from among five choices which represented access points between Biscayne Bay and the open ocean (see Figure 1). The results reported in Table 25 indicate a pattern of preferences that appears to be closely aligned with current residential distributions and launch sites. It is difficult to identify any consistent differences between the three groups suggesting that respondents may simply prefer locations that are most convenient given their typical boat launching sites and boating activities.

Another indication of the importance of convenience in reef siting is given by the respondents' willingness to travel to use a reef site. Respondents were asked to mark the maximum amount of time they would travel from their usual launch site to use a new reef site. The responses reported in Table 26 indicate a clear preference for sites within 1 hour or less of the launch site. Again there is surprising amount of consistency for the three groups

Table 25. Respondents' preferences for the siting of a new artificial reef by fishing and diving user groups and nonusers for total sample

Potential Site	Fishing Users	Diving Users	Nonusers
		%	
Off Haulover Cut	22.9	17.4	14.8
Off Government Cut	10.6	15.9	10.5
Off Biscayne Channel	13.9	17.4	17.5
Off Sands Cut	24.9	30.4	24.3
Off Caesar Creek	27.8	18.8	33.0
No Response	(8)	(3)	(81)

Table 26. Respondents' maximum amount of time willing to travel to use a new artificial reef by fishing and diving user groups and nonusers for total sample

Maximum Time	Fishing Users	Diving Users	Nonusers
		%	
Less than 15 minutes	4.9	5.8	5.5
15 to 30 minutes	21.5	17.4	20.8
30 to 45 minutes	32.0	26.1	30.0
45 to 60 minutes	25.9	31.9	26.3
More than 1 hour	15.8	18.8	17.5
No Response	(6)	(2)	(86)

indicating that current user groups are as much influenced by travel time to a site as current nonusers. The responses may also suggest that there is a certain "threshold" for travel time on a boating trip that will inhibit site usage regardless of the perceived qualities of the site.

6.3 Contingent Valuation of Artificial Reefs

6.3.1 An Overview of Contingent Valuation

The contingent valuation (CV) method uses direct surveys to elicit individual's value of local public goods such as recreation facilities. The basic objective of CV is to determine an individual's willingness to pay and/or willingness to accept compensation for changes in the supply or quality of a local public good. A hypothetical, but realistic, situation is described to the respondent and a payment or compensation mechanism is used to elicit the respondent's monetary value for the change in the local public good. The payment or compensation mechanism can be of three basic types:

- an open-ended question in which the respondent is simply asked how much they would pay and/or accept;
- a closed-ended question in which the respondent is asked if they would pay and/or accept a specific dollar amount and the respondent can respond yes or no;
- an iterative bidding question in which the respondent is first asked to respond to a specific dollar amount with a yes or no response and then incremental increases or decreases are presented and the respondent is again asked to respond yes or no until the maximum payment and/or compensation is determined.

There is an extensive literature on the advantages and disadvantages of each type of mechanism. The interested reader should consult Milon and Johns (1982), Bockstael et al. (1985), or for a comprehensive discussion, Cummings et al. (1986). Briefly, the literature indicates that the closed-ended and iterative bidding type questions are the most realistic for respondents and most likely to yield reasonable responses.

The literature also indicates that questions about respondent's willingness to accept compensation for changes in a local public good may lead to unreliable responses. Individuals are rarely placed in situations where they are asked to accept compensation for the loss of a park or the right to use a public facility. Because this type of situation is not realistic to most respondents, their responses will probably be poorly considered and not representative of meaningful economic value.[4]

In this study closed-ended and iterative bidding payment mechanisms were used to elicit information about respondents' willingness to pay for a new artificial reef along the Dade County coast. This was selected as the most realistic setting for the CV analysis because it was unlikely that respondents would seriously consider any proposal to pay for the already

[4]For example, the Bockstael et al. (1986) study of South Carolina artificial reefs used a closed-ended compensation format based on the notion of respondent's willingness "...to sell their rights to use artificial reefs during a given day." (p. 56) Since artificial reefs are open access facilities where exclusion would be prohibitively expensive, it is difficult to imagine a situation where a respondent would realistically sell this fictitious right and then refrain from using the artificial reefs except for sake of conscience. This type of CV setting is clearly hypothetical to the respondent and it is unlikely that it provides any incentives for careful deliberation. This study also used a more realistic closed-ended payment format (willingness to donate for reef program maintenance) but the two formats presented different ranges of dollar payments so the results are not directly comparable.

existing artificial reefs and a hypothetical permit or license to use the existing reefs would also be unrealistic and cause considerable confusion.[5]

To evaluate the influence of alternative payment mechanisms on respondents' valuation of artificial reefs, the sample was (randomly) partitioned into three subgroups and each subgroup was presented with one of three alternative payment formats (copies of each payment format are included in Appendix B). The three formats were:

- a closed-ended voluntary contribution to a public trust fund[6] that would be used to build a new reef;
- a closed-ended public referendum on a boat fuel tax whose proceeds would also be earmarked to a public trust fund; and,
- an iterative bidding process in which boat fuel tax payments were used to elicit maximum willingness to pay to a trust fund for a new reef.

Each format gives respondents different incentives for "truthfully" responding to the hypothetical valuation setting. As a general principle, if respondents are inclined to understate their true preferences for artificial reefs, it would be expected that the voluntary contribution format would lead to the lowest valuation of the three formats. Other hypotheses about responses to the different valuation formats can be developed but are not done so in this report. The interested reader is referred to Milon (1986a and 1986b) which contains an extended discussion on the theoretical basis for the valuation format experiment conducted in this project.

For each format respondents were asked to indicate a "Yes" or "No" to a specific annual dollar payment to the artificial reef trust fund. The amount of the dollar payment ranged from $5 to $40 by $5 increments across each format group. Respondents using the bidding format were given the option of specifying a smaller (larger) amount if the initial payment suggested was greater than (less than) their maximum willingness to pay. In addition, approximately 50 percent in each format group were asked to sign their name to their payment response indicating serious consideration of the reef development proposal. Responses

---

[5]The State of Florida presently does not have a salt water fishing license. Recent legislative efforts to initiate a license program have met with vocal opposition from the sportfishing community. A proposal to initiate a license or permit for artificial reef use would be met with similar opposition that would obscure the basic issue of reef valuation.

[6]The trust fund concept is used in each valuation format to make it clear to respondents that their "payments" would be earmarked solely for reef development. While such a fund does not currently exist in Dade County, the fund concept makes the valuation context more realistic in that respondents perceive that such a program could be implemented. The State of Louisiana has in fact created such a trust fund for artificial reefs in the recently enacted Louisiana Fishing Enhancement Act.

from the fishing and diving sections of the survey were used to categorize respondents into user (either fishing or diving at artificial reefs) and nonuser groups.

6.3.2 Results of the Contingent Valuation Experiment

The mean payment amounts presented to respondents in the three format groups are reported in Table 27. Sample size in each cell is given by the sum of the positive and negative responses. Since the amount of the payment was random across the $5 to $40 range for each format, each amount has an equal probability of being included in the respondent group and the expected mean payment per format group is $22.50. The means reported in Table 27 vary slightly from this expected mean but a multiple range test of differences in mean payment amounts by format and respondent group indicated no statistically significant difference. Thus, there is no statistical bias in the sample design caused by differences in format or the classification into respondent groups.

To determine the influence of the alternative valuation formats and various characteristics of the respondents on responses to the willingness to pay questions, a statistical analysis using a probit form of regression analysis was performed. Probit analysis uses the Yes or No responses as the dependent variable in a predictive equation in which independent variables such as the amount of the payment to the trust fund, the income of respondents, and prior use of artificial reefs are used to estimate the probability of a Yes

Table 27. Mean payment amounts and number of positive/negative respondents by valuation format and respondent group*

Group	Voluntary	Referendum	Bidding Game
Users	$23.43 [46/39][1] (11.41)[2]	$23.37 [55/46] (11.31)	$23.40 [63/34] (12.24)
Nonusers	$22.74 [99/188] (11.58)	$22.56 [142/152] (11.57)	$21.91 [146/124] (11.95)

*Multiple range test of differences in mean offer amounts for all mechanisms and respondent groups indicated that means are not statistically different from each other at the .05 level of significance.

[1]Number of positive/negative responses across all initial offer amounts.

[2]Standard deviation of the mean.

response to the contingent valuation exercise.[7] In equation form this can be represented as:

Prob(Yes) = f(Payment, Valuation format, Income, Socioeconomic characteristics).

For this analysis two models are estimated for the user and nonuser groups. Model I is a pooled model in which all three valuation formats are used; the voluntary contribution format is the "base" or intercept and the referendum and bidding formats are represented as dummy variables in the probit model. Since all three formats share the same range of payments, the payment variable is continuous. Model II is a pairwise comparison model using only the referendum and bidding format responses. In this model the referendum format is used as the intercept and the bidding format enters as a dummy variable. Both Models I and II include variables to measure the influence of the signature request, income, the total number of days engaged in fishing and diving activities during the prior six months, and membership in fishing or diving clubs on the probability of a positive response to the contingent valuation request.

Results from the statistical analysis are presented in Table 28. Considering first the user group, the results for Model I show that the payment amount had a negative and statistically significant influence on responses. As the dollar amount of the payment increased, the probability of a Yes response decreased. This is as expected and indicates that respondents did not respond to the contingent valuation setting in a purely random manner. The valuation formats did not influence users' responses since neither format variable is statistically different from 0 at the .10 level of significance. The statistically insignificant coefficient for the signature variable indicates that the response pattern for respondents who were asked to and did sign their name to their response was no different from those who were not asked to sign their name. To the extent that the act of signing one's name indicates that the respondent has seriously considered the valuation context, this result suggests that most respondents gave careful consideration to the payment request. The only other variable that was statistically different from 0 in Model I was income. The coefficient indicates that the higher the level of respondent income, the greater the probability of a positive response. The fact that the fishing and diving effort and the club member variables were not significant suggests either that users' willingness to pay for an artificial reef is not influenced by their commitment to these activities or that there was not sufficient variation

[7]Another method for evaluating such discrete response results is logit analysis. Probit and logit analysis are very similar except that probit assumes a normal distribution for the error term of the predictive equation while the logit model assumes a logistic distribution (Maddala). The two distributions are very close to each other, except at the tails of the distribution, so the results are not likely to be very different. A more extensive discussion of model assumptions and statistical estimation for the discrete choice model presented here is contained in Milon (1986a).

in these variables among the user group to influence the response probabilities. The results from Model II for the user group are similar. The coefficient for the bidding format variable indicates that this format tended to increase the probability of a positive response relative to the referendum format but again the effect is not statistically significant. The results for the other variables in Model II are similar except that the income variable is not significant in this comparison.

The results for nonusers in Table 28 indicate very different responses than for the user group. First, in Model I both the referendum and bidding formats had a positive and statistically significant effect relative to the voluntary contribution format. This suggests that the voluntary format encouraged nonusers to understate their willingness to pay for reef development. By contrast in Model II, the bidding format variable is not statistically significant indicating no clear understatement bias in responses to the referendum and bidding formats. In both models the signature variable is not significant but it is interesting to note that the variable is negative in both models and the t-statistic for the coefficients are much higher than in the user models. Income again is statistically significant in both models. Not surprisingly, total days fishing and diving is positive and statistically significant in both nonuser models indicating that current nonusers who actively participate in fishing and diving are more likely to indicate a positive response to the valuation question. This suggests that the more active nonusers may perceive that they will use the artificial reefs at some time in the future or they may believe that artificial reefs contribute to the overall fishery productivity of the area. It is difficult to distinguish the exact motives for these nonusers but their responses indicate that the current reef users are not the only group that has a positive economic valuation for reef development.

The results of the probit models in Table 28 indicate the changes in the probabilities of a positive response to the payment setting given different valuation contexts and characteristics of the respondents. These models can be used to estimate the mean and distribution of respondents' willingness to pay for an artificial reef.[8] The results are reported in Table 29 for the user and nonuser groups and for each valuation context. For the user group the mean and median values indicate a rather consistent valuation pattern with the

---

[8]The technique for converting the probit predictive model into an estimating equation for willingness to pay is a statistical transformation of the estimated coefficients using the variance of the error term. The result is an equation in which individual characteristics of the respondents and of the valuation context can be used to generate a distribution of willingness to pay values. This method differs from the traditional approach to analysis of discrete choice contingent valuation models as outlined in Milon (1986a). Complete details on this technique are presented in Cameron and James (1987).

Table 28. Maximum likelihood probit comparison of willingness to pay for a new artificial reef with alternative valuation formats

	Users		Nonusers	
	Model I	Model II	Model I	Model II
Intercept	.608** (2.01)	.954*** (2.71)	-.326** (2.11)	-.099 (.568)
Payment	-.036*** (5.10)	-.041*** (4.77)	-.016*** (4.23)	-.010** (2.12)
Referendum format (0 or 1)	.064 (0.33)	-	.355*** (3.31)	-
Bidding format (0 or 1)	.304 (1.53)	.272 (1.40)	.490*** (4.48)	.136 (1.28)
Signature (0 or 1)	.003 (.017)	-.015 (.077)	-.087 (.986)	-.070 (.655)
Income (1,000s)	.006* (1.84)	.005 (1.61)	.004*** (2.61)	.004* (1.90)
Total days fishing and diving	-.001 (.004)	-.004 (.592)	.007*** (2.45)	.009*** (2.40)
Club member	.304 (1.54)	-.099 (.378)	.199 (1.25)	.013 (.065)
N	283	198	851	564
χ^2	32.96***	28.88***	56.41***	15.74**

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)
t-statistic in parentheses

Table 29. Mean annual willingness to pay for an artificial reef for alternative valuation formats by user and nonuser groups with multiple range test of differences in format means

Group	Valuation Format		
	Contribution	Referendum	Bidding
Users	$18.04* ($17.77)[1] [$17.13-$20.52][2]	$19.75* ($19.47) [$19.01-$21.77]	$26.57 ($26.21) [$25.64-$28.72]
Nonusers	$1.14 ($0.00) [-$12.84-$22.25]	$22.85 ($21.09) [$8.07-$39.75]	$31.93 ($30.11) [$18.93-$51.55]

*denotes pairs of means which are not statistically different at the .05 level of significance. Multiple range test accounts for unequal sample size.

[1]Medians reported in parentheses.

[2]95% confidence interval for estimate reported in brackets.

bidding format eliciting the highest dollar amount. A multiple range test of the user means indicates that the valuation from the contribution and referendum formats were not statistically different, a result consistent with the results in Table 28. In addition, the closeness of the mean and median values indicates that the distribution of the willingness to pay values is tightly clustered; this can be interpreted as evidence of consistency among the user group about their valuation of artificial reef development.

The results for the nonuser group in Table 29 show the influence of the different valuation formats and the greater variability among nonuser responses. The very low valuation for the voluntary format ($1.14) reflects the tendency for this format to cause respondents to understate their preferences. The referendum and bidding formats produce mean values which are more consistent with the user group means although somewhat higher. A multiple range test for the nonuser group means indicated that they are all statistically different.

6.4 Travel Cost Measures of Artificial Reef Benefits

6.4.1 An Overview of Travel Cost Methods.

The travel cost model of recreation site user behavior is the most commonly used method of valuing recreation facilities and is recommended for most water and fishing related projects (Huppert, 1983; U.S. Water Resources Council, 1983). The fundamental assumption of this valuation model is that individual's decisions to use recreation sites are based on the travel costs to these sites and changes in these travel costs can be used to measure the value of a particular site. While this is a well known methodology, there are several alternative versions of the basic travel cost framework. These versions can be grouped under the general headings of a) single site models and b) multiple site models. Detailed discussions on various aspects of these models are available in Bockstael et al. (1985), Loomis et al. (1986), Milon and Johns (1982), and Stynes and Peterson (1984). The following is a brief overview of the main features and modeling alternatives in these general groups.

Single site models express the demand for one particular site or a group of similar sites as a function of the travel costs to the site(s). This relationship can be expressed as:

$$V_i = f(TC_i)$$

where V is the number of visits to a site by the ith individual or a group of individuals in the ith travel zone and TC is the travel cost associated with the trip. Although either individual or zonal visit data can be used, most recent applications of the travel cost model have used the individual as the focus of analysis. Specific socioeconomic characteristics of the individuals can be used as independent variables in this model to explain variation in visit behavior. Alternatively, several sites can be grouped together in a model of the form:

$$V_{ij} = f(TC_{ij}, Z_j)$$

where the index j indicates a particular site within a group of sites and Z indicates one or more characteristics of each site within the group. This latter model can also include socioeconomic characteristics. This model is more complete than the first site model since it allows site characteristics to influence the site choice decision as well as the travel costs to the site. This type of model is frequently described as a "single equation pooled site" model.

The principal shortcoming of these single site models is that they do not directly consider the effects of travel costs to substitute sites on the decision to visit a particular site. These travel cost substitution effects are accounted for in multiple site models. The simplest form of a multiple site model is:

$$V_{ij} = f(TC_{ij}\ ,\ TC_{ik}) \quad \text{for all } k = 1,\ldots,n\ ;\ \ j \neq k$$

This model estimates the demand for the jth site as a function of the travel costs to that site by the ith individual and the travel costs to the other k sites for that individual. This type of model is frequently described as a "single equation with multiple site costs" model. Alternatively, each of the 1 thru n sites can be modeled as a function of its own travel costs and the resulting set of single site equations estimated as a system of demand equations. This model is described as a "multiple equation demand system."

Another version of the basic multiple site model is one in which the decision to visit a particular site on a single choice occasion is expressed as a probability. Once again the costs of substitute sites enter as explanatory variables. The probability of visiting each site can then be determined for each individual. This relationship can be expressed as:

$$P_{ij} = e^{a+b_1x_{1j}\ldots+b_nx_{nj}} \Big/ \sum_k e^{a+b_1x_{1k}\ldots b_nx_{nk}}$$

where $x_1,\ldots,x_n$ are independent variables (travel costs, site characteristics, etc.). For each individual i, the P_{ij}'s will sum to one across all sites included in the choice set. The probabilities can then be used to construct a demand curve for a particular site. Such a model is described as a "single equation multinomial logit." Other versions of this probability framework have been developed and are typically referred to as "site share" models. The principal distinction between these share models and the multinomial model is the specification of the underlying utility function that generates the functional form of the probability generating function. A discussion of these model alternatives is available in Morey (1981).

A major shortcoming of both the single site and multiple site models discussed above is that both consider the demands of <u>users</u> only. Within these modeling frameworks there is no way to estimate the demand for a new site by those who are currently nonusers. One approach to avoid this shortcoming is through nested choice demand models. These models adopt a sequential choice framework in which both the decision to participate in an activity and the choice of sites are considered. In the context of artificial reefs, this nested choice process could be described as 1) the decision whether to fish (dive) at an artificial reef, and 2) which artificial reef to choose. Variables such as an individual's boat length, experience, equipment, knowledge of local waters, and the relative differences between reef and nonreef sites may be used to explain the first choice. Site-specific characteristics such as fishing quality, accessibility and travel costs to the site could be used to explain the second choice. The model could also be expanded to include a third stage in which a decision such as whether to fish offshore or inshore or whether to participate in fishing (diving) is also considered. Unfortunately, there is no "correct" way to structure the sequence of choices so that nested choice models must be developed with the information available about individuals and sites.

The remainder of this section presents the statistical results from estimating the various travel cost models described above. Estimates of the individual economic benefits from each of the modeling frameworks are also presented. These results are intended to give the general reader a basic understanding of the statistical basis for the estimated use benefits. The more specialized reader interested in technical and methodological aspects of these models should consult Milon (1988a).

Because travel costs are the critical component of economic benefit measures from travel cost models, estimates of travel costs to artificial reef sites were based on as much user specific data as possible. In this analysis, it is assumed that fuel costs are the only expense item that changes with reef use. This is a reasonable assumption given that reef users also fish at other sites and it would be difficult to partition trip expenses across different sites. To estimate user-specific fuel costs, the nautical distance to each reef site was calculated for seven launch sites along the Dade county coast.[9] Travel time to these sites was then calculated using average boat running speeds for different engine horsepower groups and navigational features of each launch site (e.g. distance to ocean inlet, access to Intracoastal

[9]The specific launch sites from north to south were Baker's Haulover, Pelican Island (79th St. causeway), Watson Island, Dinner Key, Crandon Park, Matheson Hammock, and Homestead Bayfront Park. All of these sites have both wet slips and boat launching ramps to accommodate most types of boats. Respondents who launched at other sites (including their own private docks) were assigned to the closest launch site from among these seven.

Waterway).[10] The estimated travel time to each site was then converted to fuel use based on respondents' reported average fuel use per hour of running time (assuming normal boating conditions). Fuel use was converted to a monetary expense using a uniform rate of $1.25 per gallon of fuel.[11]

6.4.2 A Pooled Site Model

The first travel cost model presented is a single equation pooled site model estimated for all anglers using the artificial reefs. This model implicitly assumes that all artificial reef sites have the same demand for a given travel cost expense and constant site quality. The results for this model are:

$$V_{ij} = -9.53^{***} - 7.38^{***}\ TC_{ij} + .001\ Y_i + 1.04^{***}\ CM_j + .55^{**}\ CCV_j + .669^{***}\ EQI_i + .004^{***}\ EHP_i$$

$R^2 = .23$, $F = 69.72$, $N = 1736$

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)

where V_{ij} are the visits by the ith individual to the jth reef site, TC_{ij} are the travel costs for the ith individual, Y is household income, CM and CCV are measures of site quality (in this case the mean pounds per unit effort for each site, CM, and the coefficient of variation for mean pounds per unit effort for each site, CCV (Table 12)), EHP is the engine horsepower rating of the individual's boat, and EQI is an index variable for the types of equipment on the

---

[10]Average boat running speeds for engine horsepower groups assumed normal seas and light boat traffic conditions. The running speed groupings were: 10 miles per hour (mph) for engines less than 50 horsepower (hp), 14 mph for engines rated 50 to 100 hp, 16 mph for engines rated 100 to 150 hp, 18 mph for engines rated 150 to 200 hp, 20 mph for engines rated 200 to 250 hp, 22 mph for engines rated 250 to 400 hp, and 18 mph for engines rated over 400 hp. These estimated running speeds are based on conversations with local boat dealers since there are no published data on actual running speeds for engine and boat size groups.

[11]The complete equation for estimating travel costs to a site is given by:

$$(D_{jm}/RS_i) \times BFM_i \times \$2.50$$

where D is the distance to the jth reef site from the mth launch site, RS is the running speed per hour for individual i, BFM is the boat fuel mileage per hour for individual i, and $2.50 is the round-trip cost per gallon of fuel. It should be noted that travel time to a site is also a relevant constraint on the reef site use decision. This component can be added to travel costs by multiplying travel time by the individual's wage rate. In this analysis the opportunity cost of travel time is set equal to zero because alternative specifications using different fractions of the wage rate (1.0, 0.5, and 0.25) did not improve the performance of the statistical models. The implication of this procedure is that estimated benefits are likely to be "conservative" estimates of the true benefits.

respondent's boat (Loran, depth finder, fish finder and two-way radio). The model is estimated for all anglers who used at least one reef site; zero values are included if the user did not use a specific site. The econometric procedure accounts for the inclusion of zero values in the dependent variable using a two-stage Tobit estimation technique (Maddala, 1983).

Most variables in the model have the expected sign and are highly significant. For example, the coefficient for the travel cost variable indicates a negative relationship between cost and site visitation and is statistically different from zero. The mean catch rate variable, CM, is positive indicating a direct relationship between catch and site visitation. Similarly, catch variability, CCV, is positive indicating anglers may prefer some uncertainty in mean catch rates in the hope of catching larger fish at specific reef sites. While these results are generally consistent with expected angler behavior, it should be noted that aggregate measures of fishing success such as CM and CCV may not be meaningful measures of artificial reef site quality where the species composition of catch is as diverse as that on the Dade County reef system. In addition, the equipment index, EQI, and the engine horsepower, EHP, are highly significant indicating that investments in boating equipment are an important determinant of site visitation. Unfortunately, the explanatory power of the model as measured by R^2 is low but relatively good for cross-section travel demand studies of this type. Other explanatory variables such as membership in fishing clubs or other socioeconomic characteristics added little to the model's performance.

User benefit estimates can be derived from the pooled site model either by assuming that all artificial reef sites were eliminated and could not be used or by assuming the addition of a new reef site. For this exercise, the most relevant case is the addition of a new site. Assuming the new site would be located in a central location (off Government Cut) and characteristics of the new site are typical for the existing sites, the resulting benefit estimates are for an "average" artificial reef site.[12] Average annual reef user benefit estimates per individual with the 95th and 5th percentiles of the distribution from this model are:

---

[12]Because the income variable is not significant in the pooled site model, the calculated user benefit measure is a compensating variation (CV) which can be calculated by the formula:

$$CV_{ij} = (.5(V_{ij})^2/B) - (.5(V^*_{ij})^2/B)$$

where B is the estimated coefficient for the travel cost variable and V_{ij}, V^*_{ij} are the initial number of visits at the existing travel costs and "new" number of visits with the site addition, respectively. The new number of visits for each individual is estimated directly from the pooled site predictive model. Technically, this is an "expected" compensating variation. A detailed discussion of the conceptual basis for the compensating variation measure of use benefits is provided in Milon and Johns (1982).

Mean: $20.41

Upper bound: $24.32

Lower bound: $ 0.00

It is important to note that these estimates apply only to anglers who have used the artificial reefs. Note also that the minimum benefits are $0.00 implying that even some anglers who currently use artificial reefs would not benefit from a new reef. This would be true regardless of the specific location of the new reef since the new site would be a greater distance than an existing reef for at least one user. For the site used in this analysis, approximately 73 percent of the current users would benefit.

6.4.3 A Single Site Model with Substitute Prices

The second travel cost model presented is a single equation with multiple site costs model. This model estimates the demand for a specific site and considers the effect of travel costs to substitute sites. Unfortunately, since only one site demand is estimated, substitute site quality cannot be evaluated in the model. This model was estimated for site "C" (see Figure 1) because this is the most centrally located artificial reef in the system and it has been the principal Dade County reef program development site. Only other artificial reefs are considered as substitutes for this analysis under the assumption that nonreef sites are not equal substitutes. This assumption is likely to lead to inflated benefit measures if nonreef sites are indeed substitutes. The results for this model are:

$$V_{iC} = .27 - 41.60^{***}TC_{iC} + 33.29^{**}TC_{iB} + 5.65^{*}TC_{iA} + 4.93^{***}TC_{iD} + .50^{***}EQI_i$$

$R^2 = .26$, $F = 16.69$, $N = 248$

(*,**,*** indicate significance at the .10, .05 and .01 level, respectively)

where TC_{ij} are the travel costs to each reef site, and the other variables are as defined above. Once again zero values for nonusers of site C are included and accounted for in the estimation using a two-stage Tobit procedure. The travel cost variable for site C, the target site, is statistically significant with the expected sign and all of the other travel cost variables to other sites are significant. The sign for the travel costs to other sites suggest that these artificial reef sites are substitutes in the decision to visit site C. Sites E, F and G were excluded from the model because a mean square error test (Toro-Vizcarrondo and Wallace) indicated these sites did not improve the performance of the model. The other variable in the equation that is significant is the equipment index, EQI. Again, the R^2 statistic is not high indicating there is considerable randomness in the site choice decision.

User benefit estimates can be derived for this model by assuming that site C was eliminated and users were forced to use other reef sites. Alternatively, benefits could also be derived under the assumption that a new site identical to site C was constructed. Again, the benefit measures would vary depending on the exact location of the new site. The resulting estimates are a measure of the user benefits for a reef site with quality and substitution characteristics comparable to site C.[13] Average user benefits per individual with the 95th and 5th percentiles of the distribution for the single equation/multiple site travel cost model are:

Mean:	$20.70
Upper bound:	$91.91
Lower bound:	$ 0.00

These benefit estimates indicate that there is a relatively minor difference between the demand for an "average" reef site as measured by the preceding pooled site model and the demand for site "C" measured with this model. Note again that not all users would benefit from this new site.

6.4.4 A Demand System Model

The third travel cost model presented is a multiple equation demand system model. This model considers the demands for each reef site as part of a system of demand equations specified in terms of travel costs to each site and alternative sites. The advantage of this method is that it recognizes the interdependence between site use decisions although it does

---

[13]Once again the income variable is not significant so the calculated user benefit measure is a compensating variation. The main distinction between the single equation model and the pooled site model is that the travel cost coefficient, B, now accounts for the omitted variable bias that results from the exclusion of substitute site travel costs in the pooled site model. With the second assumption of the construction of a new site, the formula for user benefits is:

$$CV_{iC} = A[TC_{iC}^{*} - TC_{iC}] + 1/2\ B_C[(TC_{iC}^{*})^2 - (TC_{iC})^2] + [TC_{iC}^{*} - TC_{iC}]\ [\sum_{i} \sum_{j \neq C} B_j TC_{ij}]$$

where TC* is the travel cost to the new site, TC is the travel cost to site C, A is the intercept of the estimating equation, and B_j are the estimated coefficients for the substitute site travel costs. For uniformity, the same "central" location for the new reef is used in this calculation as was used in the pooled site model benefit calculation. Some users will gain while others will not with the new location.

not directly include differences in site quality.[14] The model estimation also assumes that only other artificial reefs are substitutes. As with the single equation/multiple site cost model, this assumption leads to inflated benefit measures if nonreef sites are true substitutes. The estimated parameter coefficients for this model are presented in Table 30 where the variables are defined as above.

Results from this model are more difficult to interpret but they tell the same basic story as the preceding single equation model. In most of the equations the own travel cost variable for each site is negative and statistically significant. Many of the coefficients for the substitute sites travel costs, however, are not significant. Substitute sites were excluded from each demand equation using a mean square error test procedure similar to that used for the preceding single site model. The equipment index is significant in each equation. Focusing on the equation for site C, once again the travel cost variables are significant and quite similar to the single equation model. This suggests that the correlation across sites in the demand system model is low and the econometric procedure did little to alter the estimating efficiency for the basic relationships in the site demand model.

User benefit estimates from this model can be derived by following the same procedure as that used for the single equation travel cost model with site C the focus of analysis. Average annual user benefits per individual with the 95th and 5th percentiles of the distribution for the multiple equation demand system travel cost model are:

Mean: $18.84
Upper bound: $85.58
Lower bound: $ 0.00

Given the similarity of the estimated demand equations for site C from the single equation and multiple site system models, it is not surprising that the benefit estimates from the two models are about the same. Again this suggests that there is little advantage to the demand system approach in this locational setting.

[14]The multiple equation demand system model is estimated using a seemingly unrelated regressions procedure. This procedure improves the efficiency of the estimation if the site demands are correlated (Kmenta, pp. 517-528). Cross-price symmetry is not imposed on the demand system.

Table 30. Multiple equation travel cost demand system for artificial reefs, seemingly unrelated regressions

Artificial reef sites	Intercept	TC_A	TC_B	TC_C	TC_D	TC_E	TC_F	TC_G	EQI
A	.386 (.50)	-8.38 (10.93)	3.56 (12.25)	.21 (2.99)	-1.73 (2.04)	-	-	-	.32* (.19)
B	-.174 (.12)	-23.66*** (9.12)	-19.97** (10.28)	6.84*** (1.54)	-	-	-	-	.29* (.16)
C	.116 (.608)	16.49* (8.91)	11.06*** (3.55)	-25.97** (12.39)	1.28 (1.50)	-	-	-	.25** (.13)
D	.300 (.331)	3.45 (6.59)	-	-3.29* (1.89)	-1.61* (.90)	.60 (2.74)	-	-	.21* (.11)
E	1.054** (.47)	-	-	.47 (2.72)	-1.92 (1.67)	-3.47 (3.72)	.33 (6.61)	3.00 (3.59)	.38** (.17)
F	.056 (.42)	-	-	3.05 (2.43)	-.64 (1.48)	2.85 (3.32)	-12.69** (6.00)	6.37* (3.25)	.55*** (.15)
G	.602 (.53)	-	-	-	-	2.92 (3.91)	9.49 (6.82)	-9.88*** (3.46)	.49*** (.19)

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)
Standard error in parentheses

6.4.5 A Multinomial Logit Model

The fourth travel cost model presented is a single equation multinomial logit model. In this model each individual trip decision is used to estimate the likelihood a trip will be taken to a specific reef site given the travel costs and quality of that site. In this model, user characteristics are not considered so only site characteristics enter the estimating equation. Using the same assumptions that only other artificial reefs are substitutes and that site quality can be represented by the pounds per unit effort success rates, the estimated coefficients for this model are:

$$\log(P_i/P_j) = -871.53^{***}\ TC_{ij} + .027\ CM_j + .888^{***}\ CCV_j$$

$\rho^2 = .08$, $\chi^2 = 340.38$, N=2386

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)

where the variables TC, CM, and CCV are as defined above. The coefficients in the multinomial logit equation have a different interpretation than the standard regression model. The coefficients measure the change in the log of the odds of visiting a site given a change in the travel costs or quality of a site. Because individual-specific characteristics such as income or club membership do not change for the choice alternatives, these variables are not included in the model. As expected, the travel cost variable is negative and significant indicating that as travel cost to a particular site increases, the probability of using that site decreases. The coefficient for the catch success variable, CM, indicates that as catch per unit effort and variability at a site increases, the likelihood of use increases. These results are consistent with the other models although the coefficient for CM is not statistically different from zero.

User benefit estimates can be derived from the multinomial logit model following a similar procedure to that for the other travel cost models although with a few modifications. Benefits can be calculated based either on an assumption that a site (e.g. site C) is eliminated and trips must be reallocated to other sites or that a new site is constructed. With the multinomial logit model, the latter assumption yields a probabilistic benefit estimate since it is based on the probability of using the new site.[15] Average annual user benefits per individual with the 95th and 5th percentiles of the distribution for the multinomial logit travel cost model are:

Mean:	\$ 6.15
Upper bound:	\$27.55
Lower bound:	\$ 0.00

The mean benefit estimates from the multinomial logit model are lower reflecting the fact that the individual benefits of a new site are weighted by the probability the individual will actually use that site. This differs from the preceding models which gave deterministic benefit estimates that did not account for the likelihood of participation.

6.4.6 A Nested Multinomial Logit Model

As discussed earlier, a limitation of the previous four travel cost models is that each is estimated for artificial reef users only. There is no way to measure the benefits for anglers who are currently nonusers but who might be users of a new artificial reef. Nested choice travel demand models provide a framework for addressing this issue. The nested choice model presented here can be described in three parts using the tree diagram below and the zonal breakdown of Dade County coastal waters presented in Figure 1 (p. 9).

---

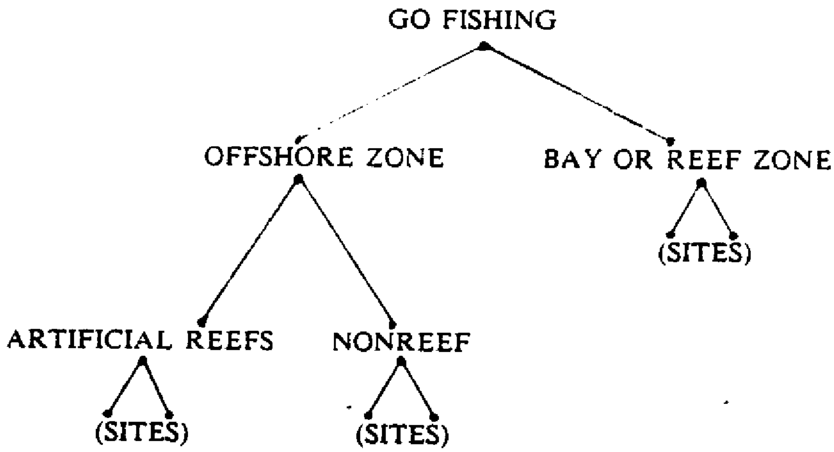
[15]The model is probabilistic in that there is uncertain substitution between sites given a change in site availability but no change in site characteristics. Using the estimated model to predict the likelihood of participation and assuming no income effects, an expected compensating variation measure of user benefits can be derived by the formula:

$$CV_{iC} = P_i(TC^* - TC)$$

where P_i is the probability of using the new site, TC^* is the new travel cost for each individual, and TC is the old travel cost. Again, the same location for the new site that was used in the other models is used here. Alternatively, if site quality is not constant, user benefits would be derived by the formula:

$$CV_{iC} = (TC^* - TC) + 1/B_{TC}(B_Z(Z^* - Z))$$

where B_{TC} and B_Z are the multinomial coefficients for travel cost and site quality and Z^*, Z are the new and original site quality, respectively. Given that the multinomial logit model is estimated on individual per trip decisions, this use benefit measure is a per trip measure. Total use benefits are estimated by multiplying the per trip CV by each individual's estimated number of trips. Rowe (1985) provides a more extensive discussion on benefit estimation with the multinomial logit model.



Given an angler's decision to go fishing on an individual day, the first choice is whether to go to the offshore zone or the bay and reef (near shore) zone. This choice may be determined by factors such as the size of the angler's boat, the engine horsepower, the years of boating experience, and weather conditions. If the decision is to go to the bay or reef zones, the decision whether to go to an artificial reef site is not part of the choice set since the artificial reef sites are located in the offshore zone. If the angler does decide to go offshore, then the second choice is whether to use the artificial reefs. This choice may be influenced by the angler's perception of fishing quality at the artificial reefs, the type of equipment on board, the angler's knowledge of reef locations, and other socioeconomic factors. Finally, the angler must choose among the reef and nonreef sites in the offshore zone based on expected catch, travel costs and time to each site, and other features of each site.

This three level nested travel choice model can be estimated sequentially by first modeling the site choice decision across all offshore and inshore sites for both artificial reef users and nonusers. This site choice decision model for all anglers is comparable to the multinomial logit model presented above except now the choice set facing each angler (users and nonusers) must be explicitly included in the model structure. Site choice data for nonusers were collected as part of the survey (see Section 4.1 discussion of fishing trip data) and were merged with user data to provide a complete set of site choices during the survey year. Using the zonal breakdown of Dade County coastal waters presented in Figure 1, destination characteristics data were constructed from reported catch statistics (Table 12) and calculated travel costs to each destination using the same procedure described in footnote 11.

The first level model that results from this estimation process is given by the equation:[16]

$$\log(P_k/P_K) = -402.053^{***}\ TC - .454^{***}\ TT + .514^{***}\ CM + .799^{***}\ CCV + .079^{***}\ A$$

$\rho^2 = .11$, $\chi^2 = 2284.59$ N = 8,179 Cases; 69,863 Choices

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)

where the variables are as described above except for the new variables TT, travel time to each site, and A, a reef specific variable for the (average) age of the reef site. The estimation results for this level of the nested choice model tell a similar story to the multinomial logit model presented above for only artificial reef sites. Travel costs and travel time are significant determinants of site choice for all anglers. Site quality as measured by CM and CCV is also an important factor in all site choices. Unfortunately, this measure does not capture the influence of species-specific catch at each site.

This estimated site choice model for users and nonusers can then be used in the second level of the decision model, that is, the choice of artificial reef or nonreef sites given a decision to go offshore. First, the estimated model coefficients are used to calculate the "inclusive" or "accessibility" value of the reef and nonreef alternatives. This value measures the relative worth of one subset of choices for each individual in the sample. In this case the inclusive value measures the relative worth of each subset of alternatives based on fishing

---

[16]Mathematically the first level of the nested probabilistic choice model can be represented as:

$$Pr(Site_k) = P_{k|\ell,j} = e^{B^*X_{\ell jk}} / \sum_K e^{B^*X_{\ell jK}}$$

where ℓ indexes inshore and offshore zones, j indexes artificial reef and nonreef habitat types in the offshore zone, k indexes reef and nonreef sites, B* is the coefficient vector and X is the matrix of site characteristics. A detailed discussion of econometric issues related to estimation of the nested choice model is available in Maddala, pp. 67-76. Milon (1988b) provides a more technical discussion of the theoretical and econometric aspects of the complete nested choice model.

quality, site characteristics, and travel costs.[17] The inclusive value is then used in a second stage equation which models the decision whether to choose the reef alternative on a fishing trip given certain characteristics of the angler such as knowledge of local waters, specialized equipment, years of experience and socioeconomic factors. This two level decision problem could be described as a choice of the best site from within the offshore artificial reef or nonreef alternatives and then a choice between these two best sites on each fishing trip. Note that while this choice is modeled for each angler in the sample, there is no consideration of weather, seasonal, or target species objectives that may influence the choice of destination. The results of this estimation of the second level in the nested choice model are:[18]

$$\log(P_j/1-P_j) = -1.653^{***} + .196^{***}\ I + .445^{***}\ EQI + 1.659^{***}\ OP + .484^{***}\ RAC - .009^{**}\ YBD + .176^{*}\ MFDC - .010^{***}\ Y$$

$\rho^2 = .17$ $\chi^2 = 1024.67$ N = 4,838 Cases; 9,676 Choices

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)

where I is the inclusive value for the subsets of offshore artificial reef and nonreef type sites, EQI is the boating equipment index, OP is the individual's opinion whether artificial reef sites are more productive than other sites (see Section 6.2 above), RAC is a dummy variable equal to 1 if the individual is Hispanic or 0 otherwise, YBD is the number of years boating in

---

[17] The inclusive value is a scalar summary of the expected value of a set of travel choice alternatives. It represents the systematic component of utility for each choice set and individual. It can be represented as:

$$I_j = 1/u \ln\left(\sum_{j \in J} e^{uV_{ij}}\right)$$

where u is the utility scale and V denotes the relative utility weights of the characteristics associated with particular sites and group alternatives (reef versus nonreef alternatives). In this application of the model, the utility scale is a constant. The inclusive value construct is valid in higher levels of the nested choice framework only if the estimated coefficient is less than 1 but greater than 0. A complete discussion of the inclusive value construct is available in Ben-Akiva and Lerman, pp. 300-304 or Maddala, pp. 67-76.

[18] The second level of the choice model can be represented as:

$$\Pr(\text{Habitat}) = P_{j|\ell} = e^{a^{*}Y_{ij} + I_{ij}} / \sum_{J} e^{a^{*}Y_{iJ} + I_{iJ}}$$

where a* is the coefficient vector, Y is a matrix of socioeconomic and individual-specific variables, and I is the inclusive value from the first level of the model.

the County, and MFDC is a dummy variable for membership in a fishing club. All coefficients except for the MFDC variable are significant at the .01 level or above. The inclusive value coefficient is within the unit interval and significantly different from 0 indicating that the nested choice structure is a valid model of reef use decisions. The coefficient on EQI indicates that as the amount of electronic equipment on the angler's boat increases, so does the likelihood of using an artificial reef site. Anglers are also more likely to use reefs if they believe reefs are more productive than other sites. The RAC coefficient indicates that Hispanics are more likely to use artificial reefs than non-Hispanic ethnic groups. This result may indicate that Hispanics use artificial reefs due to some preference for species that are commonly caught at artificial reef sites (e.g. amberjack, groupers, snappers). However, this conjecture cannot be tested since species-specific catch was not collected in the survey. The number of years experience boating in County waters had a negative effect on the likelihood of reef use.

The third and final level in the nested choice model is the decision whether to go offshore or not and is a function of the expected worth of each alternative. This suggests that a new inclusive value from the second level of the decision model should be included with other variables to estimate the probability of participation offshore.[19] The resulting equation takes the form:[20]

$$\log(P_\ell/1-P_\ell) = -2.429^{***} + .139^{***}\ II + .008\ BL + .005^{***}\ EHP + .289^{***}\ EQI - .009^{***}\ AGE - .010^{***}Y$$

$\rho^2 = .26 \quad \chi^2 = 2484.15$

(*,**,*** indicate significance at the .10, .05, and .01 level, respectively)

where II is the second level inclusive value, BL is the angler's boat length, EHP is the boat's

[19]The inclusive value from the second level of the choice model can be expressed as:

$$II_\ell = \ln\left(\sum_j e^{a^*Y_{ij} + I_{ij}}\right)$$

where the variables are as defined previously.

[20]The third level of the choice model can be represented as:

$$Pr(Zone) = P_\ell = e^{c^*W_\ell + II_\ell} / \sum_L e^{c^*W_L + II_L}$$

where c* is the coefficient vector, W is the matrix of boat and individual specific variables, and II is the second level inclusive value.

horsepower, EQI is the equipment index, AGE is the angler's age, and Y is annual income. Again the inclusive value is significantly different from zero and indicates there is some advantage to the multi-level estimation model. Of the three boat characteristic variables, only EHP and EQI have a significant effect on the probability of going offshore. The age and income variables indicate that as the age and income of the angler increase, the probability of offshore trips decreases. While the predictive power of this equation (as measured by ρ^2) and the preceding two levels of the model are not particularly high, the statistic(s) does suggest that the model describes some part of the complex decision process that anglers use to select marine fishing sites.

As with the other travel cost models discussed above, the nested choice model can also be used to estimate use benefits from existing artificial reefs or for a new reef site. In this model, however, the benefit estimate applies to all anglers in the sample and not just to users of the reef sites. The benefits to all anglers are weighted by the probability that they will actually use a site.[21] Total benefits per angler are based on the expected number of trips each angler would make to a new reef site. Average annual user benefits per angler with the 95th and 5th percentiles from the nested travel choice model are:

Mean: $ 3.14

Upper bound: $17.54

Lower bound: $ 0.00

Although these benefit estimates are lower than the estimates from the four other travel cost models, it should be noted that these measures apply to all private boat anglers and not just current users of the artificial reefs. This distinction will be important when these individual use benefit estimates are extrapolated to the population in the next section of the report.

---

[21] Following Hanemann's (1982) extension of Small and Rosen's (1981) approach to estimate the use benefits from choice models such as the one presented here, the formula for individual use benefits from the introduction of a new reef site is:

$$\left(\sum_{\ell} e^{c^* Z_\ell^2 + \Pi_\ell^2} - \sum_{\ell} e^{c^* Z_\ell^1 + \Pi_\ell^1}\right) / \sum_{\ell} \lambda e^{c^* Z_\ell^2 + \Pi_\ell^2}$$

where the variables are as defined previously, λ is the compensated income effect, and the superscripts 1,2 refer to the choice sets before and after the introduction of the new reef, respectively. Individual use benefits must be multiplied times the expected number of trips to determine use benefits for the full period.

6.5 Total Resident Use Benefits of Artificial Reefs

6.5.1 Introduction.

The preceding discussion has demonstrated the different valuation methods (contingent valuation and travel cost) and the diverse variations of these basic methods that can be used to identify individual use benefits. While each method and variation has particular strengths and weaknesses, there is no clear-cut "best" model that emerges from this analysis. Rather, the different benefit estimates must be used to construct a range of total population benefit projections consistent with the survey design and assumptions of the valuation methods.

As described in Section 2.0, the sample frame was designed to provide information about both artificial reef user and nonuser benefits from artificial reefs. The consistency of the response rates with the stratification profile (Table 3) indicates that the sample is as representative as possible of the Dade County boater population. However, extensions of the individual use benefit estimates from the different methods must be properly linked to the appropriate population group. For example, the contingent valuation method was used for all respondents to the survey regardless of whether the respondent had recently (within the past six months) engaged in those activities most likely to benefit from artificial reefs (fishing and diving). The user group with this method was defined as those respondents who had recently fished or dived at artificial reef sites. On the other hand, the travel cost method applications were limited to those respondents who had recently participated in saltwater sportfishing. From this group users were defined as respondents who had recently fished at artificial reefs and nonusers were those had fished elsewhere. These differences mean that the contingent valuation estimates are applicable to a larger population group than the travel cost estimates. In addition, the contingent valuation estimates may reflect a broader array of possible benefits than the travel cost estimates which are based solely on fishing activity and success.

It is also important to keep in mind the valuation context for benefit estimation. In each case, the valuation premise was the introduction of a new "centrally located" artificial reef which was representative of existing Dade County reef sites. Thus, the benefit estimates are for a single (marginal) reef site and are not directly applicable to the entire reef system. To the extent, however, that this new site is indicative of typical (average) use benefits from a reef site, the estimated site benefits can be extended to the existing sites in the system to approximate the total benefits of the reef system.

6.5.2 Resident Population Benefit Estimates.

Annual use benefits to the resident population for a new reef site are presented in Table 31 for each benefit estimation method. Beginning with the contingent valuation calculations in the top part of the table, the basis for each estimate of the population group should be noted. For the contingent valuation groups, the user share of the sample was estimated as the weighted average of respondents who used the artificial reefs for fishing or diving (Tables 6 and 15) as a percentage of the total sample (Table 3). This percentage (24.5 percent) was multiplied by the total Dade County resident boat owner population (23,092) as defined in Table 3. The nonuser population was defined as the remaining share of the total. Benefit estimates for each contingent valuation format are mean values as reported in Table 29.

On the basis of the users' benefits as measured by the contingent valuation formats, total annual benefits range from $102,063 to $150,306. Depending on the contingent valuation format, the additional benefits for nonusers can have a significant effect on total benefits. Nonusers' benefits range from $19,875 to $556,668, leading to a range of total benefits for users and nonusers of $121,937 to $706,974. Given that the lowest nonusers' benefits resulted from the contribution format and this format is likely to yield downwardly biased estimates, the estimates from the latter two formats should be considered more reliable.

Population estimates for the travel cost models are based only on the fraction of the sample that participated in saltwater fishing during the study period. Approximately 75 percent fished (Table 5) and of this group about 29 percent were users of the artificial reefs (Table 6). Applying these percentages to the total boater population (Table 3) yields an estimate of the user population with the remaining anglers defined as nonusers of the artificial reefs. Total benefit estimates from each travel cost model are based on average values reported in previous sections.

Total angler user benefits range from $30,387 to $102,279 for the first four travel cost models in Table 31. Since the user population is the same across the models, the variation is due solely to differences in estimated individual user benefits. The total angler benefits from the nested multinomial logit model are $54,652. Thus, even though the nested model yielded the lowest benefit estimate per individual, the total population of anglers is larger than just artificial reef users so that the nested model results are consistent with the other results.

The similarities and differences between the contingent valuation and travel cost benefit estimates reveal important information about the economic value of artificial reefs. All of the estimates of the value of a new artificial reef for the angler user group vary from $30,387 to $150,306; these estimates are reasonably consistent given the variety of benefit estimation methods used. Thus, both the contingent valuation or travel cost methods can be used to measure angler <u>user</u> benefits. However, it is clear that nonusers perceive a significant benefit from artificial reefs as reflected in the responses to the contingent valuation questions. Whether these perceived benefits are due to expected future use, expected improvements in

Table 31. Resident population annual benefit estimates for an artificial reef site with contingent valuation and travel cost methods

Methods and population group		Subtotal	Total
CONTINGENT VALUATION METHODS			
Contribution			
Users:	5,657 × $18.04	$102,062	
Nonusers:	17,434 × $1.14	$ 19,875	
			$121,937
Referendum			
Users:	5,657 × $19.75	$111,726	
Nonusers:	17,434 × $22.85	$398,367	
			$510,093
Bidding			
Users:	5,657 × $26.57	$150,306	
Nonusers:	17,434 × $31.93	$556,668	
			$706,974
TRAVEL COST METHODS			
Pooled Site			
Users:	4,941 × $20.45		$101,043
Single Site with Substitute Prices			
Users:	4,941 × $20.70		$102,279
Demand System			
Users:	4,941 × $18.81		$ 92,940
Multinomial Logit			
Users:	4,941 × $ 6.15		$ 30,387
Nested Multinomial Logit			
All anglers:	17,405 × $3.14		$ 54,652

the local fishery habitat, or simply for general community enjoyment, these nonuser benefits for a new artificial reef can only be measured with the contingent valuation method. Benefit estimates for new reef sites that are based only on travel cost methods are likely to understate the full economic value.

It was pointed out in the preceding discussion that there are several ways to estimate the benefits of an artificial reef. Since the benefit estimates presented in this report are for a new artificial reef, it is not completely correct to extrapolate these marginal benefit estimates to an average site in the existing Dade County reef system. However, for illustrative purposes, a lower bound estimate on the use benefits of the existing sites can be based on the travel cost method results. Using an average annual benefit of $75,000 per site for angling uses, the annual benefits of the 7 sites in the reef system are $525,000. Assuming this annual benefit is based on an initial (sunk) investment with no further costs, the total present value of this stream of annual use benefits can be determined by dividing the annual benefits by an appropriate capitalization rate.[22] Assuming the existing reefs would last in perpetuity and the capitalization rate for public sector investments is 3 percent, the present value of the reef system is $17,500,000. Increases (decreases) in the capitalization rate would reduce (raise) the present value as would different assumptions about the longevity of the existing artificial reefs. Alternatively, an upper bound that would encompass most expected benefits could be defined by using an average annual benefit estimate from the contingent valuation methods. Using an estimated per site benefit estimate of $550,000 and the same capitalization rate of 3 percent, the total present value of the existing reefs is $128,333,333 ((550,000 x 7)/.03). This range of estimated present value benefits illustrates the significance of different valuation methods and assumptions, and the difficulty of defining a precise economic value for an artificial reef system.

This conceptual approach could also be applied to estimate the present value of only one new reef but with one important exception. Since a new reef would require an investment of funds for material, transportation, etc., these initial costs must be accounted for <u>before</u> the benefits from a new site can accrue. The most appropriate procedure to use for this type of accounting is benefit-cost analysis. A complete discussion of benefit-cost analysis for coastal recreation project planning is provided in Milon and Johns (1982).

Finally, it is important to note that although this study attempted to identify as many private boat uses of the Dade County artificial reefs as possible, it did not include charter and party boat uses for sport fishing and diving. These uses are an important part of the total value of the reef system to the community because they attract anglers and divers who

---

[22]The benefit capitalization approach is a standard practice used in many resource valuation contexts such as land or property valuation. This approach uses the simple formula $V = B/r$ in which V is the value of the resource, B is the annual stream of benefits, and r is the capitalization rate. Since this approach is conceptually equivalent to annuity valuation, appropriate adjustments can be made if the resource has a finite useful life.

live outside the County and have an economic impact on the community through their spending for boat services, food and lodging, and other trip related expenses. An effort to identify these uses and the associated economic impact in this study was unsuccessful due to a lack of cooperation by local charter boat operators. A full accounting of these economic benefits would provide a more complete measure of the total economic value of the reef system.

7.0 SUMMARY AND RECOMMENDATIONS FOR FUTURE RESEARCH

7.1 Summary

The current popularity of artificial reef development, due in part to the National Marine Fisheries Enhancement Act of 1984, has created a need for information about the economic benefits of artificial reefs and research methods to estimate these benefits. This study identified and evaluated the activity patterns of registered recreational boaters in Dade County, Florida. Based on a mail survey of 3600 registered boat owners with an overall response rate of 45 percent, usage rates of Dade County coastal waters and artificial reefs by sport anglers and divers were determined. These survey results were used to estimate the economic benefits of artificial reefs and to evaluate the range of benefit estimates with different valuation methods. The major findings of this study can be summarized as follows:

* Saltwater fishing was the most common activity with 75 percent of total boating days; cruising was the second most popular activity followed by diving and skiing.

* Approximately 29 percent of those anglers who fished during the survey period used an artificial reef. Reef users and nonusers tended to differ in the types of boating equipment they owned, their membership in fishing and clubs, age, and other socioeconomic characteristics. The main reason cited by reef users for fishing at artificial reefs was the chance to catch more fish. Many nonusers did not know about the artificial reef sites.

* A variety of fishing methods were employed by artificial reef users; bottom fishing was the most common but drift fishing and trolling were also popular.

* Catch rates at artificial reefs as measured by number and pounds per unit effort were generally higher than at nonreef sites. These measures are not an unambiguous indicator of better fishing at artificial reefs because reef users also generally had higher

catch rates at nonreef sites than nonusers. Also, the survey did not collect species-specific catch data so the significance of the catch rate measures cannot be directly related to target species objectives.

* Approximately 13 percent of the sport divers who responded to the survey used the artificial reefs during the survey period. As with the anglers who used the artificial reefs, divers using the artificial reefs had more boating equipment, more were members of fishing and diving clubs, and they were slightly younger than nonusers.

* The majority of divers using the reefs participated in sightseeing and/or photography as opposed to spearfishing; the percentage of users engaged in spearfishing at artificial reefs was about the same as the percentage of spearfishing by nonusers. Catch rates for spearfishing at the artificial reefs were generally much lower than catch rates by anglers at the reefs. However, sample sizes for spearfishing at specific reef sites were very low so these results should be interpreted with caution.

* The main reason cited by divers for using the artificial reefs was that the sites were easy to locate. Many nonusers did not know about the reefs or thought the sites were too hard to find.

* Results from a contingent valuation experiment using three different valuation formats indicated that current users of the reef system have a positive annual willingness to pay for a new reef site ranging on average from $18.04 to $26.57 per respondent across the different formats. Nonusers also had a positive willingness to pay ranging from $1.14 to $31.93; the wider range reflects the influence of the valuation formats.

* Five different model variations on the basic travel cost method were also estimated based on anglers' site usage patterns. Generally, the alternative models indicated that travel costs to a site, catch rates at the site, the angler's boating equipment, and certain socioeconomic characteristics were significant determinants of artificial reef use and site selection. Benefits estimated from the travel costs models for reef users ranged from $6.15 to $20.70 per respondent. Benefits estimated from a more encompassing nested choice model including both users and nonusers were $3.14.

* Extensions of the individual benefit estimates from the different valuation methods to the general Dade County boating population resulted in a range of total economic benefits for a new artificial reef site. Total annual benefits from the contingent valuation methods ranged from $121,937 to $706,974. These benefits are for users and nonusers and may include certain benefits not directly related to expected use of an artificial reef site. Total annual benefit estimates from the travel cost models apply only to expected use benefits for anglers; these estimates range from $30,387 to $102,279.

* Annual benefit estimates for a new artificial reef site were extrapolated to the existing Dade County reef system. Under certain assumptions about reef usage and the longevity of the reef system, the benefit capitalization approach was used to approximate the present value of the system. With a 3 percent capitalization rate and a "best estimate" of the annual benefits from the different estimation methods, the present value of the system ranged from $17,500,000 to $128,333,333. In light of the different uses and reasons for artificial reefs, it was difficult to define a narrower range of total economic value.

* Because this study was limited to private boater uses of artificial reef sites and did not include charter boat uses, these estimated economic benefits are only a part of the total economic value of the Dade County artificial reefs.

7.2 Recommendations for Future Research

The results of this research illustrate that there are a variety of reasons why individuals may perceive economic benefits from artificial reefs. Given the flexibility of the contingent valuation method to evaluate the use and nonuse motives for these perceived benefits, a useful extension of the experiments conducted in this project would be to add questions directed to individual's specific motives for reef development. This would allow a more complete accounting of the individual benefit components and provide a more complete understanding of the public's perceptions of artificial reef development.

This study has demonstrated that mail survey techniques can be used to identify artificial reef users and to provide information for estimating economic benefits. However, there are certain limits on mail surveys that may hinder useful future research. For example, information about target fish species and species-specific catch would permit more refined linkages between angler participation rates and specific site usage. But, in areas where a wide variety of species are available such as in South Florida, this becomes a virtually impossible task to accomplish in a mail survey. To the extent that species-specific information is relevant for reef design and fishery management decisions, future researchers may want to explore combinations of interview and mail surveys in which trained interviewers can address the species catch aspects of data collection.

Data about charter and party boat uses of artificial reefs are also difficult to collect with mail surveys. Charter operators are often reluctant to provide lists of customers' names and addresses or to handle even basic customer response cards that could be used to develop a sample frame. These limitations again suggest the need for some type of interview survey to assess the economic benefits of artificial reefs attributable to charter boat customers.

Finally, more research attention needs to be given to analysis of the benefits of artificial reefs to sport divers. The results of this survey indicate that only a portion of the divers using the reefs are attracted for the fish catch attributes of the sites. For this reason it was difficult to define a specific set of characteristics for reef sites that could be used in a travel cost model for divers. To the extent that divers are a relevant group of beneficiaries from artificial reef development, research on the source of benefits to this group will improve reef siting and design decisions.

REFERENCES

Ben-Akiva, M. and S.R. Lerman. 1985. Discrete choice analysis: Theory and application to travel demand. MIT Press, Cambridge, Mass.

Bockstael, N., A. Graefe and I. Strand. 1985. Economic analysis of artificial reefs: An assessment of issues and methods. Artificial Reef Development Center Technical Report No. 5, Sport Fishing Institute, Washington, DC.

Bockstael, N., A. Graefe, I. Strand and L. Caldwell. 1986. Economic analysis of artificial reefs: A pilot study of selected valuation methodologies. Artificial Reef Development Center Technical Report No. 6, Sport Fishing Institute, Washington, DC.

Buchanan, C.C. 1973. "Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina." Marine Fisheries Review 35(9):15-22.

Cameron, T.A. and M.D. James. 1987. "Efficient estimation methods for "closed-ended" contingent valuation surveys." Review of Economics and Statistics 69(2):269-276.

Cummings, R.G., D.S. Brookshire, and W.D. Schulze. 1986. Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Totowa, NJ: Rowman and Allanheld.

Ditton, R.B., A.R. Graefe, A.J. Fedler and J.D. Schwartz. 1979. "Access to and usage of Liberty Ship reefs in Texas." Marine Fisheries Review 42(5):25-31.

Ditton, R.B. and J. Auyong. 1984. Fishing offshore platforms central Gulf of Mexico. OCS Monograph MMS84-0006, Minerals Management Service, U.S. Department of Interior, Metairie, Louisiana.

Hanemann, W.M. 1982. "Applied welfare analysis with qualitative response models." California Agricultural Experiment Station, Working Paper No. 241, University of California, Berkeley (mimeo).

Huppert, D.D. 1983. NMFS guidelines on economic valuation of marine recreational fishing. NOAA Technical Memorandum NOAA-TM-NMFS-SWFC-32, Department of Commerce, Washington, DC.

Kmenta, J. 1971. Elements of econometrics. Macmillan, New York.

Liao, D.S. and D.M. Cupka. 1979. Economic impacts and fishing success of offshore sport fishing over artificial reefs and natural habitats in South Carolina. South Carolina Marine Resources Center Technical Report 38, Charleston, S.C.

Loomis, J.B., C.F. Sorg, and D.M. Donnelly. 1986. "Evaluating regional demand models for estimating recreation use and economic benefits: A case study." Water Resources Research 22(4):431-38.

Maddala, G.S. 1983. Limited-dependent and qualitative variables in econometrics. Cambridge University Press, Cambridge, England.

Milon, J.W. and G. Johns. 1982. A handbook for economic analysis of coastal recreation projects. Florida Sea Grant College Technical Report 45, University of Florida, Gainesville, FL.

Milon, J.W. 1986a. "Strategic incentives revisited: Valuation contexts and specification comparability for local public goods." Food and Resource Economics Department Staff Paper 301, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

Milon, J.W. 1986b. "Public preferences for marine fisheries enhancement: An experimental analysis of alternative public choice methods." Policy Studies Review 6(2):382-388.

Milon, J.W. 1988a. "Travel cost methods for estimating the recreational use benefits of artificial marine habitat." Southern Journal of Agricultural Economics 20(1):(forthcoming).

Milon, J.W. 1988b. "A nested demand shares model of artificial marine habitat choice by sport anglers." (unpublished manuscript).

Morey, E.R. 1981. "The demand for site-specific recreational activities: A characteristics approach." Journal of Environmental Economics and Management 8:345-371.

Rowe, R.W., Energy and Resource Consultants, Inc. 1985. Valuing marine recreational fishing on the Pacific coast. Administrative Report LJ-85-18C, Southwest Fisheries Center, National Marine Fisheries Service, La Jolla, CA.

Samples, K.C.. 1986. A socioeconomic appraisal of fish aggregation devices in Hawaii. Marine Economics Report, University of Hawaii Sea Grant College Program, Honolulu, Hawaii.

Small, K.A. and H.S. Rosen. 1981. "Applied welfare economics with discrete choice models." Econometrica 49(1):105-130.

Stynes, D.J. and G.L. Peterson. 1984. "A review of logit models with implications for modeling recreation choices." Journal of Leisure Research 16(4):295-310.

Thompson, M.E. and K.J. Roberts. 1985. "Contingent valuation of recreational diving at petroleum rigs, Gulf of Mexico." Transactions of the American Fisheries Society 114(2).

Toro-Vizcarrondo, C. and T.D. Wallace. 1968. "A test of the mean square error criterion for restriction in linear regression." Journal of the American Statistical Association 63(4):558-572.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1985. National artificial reef plan. Washington, D.C.

U.S. Water Resources Council. 1983. Economic and environmental principles and guidelines for water and related land resources implementation studies. Washington, DC.

APPENDIX A: SURVEY QUESTIONNAIRE

SPECIAL DADE COUNTY
RECREATIONAL BOATING SURVEY

YOUR ANSWERS ARE AN IMPORTANT SOURCE OF INFORMATION ABOUT RECREATIONAL BOATING IN DADE COUNTY. THIS SURVEY IS DESIGNED TO PROVIDE INFORMATION ABOUT BOATER'S USE OF FISHING AND DIVING RESOURCES. SINCE ONLY A FEW BOATERS HAVE BEEN SELECTED, IT IS VERY IMPORTANT THAT YOU RETURN A COMPLETED SURVEY--EVEN IF YOU HAVE NOT USED YOUR BOAT FOR FISHING AND DIVING.

PLEASE FOLLOW THE DIRECTIONS CAREFULLY. THEY WILL KEEP YOU FROM ANSWERING QUESTIONS THAT DO NOT APPLY TO YOU. THANK YOU FOR YOUR INTEREST IN RECREATIONAL BOATING--DON'T FORGET TO SEND FOR YOUR FREE PUBLICATIONS BY ENCLOSING THE REQUEST FORM WITH YOUR COMPLETED QUESTIONNAIRE IN THE PREPAID ENVELOPE.

SEA GRANT

SECTION 1

IN THIS SECTION WE WANT TO KNOW SOME IMPORTANT FACTS ABOUT THE BOAT YOU USE FOR SALT-WATER RECREATION. IF YOU HAVE RECENTLY BOUGHT A NEW BOAT, PLEASE GIVE THE INFORMATION FOR THIS NEW BOAT.

1-1 What is the overall length of your boat? (FILL IN THE BLANK)

____________ FEET

1-2 What type of engine does this boat have? (PLEASE CIRCLE)

1 OUTBOARD
2 INBOARD-OUTBOARD
3 INBOARD

1-3 What is the total horsepower of the engine(s)? (FILL IN BLANK)

____________ HP

1-4 What is the fuel capacity on your boat? Include any spare tanks you normally take with you. (FILL IN BLANK)

____________ GALLONS

1-5 How many gallons of fuel, on average, does your boat use per hour of running time? Base your estimate on a typical trip in normal seas.

____________ GALLONS PER HOUR

1-6 Does your boat have any of the following equipment? (PLEASE CIRCLE ALL THAT APPLY)

1 DEPTH-FINDER   4 COMPASS
2 LORAN   5 RADAR
3 TWO-WAY RADIO   6 FISH-FINDER

1-7 Approximately how many days during the last 6 months did you use this boat in each of the following activities? If you used the boat in more than one activity on a single day, please consider only the primary activity on that day. PUT A ZERO IN EACH SPACE IF YOU DID NOT PARTICIPATE IN THAT ACTIVITY.

NUMBER OF DAYS SALTWATER FISHING ________ DAYS
NUMBER OF DAYS SKIN AND SCUBA DIVING ________ DAYS
NUMBER OF DAYS WATER SKIING ________ DAYS
NUMBER OF DAYS PLEASURE CRUISING ________ DAYS

IF YOU DID GO SALTWATER FISHING IN THE PAST 6 MONTHS, PLEASE CONTINUE TO SECTION 2 ON THE NEXT PAGE. IF YOU DID NOT GO FISHING, PLEASE SKIP TO SECTION 3, PAGE 8.

SECTION 2

IN THIS SECTION WE WANT TO KNOW ABOUT YOUR USE OF THIS BOAT FOR SALTWATER FISHING DURING THE LAST 6 MONTHS. IN ANSWERING THESE QUESTIONS, PLEASE REFER TO THE ENCLOSED MAP.

2-1 Please look at the enclosed map. Notice that the map denotes 6 fishing zones marked as North Bay, North Reef, etc. Considering all the saltwater fishing you did during the last 6 months, how many trips did you take to go saltwater fishing in your boat in each of these six zones? (FILL IN THE BLANKS)

NUMBER OF FISHING TRIPS IN THE NORTH BAY ZONE ________ TRIPS
NUMBER OF FISHING TRIPS IN THE NORTH REEF ZONE ________ TRIPS
NUMBER OF FISHING TRIPS IN THE NORTH OFFSHORE ZONE ________ TRIPS
NUMBER OF FISHING TRIPS IN THE SOUTH BAY ZONE ________ TRIPS
NUMBER OF FISHING TRIPS IN THE SOUTH REEF ZONE ________ TRIPS
NUMBER OF FISHING TRIPS IN THE SOUTH OFFSHORE ZONE ________ TRIPS

2-2 Please look at the map again. Note that 7 sites are highlighted in red to mark ARTIFICIAL REEF SITES. Did you fish at any of these sites during the last 6 months?

1 YES ⟶ CONTINUE TO THE NEXT QUESTION BELOW
2 NO ⟶ SKIP TO SECTION 2-PART B, PAGE 6.

2-3 Please indicate the number of times you fished at each artificial reef site in the last 6 months and your usual launch location when you fished at these sites. For example, if you launched at Haulover Park, write that in. If you launched from a private dock or marina, write in the street number for the dock or the name of the marina.

ARTIFICIAL REEF SITE	# OF TRIPS IN LAST 6 MONTHS	USUAL LAUNCH LOCATION
A	________	________
B	________	________
C	________	________
D	________	________
E	________	________
F	________	________
G	________	________

PLEASE CONTINUE TO THE NEXT PAGE

PLEASE THINK BACK TO YOUR LAST TRIP TO ONE OF THESE ARTIFICIAL REEF SITES AND ANSWER THE FOLLOWING QUESTIONS.

2-4 In which month did your last saltwater fishing trip to an artificial reef site occur? (PLEASE CIRCLE)

1	JANUARY	4	APRIL	7	JULY	10	OCTOBER
2	FEBRUARY	5	MAY	8	AUGUST	11	NOVEMBER
3	MARCH	6	JUNE	9	SEPTEMBER	12	DECEMBER

2-5 Please write in the location where you launched your boat.

____

2-6 Approximately how many miles did you drive and how long did it take to go from your home to your launch site on your last trip? If you launched from a dock at your home, please just write in 0 for both miles driven and time.

________ MILES DRIVEN FROM HOME TO LAUNCH SITE
________ MINUTES TO DRIVE FROM HOME TO LAUNCH SITE

2-7 How much time in total did you spend on this fishing trip from when you first left the dock to the time when you returned to the dock? (FILL IN THE BLANK)

________ HOURS

2-8 How many hours did you spend on this last fishing trip actually fishing in each of the six fishing zones marked on the enclosed map? (FILL IN THE BLANKS)

________ HOURS FISHING IN THE NORTH BAY ZONE
________ HOURS FISHING IN THE NORTH REEF ZONE
________ HOURS FISHING IN THE NORTH OFFSHORE ZONE
________ HOURS FISHING IN THE SOUTH BAY ZONE
________ HOURS FISHING IN THE SOUTH REEF ZONE
________ HOURS FISHING IN THE SOUTH OFFSHORE ZONE

2-9 How many hours did you actually fish at each of the 7 artificial reef sites highlighted in red on the enclosed map? (FILL IN EACH BLANK AS APPROPRIATE)

________ HOURS AT SITE A
________ HOURS AT SITE B
________ HOURS AT SITE C
________ HOURS AT SITE D
________ HOURS AT SITE E
________ HOURS AT SITE F
________ HOURS AT SITE G

** PLEASE CONTINUE TO THE NEXT PAGE **

2-10 Note that the names of the wrecks sunk at each artificial reef site are listed on the right hand side on the enclosed map. If you were fishing at a specific wreck or several wrecks on your last trip, please write in the name of that wreck(s) below. (WRITE IN ALL THAT APPLY)

____

____

____

____

____

2-11 What fishing methods did you use when you fished at the artificial reef sites? (CIRCLE ALL THAT APPLY)

1 BOTTOM FISHING
2 DEEP TROLLING
3 SURFACE TROLLING
4 DRIFT FISHING
5 SURFACE CASTING

2-12 What fishing methods did you use when you fished at other spots besides the artificial reefs? (CIRCLE ALL THAT APPLY).

1 BOTTOM FISHING
2 DEEP TROLLING
3 SURFACE TROLLING
4 DRIFT FISHING
5 SURFACE CASTING

2-13 What was the average water depth at the other spots you fished on your last fishing trip? (CIRCLE ONLY ONE NUMBER)

1 LESS THAN 50 FEET
2 51 - 100 FEET
3 101 -200 FEET
4 201 -300 FEET
5 301 -400 FEET
6 401 -500 FEET
7 MORE THAN 500 FEET
8 DON'T KNOW

** PLEASE CONTINUE TO THE NEXT PAGE **

2-14 How many people went out with you in your boat on your last fishing trip to the artificial reefs? (FILL IN THE BLANK).

__________ PEOPLE

2-15 Please write in the total number and total weight of the fish you and your fishing party caught (either kept or released) AT ARTIFICIAL REEF SITES and AT THE OTHER SPOTS you fished on your last fishing trip.

	TOTAL NUMBER	TOTAL WEIGHT
CAUGHT AT ARTIFICIAL REEFS	____	____ POUNDS
CAUGHT AT OTHER SPOTS	____	____ POUNDS

2-16 Below is a list of reasons why you might decide to fish at an artificial reef site. Please circle the number which indicates whether this reason was VERY IMPORTANT = 1 or NOT IMPORTANT AT ALL = 4 in your decision to fish at an artificial reef site. (CIRCLE ONE NUMBER FOR EACH REASON)

	VERY IMPORTANT	SOMEWHAT IMPORTANT	NOT VERY IMPORTANT	NOT IMPORTANT AT ALL
Better chance of catching fish....	1	2	3	4
Previous fishing success at sites.	1	2	3	4
Sites are close to shore..........	1	2	3	4
Wanted to fish near other boats...	1	2	3	4
Other fishermen had recommended sites	1	2	3	4
Sites are easy to locate..........	1	2	3	4

**PLEASE TURN TO SECTION 3, PAGE 8 **

SECTION 2-PART B

PLEASE THINK BACK TO YOUR LAST SALTWATER FISHING TRIP IN YOUR BOAT AND ANSWER THE FOLLOWING QUESTIONS.

2-17 In which month did your last saltwater fishing trip occur? (PLEASE CIRCLE)

1 JANUARY	4 APRIL	7 JULY	10 OCTOBER
2 FEBRUARY	5 MAY	8 AUGUST	11 NOVEMBER
3 MARCH	6 JUNE	9 SEPTEMBER	12 DECEMBER

2-18 Please write in the location where you launched your boat for your last saltwater fishing trip. For example, if you launched at Baker's Haulover, write that in. If you departed from a private dock or marina, write in the street number for that dock or the name of the marina.

____

2-19 Approximately how many miles did you drive and how long did it take to go from your home to your launch site on your last trip? If you launched from a dock at your home, please write in 0 for both miles driven and time.

__________ MILES DRIVEN FROM HOME TO LAUNCH SITE

__________ MINUTES TO DRIVE FROM HOME TO LAUNCH SITE

2-20 How much time in total did you spend on this fishing trip from when you first left the dock to the time when you returned to the dock? (FILL IN THE BLANK)

__________ HOURS

2-21 How many hours did you spend on this last fishing trip actually fishing in each of the six fishing zones marked on the enclosed map? (FILL IN THE BLANKS)

__________ HOURS FISHING IN THE NORTH BAY ZONE

__________ HOURS FISHING IN THE NORTH REEF ZONE

__________ HOURS FISHING IN THE NORTH OFFSHORE ZONE

__________ HOURS FISHING IN THE SOUTH BAY ZONE

__________ HOURS FISHING IN THE SOUTH REEF ZONE

__________ HOURS FISHING IN THE SOUTH OFFSHORE ZONE

2-22 What fishing methods did you use on this fishing trip? (CIRCLE ALL THAT APPLY)

1 BOTTOM FISHING
2 DEEP TROLLING
3 SURFACE TROLLING
4 DRIFT FISHING
5 SURFACE CASTING

**PLEASE CONTINUE TO THE NEXT PAGE **

2-23 What was the average water depth at the spots you fished on your last fishing trip? (CIRCLE ONLY ONE NUMBER)

1 LESS THAN 50 FEET
2 51 - 100 FEET
3 101 - 200 FEET
4 201 - 300 FEET
5 301 - 400 FEET
6 401 - 500 FEET
7 MORE THAN 500 FEET
8 DON'T KNOW

2-24 How many people went with you in your boat on your last fishing trip? (FILL IN THE BLANK)

__________ PEOPLE

2-25 Please write in the total number and total weight of the fish you and your fishing party caught (either kept or released) on your last fishing trip.

TOTAL NUMBER OF FISH __________

TOTAL WEIGHT OF CATCH __________

2-26 Have you ever fished at one of the artificial reef sites highlighted in red on the enclosed map? (PLEASE CIRCLE)

1 YES
2 NO → Which of the following statements best explains why you have not fished at any of the artificial reef sites? (PLEASE CIRCLE)

1 DIDN'T KNOW THEY WERE THERE
2 TOO HARD TO FIND
3 BETTER FISHING ELSEWHERE

**PLEASE CONTINUE TO SECTION 3 ON THE NEXT PAGE **

SECTION 3

IN THIS SECTION WE WANT TO KNOW ABOUT THE USE OF YOUR BOAT FOR SKIN AND SCUBA DIVING DURING THE LAST SIX MONTHS. PLEASE ANSWER THE FIRST QUESTION AND FOLLOW THE INSTRUCTIONS.

3-1 Have you used your boat for skin and scuba diving during the last 6 months?

1 YES → PLEASE CONTINUE TO THE NEXT QUESTION.

2 NO → PLEASE SKIP TO SECTION 4, PAGE 14.

3-2 Please look at the enclosed map. Notice that the map denotes 6 zones marked as North Bay, North Reef, etc. Considering all the saltwater diving you did during the last 6 months, how many trips did you take to dive from your boat in each of these 6 zones? (FILL IN THE BLANKS)

NUMBER OF DIVE TRIPS IN THE NORTH BAY ZONE ________ TRIPS

NUMBER OF DIVE TRIPS IN THE NORTH REEF ZONE ________ TRIPS

NUMBER OF DIVE TRIPS IN THE NORTH OFFSHORE ZONE ________ TRIPS

NUMBER OF DIVE TRIPS IN THE SOUTH BAY ZONE ________ TRIPS

NUMBER OF DIVE TRIPS IN THE SOUTH REEF ZONE ________ TRIPS

NUMBER OF DIVE TRIPS IN THE SOUTH OFFSHORE ZONE ________ TRIPS

3-3 Please look at the map again. Note that 7 areas are highlighted in red to denote ARTIFICIAL REEF SITES. Did you dive at any of the sites during the last 6 months? (PLEASE CIRCLE)

1 YES → CONTINUE TO THE NEXT QUESTION BELOW

2 NO → SKIP TO SECTION 3-PART B, PAGE 12.

3-4 Please indicate the number of times in the last 6 months you dove at each artificial reef site and your usual launch location when you dove at these sites. For example, if you launched at Haulover Park, write that in. If you launched from a private dock or marina, write in the street number for that dock or the name of the marina.

ARTIFICIAL REEF SITE	# OF TRIPS IN LAST 6 MONTHS	USUAL LAUNCH LOCATION
A	________	________
B	________	________
C	________	________
D	________	________
E	________	________
F	________	________
G	________	________

**PLEASE CONTINUE TO THE NEXT PAGE **

PLEASE THINK BACK TO YOUR LAST TRIP TO THESE SITES AND ANSWER THE FOLLOWING QUESTIONS.

3-5 In which month did your last diving trip to an artificial reef site occur?

1	JANUARY	4	APRIL	7	JULY	10	OCTOBER
2	FEBRUARY	5	MAY	8	AUGUST	11	NOVEMBER
3	MARCH	6	JUNE	9	SEPTEMBER	12	DECEMBER

3-6 Please write in the location where you launched your boat for this last trip.

____

3-7 Approximately how many miles did you drive and how long did it take to go from your home to your launch site on your last trip? If you launched from a dock at your home, please just write in 0 for both miles driven and time.

________ MILES DRIVEN FROM HOME TO LAUNCH SITE

________ MINUTES TO DRIVE FROM HOME TO LAUNCH SITE

3-8 How much time in total did you spend on this diving trip from when you first left the dock to the time when you returned to the dock? (FILL IN THE BLANK)

________ HOURS

3-9 How many hours did you actually spend at each of the 7 artificial reef sites highlighted in red on the enclosed map? Please give your total time at each site--not just your time in the water. (FILL IN EACH BLANK AS APPROPRIATE).

________ HOURS AT SITE A

________ HOURS AT SITE B

________ HOURS AT SITE C

________ HOURS AT SITE D

________ HOURS AT SITE E

________ HOURS AT SITE F

________ HOURS AT SITE G

3-10 Note that the names of the wrecks sunk at each artificial reef site are listed on the right hand side of the enclosed map. If you were diving at a specific wreck or several wrecks on your last trip, please write in the name of that wreck(s) below. (WRITE IN ALL THAT APPLY).

____

____

____

____

**PLEASE CONTINUE TO THE NEXT PAGE **

3-11 How many hours did you actually spend at other diving spots on this trip? Please give your total time at these other sites--not just your time in the water. (FILL IN THE BLANK)

________________ HOURS

3-12 What was the average water depth at the other diving spots you dove on your last trip? (CIRCLE ONLY ONE NUMBER)

1 LESS THAN 50 FEET
2 51 - 100 FEET
3 101 -150 FEET
4 151 -200 FEET
5 MORE THAN 200 FEET
6 DON'T KNOW

3-13 How many people went with you in your boat on your last dive trip to the artificial reefs? (FILL IN THE BLANK)

________________ PEOPLE

3-14 What activities did you and your dive party pursue at the artificial reef sites? (CIRCLE ALL THAT APPLY)

1 SIGHTSEEING/PHOTOGRAPHY
2 SPEARFISHING

→ If you did go spearfishing on your dive trip to the artificial reefs, please write in the total number and total weight of the fish you and your dive party caught AT ARTIFICIAL REEF SITES and AT THE OTHER SPOTS you dove:

	TOTAL NUMBER	TOTAL WEIGHT
CAUGHT AT ARTIFICIAL REEFS	______	______ pounds
CAUGHT AT OTHER SPOTS	______	______ pounds

** PLEASE CONTINUE TO THE NEXT PAGE **

3-15 Below is a list of reasons why you might decide to dive at an artificial reef site. Please circle the number which indicates whether this reason was VERY IMPORTANT = 1 or NOT IMPORTANT AT ALL = 4 in your decision to dive at an artificial reef site. (CIRCLE A NUMBER FOR EACH REASON).

	VERY IMPORTANT	SOMEWHAT IMPORTANT	NOT VERY IMPORTANT	NOT IMPORTANT AT ALL
Sites are close to shore..	1	2	3	4
Sites are easy to locate..	1	2	3	4
Previous diving success at sites..............	1	2	3	4
Better chance of spearing fish..................	1	2	3	4
Other divers had recommeded sites..................	1	2	3	4
Wanted to dive near other boats..................	1	2	3	4

** PLEASE TURN TO SECTION 4, PAGE 14 **

SECTION 3-PART B

PLEASE THINK BACK TO YOUR LAST DIVING TRIP IN YOUR BOAT AND ANSWER THE FOLLOWING QUESTIONS.

3-16 In which month did your last diving trip occur? (PLEASE CIRCLE)

1	JANUARY	4	APRIL	7	JULY	10	OCTOBER
2	FEBRUARY	5	MAY	8	AUGUST	11	NOVEMBER
3	MARCH	6	JUNE	9	SEPTEMBER	12	DECEMBER

3-17 Please write in the location where you launched your boat for this last trip. For example, if you launched at Baker's Haulover, write that in. If you launched from a private dock or marina, write in the street number for that dock or the name of the marina.

____

3-18 Approximately how many miles did you drive and how long did it take to go from your home to your launch site on your last dive trip? If you launched from a dock at your home, please just write in 0 for both miles driven and time.

________________ MILES DRIVEN FROM HOME TO LAUNCH SITE

________________ MINUTES TO DRIVE FROM HOME TO LAUNCH SITE

3-19 How much time in total did you spend on this diving trip from when you first left the dock to the time when you returned to the dock? (FILL IN THE BLANKS)

________________ HOURS

3-20 Please write in the location and the water depth at each spot where you went diving on your last trip. For example, if you dove at Fowey Rocks at 75 feet, write that in. If you dove about 1 mile east of Sand's Cut at 25 feet, write that in.

LOCATION	WATER DEPTH (FEET)
1. ________________	________
2. ________________	________
3. ________________	________

3-21 How many hours did you actually spend on this trip at each of the spots you listed in 3-20 above. Please give your total time at each site--not just your time in the water. (FILL IN EACH BLANK AS APPROPRIATE)

LOCATION 1. ____________ HOURS

LOCATION 2. ____________ HOURS

LOCATION 3. ____________ HOURS

** PLEASE CONTINUE TO THE NEXT PAGE**

3-22 How many people went with you in your boat on your last diving trip? (FILL IN THE BLANK)

________________ PEOPLE

3-23 What activities did you and your dive party pursue while you were diving? (CIRCLE ALL THAT APPLY)

1 SIGHTSEEING/PHOTOGRAPHY

2 SPEARFISHING

→ If you did go spearfishing on your last dive trip, please write in the the total number and total weight of the fish you and your dive party caught:

TOTAL NUMBER OF FISH ________________

TOTAL WEIGHT OF CATCH ________________

3-24 Have you ever dove at one of the artificial reef sites highlighted in red on the enclosed map? (PLEASE CIRCLE)

1 YES

2 NO → Which of the following statements best explains why, have not dove at any of the artificial reef sites? (PLEASE CIRCLE)

1 DIDN'T KNOW THEY WERE THERE

2 TOO HARD TO FIND

3 BETTER DIVING ELSEWHERE

PLEASE CONTINUE TO SECTION 4 ON THE NEXT PAGE

SECTION 4

THIS SECTION IS INTENDED TO PROVIDE INFORMATION ABOUT BOATERS' PREFERENCES FOR A NEW ARTIFICIAL REEF AND POSSIBLE SOURCES OF FUNDS TO BUILD A NEW REEF. WE WANT TO KNOW HOW IMPORTANT THESE FISHING AND DIVING FACILITIES ARE TO YOU AND OTHER BOATERS IN DADE COUNTY. ARTIFICIAL REEFS ARE VERY DIFFERENT FROM OTHER TYPES OF RECREATION FACILITIES SUCH AS MARINAS AND FISHING PIERS BECAUSE THERE IS NO WAY TO MEASURE USE OF THE FACILITY AND RECORD THE AMOUNT OF MONEY USERS ARE WILLING TO PAY FOR THE FACILITY. SURVEYS SUCH AS THIS ONE ARE THE ONLY WAY TO MEASURE THE VALUE OF ARTIFICIAL REEFS TO YOU AND OTHER DADE COUNTY BOATERS. REMEMBER--YOUR RESPONSES ARE STRICTLY CONFIDENTIAL AND WILL BE USED ONLY FOR OVERALL STATISTICAL RESULTS.

4-1 How do you feel personally about each of the statements below? Please circle the number which indicates whether you STRONGLY AGREE = 1 or STRONGLY DISAGREE = 4 with each statement. If you have NO OPINION, CIRCLE 5. (CIRCLE ONE NUMBER FOR EACH STATEMENT).

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE	NO OPINION
Artificial reefs are located too far from shore.........	1	2	3	4	5
Artificial reefs are too crowded....................	1	2	3	4	5
Artificial reefs are more productive than natural reefs	1	2	3	4	5
There are too many artificial reefs now....................	1	2	3	4	5
Artificial reefs should only be in water less than 150 feet deep.........................	1	2	3	4	5

4-2 Where would you most like to see a new artificial reef built? Please select only your first priority.

1 OFF HAULOVER CUT
2 OFF GOVERNMENT CUT
3 OFF BISCAYNE CHANNEL
4 OFF SANDS CUT
5 OFF CAESAR CREEK

** PLEASE CONTINUE TO THE NEXT PAGE **

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1	LESS THAN 15 MINUTES	5	60 TO 75 MINUTES
2	15 TO 30 MINUTES	6	75 TO 90 MINUTES
3	30 TO 45 MINUTES	7	90 TO 120 MINUTES
4	45 MINUTES TO 1 HOUR	8	MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. Is a new artificial reef important enough to you that you would be willing to contribute $________ next year to a Trust Fund which would be used exclusively to build a new artificial reef? (PLEASE CIRCLE)

1 YES
2 NO
3 UNDECIDED

If NO or UNDECIDED, which one of following statements best explain reasons for your answer:

A- A contribution of $________ is more than a new artificial reef is actually worth to me.

B- There are enough artificial reefs already.

C- I really don't know how much a new artificial reef would be worth to me.

D- Not enough information--I don't understand the question.

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

SECTION 5

IN THIS SECTION WE WANT TO ASK YOU SOME QUESTIONS ABOUT YOUR BACKGROUND WHICH WILL HELP US TO KNOW MORE ABOUT RECREATIONAL BOATERS IN DADE COUNTY AND WILL ALSO INSURE THAT ALL BOATERS ARE FAIRLY REPRESENTED IN THIS STUDY. WE WANT TO EMPHASIZE THAT ALL YOUR ANSWERS ARE STRICTLY CONFIDENTIAL. THE ACCURACY OF THIS STUDY DEPENDS UPON YOU ANSWERING ALL THE QUESTIONS.

5-1 What is your age______________YEARS OLD

5-2 Are you__________MALE _________FEMALE?

5-3 How long have you been boating in Dade County?__________YEARS

5-4 Are you a member of a fishing or diving club?

1 YES
2 NO

5-5 Are you registered to vote in Dade County?

1 YES
2 NO

5-6 How would you describe your racial background? (PLEASE CIRCLE)

1 HISPANIC
2 BLACK
3 WHITE
4 OTHER

5-7 Which of the following best describes your formal education? (PLEASE CIRCLE ONLY ONE)

1 SOME GRADE SCHOOL (GRADES 1-8)
2 SOME HIGH SCHOOL (GRADES 9-12)
3 COMPLETED HIGH SCHOOL OR EQUIVALENT
4 SOME COLLEGE OR VOCATIONAL SCHOOL
5 COMPLETED A TWO-YEAR COLLEGE DEGREE OR A VOCATIONAL TRAINING PROGRAM
6 COMPLETED A FOUR-YEAR COLLEGE DEGREE
7 COMPLETED A GRADUATE OR PROFESSIONAL DEGREE

5-8 Which of the following best describes your current employment status?

1 EMPLOYED OR SELF-EMPLOYED → PLEASE CONTINUE TO QUESTION 5-9
2 RETIRED OR NOT EMPLOYED → PLEASE SKIP TO QUESTION 5-12

5-9 How many hours do you work in an average week?

______________HOURS

5-10 How many days of paid vacation do you earn each year? Please include regular vacations and holidays. (If you are not sure, count each week of paid vacation as 5 days and add the national average of 6 paid holidays).

______________DAYS

5-11 Which of the following best describes when you do most of your boating?

1 I BOAT ON WEEKENDS, HOLIDAYS AND DURING VACATION
2 I USUALLY TAKE TIME OFF FROM WORK TO GO BOATING

5-12 What is your approximate hourly wage? If you are not paid an hourly wage what is your current annual salary (or income if self employed)?

HOURLY WAGE RATE $____________/HOUR OR
ANNUAL SALARY (INCOME) $____________/YEAR

5-13 Which of following income categories best describes your household's total family income before taxes last year?

1	LESS THAN $10,000	6	$50,000 TO $59,999
2	$10,000 TO $19,999	7	$60,000 TO $69,999
3	$20,000 TO $29,999	8	$70,000 TO $79,999
4	$30,000 TO $39,999	9	$80,000 TO $89,999
5	$40,000 TO $49,999	10	$90,000 OR MORE

THANK YOU FOR YOUR ASSISTANCE. PLEASE RETURN THE SURVEY AS SOON AS POSSIBLE IN THE SELF-ADDRESSED, PREPAID ENVELOPE PROVIDED. DON'T FORGET--FOR YOUR FREE PUBLICATIONS, FILL OUT THE ENCLOSED ORDER FORM AND SEND IT WITH YOUR COMPLETED SURVEY.

IF YOU HAVE ANY COMMENTS ABOUT THE SURVEY PLEASE WRITE THEM ON THE NEXT PAGE. YOUR COMMENTS HELP US TO IMPROVE THIS METHOD OF RESEARCH. THANKS AGAIN FOR YOUR COOPERATION.

GOOD LUCK AND HAPPY BOATING!

APPENDIX B: CONTINGENT VALUATION QUESTION FORMATS

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1	LESS THAN 15 MINUTES	5	60 TO 75 MINUTES
2	15 TO 30 MINUTES	6	75 TO 90 MINUTES
3	30 TO 45 MINUTES	7	90 TO 120 MINUTES
4	45 MINUTES TO 1 HOUR	8	MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. Is a new artificial reef important enough to you that you would be willing to contribute $_________ next year to a Trust Fund which would be used exclusively to build a new artificial reef? (PLEASE CIRCLE)

1 YES

2 NO

3 UNDECIDED

If NO or UNDECIDED, which one of the following statements best explains the reasons for your answer:

A- A contribution of $__________ is more than a new artificial reef is actually worth to me.

B- There are enough artificial reefs already.

C- I really don't know how much a new artificial reef would be worth to me.

D- Not enough information--I don't understand the question.

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

CONTRIBUTION FORMAT

4-3 Suppose a new aritifical reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1 LESS THAN 15 MINUTES	5 60 TO 75 MINUTES
2 15 TO 30 MINUTES	6 75 TO 90 MINUTES
3 30 TO 45 MINUTES	7 90 TO 120 MINUTES
4 45 MINUTES TO 1 HOUR	8 MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. Is a new artificial reef important enough to you that you would be willing to contribute $________ next year to a Trust Fund which would be used exclusively to build a new artificial reef? (PLEASE CIRCLE)

1 YES
2 NO
3 UNDECIDED

If YES, please sign your name in the space below to show your support of the proposed contribution and Trust Fund plan for artificial reefs. We ask for your signature only to guarantee that you have seriously considered this proposal. Your name will never be released to anyone outside the research team and you will not be contacted by any outside organization.

Signature:____________________

If NO or UNDECIDED, which one of the following statements best explains the reasons for your answer:

A- A contribution of $________ is more than a new artificial reef is actually worth to me.

B- There are enough artificial reefs already.

C- I really don't know how much a new artificial reef would be worth to me.

D- Not enough information--I don't understand the question.

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

CONTRIBUTION FORMAT-SIGNATURE REQUEST

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1	LESS THAN 15 MINUTES	5	60 TO 75 MINUTES
2	15 to 30 MINUTES	6	75 TO 90 MINUTES
3	30 TO 45 MINUTES	7	90 TO 120 MINUTES
4	45 MINUTES TO 1 HOUR	8	MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. One possible solution would be to add a one-year surcharge to the price per gallon of fuel sold to boaters. This surcharge would cost the average boater like you about $__________ next year. All proceeds from the surcharge would go into a Trust Fund which would be used exclusively to build a new artificial reef. This surcharge would be added only if a majority of voters voted YES in a public referendum. Would you vote YES or NO on this proposition?

1 YES
2 NO
3 UNDECIDED

IF NO or UNDECIDED, which one of the following statements best explains the reasons for your answer:

A- A surcharge of $__________ is more than a new artificial reef is actually worth to me.

B- There are enough artificial reefs already.

C- I really don't know how much a new artificial reef would be worth to me.

D- Not enough information--I don't understand the question.

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

REFERENDUM FORMAT

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1 LESS THAN 15 MINUTES	5 60 TO 75 MINUTES
2 15 TO 30 MINUTES	6 75 TO 90 MINUTES
3 30 TO 45 MINUTES	7 90 TO 120 MINUTES
4 45 MINUTES TO 1 HOUR	8 MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. One possible solution would be to add a one-year surcharge to the price per gallon of fuel sold to boaters. This surcharge would cost the average boater like you about $____________ next year. All proceeds from the surcharge would go into a Trust Fund which would be used exclusively to build a new artificial reef. This surcharge would be added only if a majority of voters voted YES in a public referendum. Would you vote YES or NO on this proposition?

1 YES

2 NO

3 UNDECIDED

If YES, please sign your name in the space below to show your support of the proposed surcharge and Trust Fund plan for artificial reefs. We ask for your signature only to guarantee that you have seriously considered this proposal. Your name will never be released to anyone outside the research team and you will not be contacted by any outside organization.

Signature:______________________________

If NO or UNDECIDED, which one of the following statements best explains the reasons for your answer:

A- A surchage of $__________ is more than a new artificial reef is actually worth to me.

B- There are enough artificial reefs already.

C- I really don't know how much a new artificial reef would be worth to me.

D- Not enough information--I don't understand the question.

** PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE**

REFERENDUM FORMAT-SIGNATURE REQUEST

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your ususal launch site in order to use this new site?

(PLEASE CIRCLE)

1	LESS THAN 15 MINUTES	5	60 TO 75 MINUTES
2	15 TO 30 MINUTES	6	75 TO 90 MINUTES
3	30 TO 45 MINUTES	7	90 TO 120 MINUTES
4	45 MINUTES TO 1 HOUR	8	MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. One possible solution would be to add a one-year surcharge to the price per gallon of fuel sold to boaters. This surcharge would cost the average boater like you about $__________ next year. All proceeds from the surcharge would go into a Trust Fund which would be used exclusively to build a new artificial reef. Would you be willing to pay this surcharge to build a new artificial reef? (PLEASE CIRCLE)

1 YES

2 NO

(IF YES) Suppose a one-year fuel price surcharge that cost the average boater about $______ next year would not raise enough money to actually build a new artificial reef. This surcharge could be increased so that the annual cost to each boater was enough to build a new reef. How much more of an increase in the one-year cost of a fuel price surcharge would you be willing to pay to guarantee that a new artificial reef would be built?

(PLEASE CIRCLE)

$0 MORE	$15 MORE
$5 MORE	$20 MORE
$10 MORE	$25 MORE

(IF NO) Which of the following 5 statements best describes your feelings about this surcharge?

A I would be willing to pay the surcharge if the one-year cost was 1/2 the amount stated.

B I would be willing to pay the surcharge if the one-year cost was 1/4 the amount stated.

C I do not want to pay any fuel price surcharge to build a new artificial reef.

D I really don't know how much an artificial reef would be worth to me.

E Not enough information--I don't understand the question.

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

BIDDING FORMAT

4-3 Suppose a new artificial reef was actually built. What would be the maximum amount of time you would spend to travel from your usual launch site in order to use this new site?

(PLEASE CIRCLE)

1	LESS THAN 15 MINUTES	5	60 TO 75 MINUTES
2	15 TO 30 MINUTES	6	75 TO 90 MINUTES
3	30 TO 45 MINUTES	7	90 TO 120 MINUTES
4	45 MINUTES TO 1 HOUR	8	MORE THAN 2 HOURS

4-4 Dade County's artificial reef program costs money to support. Suppose there was not enough money available to continue building artificial reefs. One possible solution would be to add a one-year surcharge to the price per gallon of fuel sold to boaters. This surcharge would cost the average boater like you about $ 15 next year. All proceeds from the surcharge would go into a Trust Fund which would be used exclusively to build a new artificial reef. Would you be willing to pay this surcharge to build a new artificial reef? (PLEASE CIRCLE)

1 YES

2 NO

(IF YES) Suppose a one-year fuel price surcharge that cost the average boater about $ 15 next year would not raise enough money to actually build a new artificial reef. This surcharge could be increased so that the annual cost to each boater was enough to build a new reef. How much more of an increase in the one-year cost of a fuel price surcharge would you be willing to pay to guarantee that a new artificial reef would be built?

(PLEASE CIRCLE)

$0 MORE	$15 MORE
$5 MORE	$20 MORE
$10 MORE	$25 MORE

(IF NO) Which of the following 5 statements best describes your feelings about this surcharge?

A I would be willing to pay the surcharge if the one-year cost was 1/2 the amount stated.

B I would be willing to pay the surcharge if the one-year cost was 1/4 the amount stated.

C I do not want to pay any fuel price surcharge to build a new artificial reef.

D I really don't know how much an artificial reef would be worth to me.

E Not enough information--I don't understand the question.

Please sign your name in the space below. We ask for your signature only to guarantee that you have seriously considered this proposal. Your name will never be released to anyone outside the research team and you will not be contacted by any outside organization.

Signature:________________________

PLEASE CONTINUE TO SECTION 5 ON THE NEXT PAGE

BIDDING FORMAT -SIGNATURE REQUEST