

Socioeconomic Research & Monitoring Program for the
Florida Keys National Marine Sanctuary

The Economic Impact of the
USS Vandenberg on the Monroe County Economy

July 2011

Vernon R. Leeworthy

Office of National Marine Sanctuaries
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce



Suggested Citation:

Leeworthy, Vernon R. 2011. The Economic Impact of the USS *Vandenberg* on the Monroe County Economy. Silver Spring, MD: Office of National Marine Sanctuaries, National Ocean Service, National Oceanic and Atmospheric Administration.

Table of Contents

	Page
List of Tables	ii
Preface	iii
INTRODUCTION	1
METHODS	2
Method of Estimation of Reef Use: Pre and Post Deployment	2
<i>Study Sites</i>	4
<i>On-water Sampling Periods</i>	4
<i>Number of Dive Operators</i>	4
Method of Estimating Economic Impact	4
RESULTS	5
Local Environment/Ecology (User Pressure)	5
Local Dive Charter Business	5
Local Economy	6
State and Local Tax Revenues Generated and Return on Investment	6
DISCUSSION	8
References	10

List of Tables

Table	Page
1 Study Sites.....	4
2 Net changes in total reef use following the deployment of the Vandenberg.....	5
3 Net changes in dive charter operation business following deployment of the Vandenberg.....	6
4 Net economic impacts of the deployment of the Vandenberg.....	6
5 Additional Annual State and Local Sales and Lodging Tax Revenues from the Vandenberg.....	7
6 Net Present Value of Additional State and Local Tax Revenue from the Vandenberg.....	7

Preface

Artificial reef development involves activities generally prohibited in national marine sanctuaries. Constructing on, placing matter on, and disturbing the seafloor and depositing materials or matter into a national marine sanctuary are all activities requiring an Office of National Marine Sanctuary (ONMS) permit or authorization (for full regulatory text see 15 CFR Part 922). The Florida Keys National Marine Sanctuary (FKNMS) has permitted or authorized the sinking of four ships as artificial reefs since its designation in 1990. Important to this report, are the sinking of the USS *Spiegel Grove* and the USS *Vandenberg*.

Because the ecological and socioeconomic impacts of artificial reefs are not entirely understood, ONMS will proceed cautiously in considering permits for artificial reef development in sanctuaries. Existing, permitted artificial reefs projects are required to be monitored for changes in the natural ecosystem as well as human behavior related to use of artificial and natural reefs. ONMS will use information obtained from monitoring existing artificial reefs in sanctuaries and elsewhere to evaluate future proposed artificial reef development in sanctuaries.

For socioeconomic monitoring, advocates of artificial reefs hypothesized that sinking an artificial reef in a natural reef environment would (1) reduce use (pressure) on the surrounding natural reefs, (2) increase business to local dive operators, and (3) increase economic impact measured as sales/output, income and employment in the Monroe County economy. Required socioeconomic monitoring has provided insight into these supposed benefits.

In the case of the USS *Spiegel Grove* all three of these hypotheses were supported (Leeworthy et al. 2006). Using the same methodologies, these hypotheses were tested for the USS *Vandenberg*. Unlike the USS *Spiegel Grove*, the hypothesis that introducing an artificial reef in a natural reef environment would reduce use on the surrounding natural reefs was not supported for the USS *Vandenberg*. The two hypotheses suggesting dive operator business would increase as would sales/output, income and employment in the Monroe County economy were supported. In the case of the USS *Vandenberg* the effect on total demand (use) dominated the substitution effect (switching from use of natural reefs to artificial reefs). A lower proportion of reef use is on natural reefs pre- to post-deployment of the U.S.S. *Vandenberg*, but the total use on both natural and artificial reefs increased.

To implement the socioeconomic monitoring program the Florida Fish and Wildlife conservation Commission (FWC), Division of Marine Fisheries Management, Artificial Reef Program and FKNMS formed a partnership. FWC provided a grant for pre-deployment data collection to Florida Keys Community College (FKCC) and post-deployment data collection to Artificial Reefs of the Keys (ARK). The principal investigator for both projects was Robert (Bob) Smith, President of Advanced Underwater Education, Inc. Chris Norwood of Florida Straits Diving, Inc. was in charge of both pre- and post-deployment on-water data collection. William Chalfant, Director of Diving Business and Technology at FKCC was in charge of pre-deployment logbook data collection, while Jo Ellen Sullenger of ARK was responsible for post-deployment log book data collection and administrative support of both grants. William Horn of the FWC was the grant manager. Dr. Vernon R. (Bob) Leeworthy, Chief Economist for NOAA's Office of

National Marine Sanctuaries provided analysis of the data and produced this report. Bob also serves as the Leader of the Socioeconomic Research & Monitoring Program for the FKNMS.

The results of the analysis are presented here. A separate technical appendix reports specifics of how the estimates were calculated and includes more detailed tables (see Leeworthy 2011).

INTRODUCTION

On May 27, 2009, the decommissioned US Air Force missile tracking ship and WWII U.S. Army troop transport ship, the *General Hoyt S. Vandenberg*, hereinafter the USS *Vandenberg*, was sunk in the waters off Key West in southern Florida and within the Florida Keys National Marine Sanctuary (FKNMS). At 520 feet, the USS *Vandenberg* is the largest vessel sunk as an artificial reef in the FKNMS. The permit to sink the vessel required biological and socioeconomic monitoring to inform FKNMS management about long-term effects and changes in the natural ecosystem as well as human behavior associated with artificial reef deployment. For the socioeconomic monitoring, advocates for artificial reefs hypothesized sinking an artificial reef in a natural reef environment would reduce use (pressure) on the surrounding natural reefs; would increase business to local dive operators; and increase the economic impact measured as sales/output, income and employment in the Monroe County economy.

In the case of the USS *Spiegel Grove* all three of these hypotheses were supported (Leeworthy et al. 2006). The same hypotheses were tested for the USS *Vandenberg* using the same methodologies as the USS *Spiegel Grove* study. Unlike the case of the USS *Spiegel Grove*, the hypothesis that introducing an artificial reef in a natural reef environment would reduce use on the surrounding natural reefs was not supported. The two hypotheses that dive operator business would increase and there would be a general increase in sales/output, income and employment in the Monroe County economy were supported. In the case of the USS *Vandenberg* the effect on total demand (use) dominated the substitution effect (switching from use of natural reefs to artificial reefs). A lower proportion of reef use is on natural reefs pre to post deployment of the USS *Vandenberg*, but the total use on both natural and artificial reefs increased.

Artificial Reefs of the Keys, Inc. (ARK) proposed the sinking of the USS *Vandenberg* as an artificial reef to increase local SCUBA diving charter business and thus increase net tourism revenues in the local economy. The Florida Keys are in Monroe County Florida, so the economic impacts estimated here are for the Monroe County economy. As the number of divers visiting the area should be correlated with the quality and variety of local reef habitat, establishing a new artificial reef, particularly by sinking a ship of the size of the USS *Vandenberg*, would be expected to produce economic benefits for the dive industry by drawing in higher numbers of customers. Assuming that the increased numbers of divers represents some influx of new visitors to the area, as opposed to existing visitors substituting away from other activities, the resulting economic benefits for the dive charter industry should imply a net increase in the size of the aggregate local economy.

Above and beyond its economic impact, the establishment of an artificial reef impacts surrounding marine ecosystems. These ecological impacts may be considered in two distinct categories: those stemming from the creation of new marine habitat and those stemming from changes in human impacts due to shifting diving patterns. Assessing the ecological effects of habitat creation involves complex biological models and is beyond the scope of this study. The Florida Fish and Wildlife Conservation Commission (FWC) is conducting a separate monitoring effort studying the ecological effects. However, in the present study an attempt is made to assess the ecological impacts from changes in recreational diving and fishing patterns resulting from the USS *Vandenberg*.

Proponents of sinking ships in the FKNMS hypothesize that the introduction of an artificial reef in a natural reef environment could reduce recreational use of the surrounding natural reefs, all else held constant, as divers and others shift a portion of their use from the natural reefs to the artificial reef. Assuming that recreational use constitutes a negative pressure on natural ecosystems, shifting users from natural to artificial reefs would yield an ecological benefit for the natural reefs. However, if the newly established artificial reef increases overall numbers of users of the area, the increased use could offset the shift in recreation away from natural reefs, as most divers visiting the area may visit a variety of reefs, including both natural and artificial reefs.

The research question was then whether the sinking of the USS *Vandenberg* has resulted in positive net economic and ecological benefits for the Key West area. If the Vandenberg has drawn new recreational users to the area and if these new users do not fully offset the expected shift away from natural reefs, then the introduction of this artificial reef should create a win-win situation for the local economy and ecology. Alternatively, negative ecological impacts may offset any economic gains. Examination of the USS *Vandenberg* case, as in the case of the USS *Spiegel Grove* (Leeworthy et al. 2006), may help inform future decisions to establish artificial reefs under similar circumstances.

METHODS

The complete methods of estimation will not be presented here; they are presented in Leeworthy (2011). Here simple overviews of the methods of estimating use and economic impact pre deployment (baseline) to post deployment are presented.

Method Estimation of Reef Use: Pre and Post Deployment

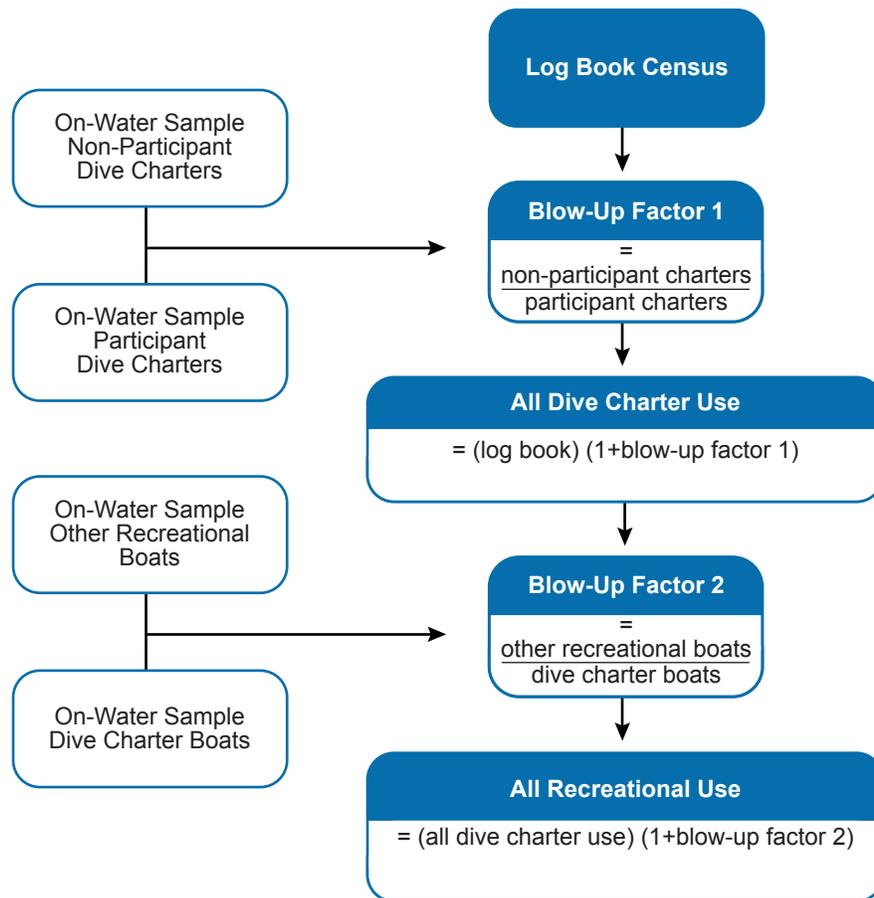
The method of estimation followed the same general method used for the USS Spiegel Grove (Leeworthy and Stone (2005). The estimation follows a five step process (Figure 1):

- 1 Sum use from dive operator logbooks.
- 2 Derive extrapolation from on-water surveys to estimate total dive operator use.
- 3 Extrapolate to total dive operator use.
- 4 Derive extrapolation factors to estimate total dive operator use, using on-water surveys, to the total for all use from all users.
- 5 Extrapolate to total use by all users.

The five steps are followed for both the pre and post deployment periods. The changes from pre to post are then calculated.

Estimates are made for each period by season (summer=June to November and winter=December to May), type of reef (artificial and natural), type of day (week day and weekend) and activity (SCUBA diving, snorkeling, fishing and other). For activity, “other” includes paying passengers that do not enter the water on dive operations. When we present data for all users the term “others” includes those who fish and paying passengers that do not enter the water.

Figure 1. Use Estimation Method for USS *Vandenberg* Study Sites



Study Sites. As with the USS Spiegel Grove (Leeworthy and stone 2005), a set of study sites had to be selected that were near the site where the USS *Vandenberg* was planned to be sunk. Local dive operators were consulted to determine which natural and artificial reefs should be used as the study sites. Table 1 lists the study sites.

Table 1. Study Sites

Natural Reefs	Artificial Reefs
Pelican Shoals	Joe's Tug
Western Sambos	Toppino Buoy
Humps	Cayman Salvager
Eye of the Needle	USS <i>Vandenberg</i>
9 Foot Stake	
Eastern Dry Rocks	
Rock Key	
Sand Key	
Western Dry Rocks	

On-water Sampling Periods. The pre deployment period was the 12-month period from May 2007 through April 2008. Seventy-two days of on-water sampling were conducted over this period stratified by type of day (week day and weekend) and by type of reef (artificial and natural). The post deployment period was the 12-month period from July 2009 through June 2010. Again, seventy-two days of on-water sampling were conducted over the period stratified by type of day and type of reef. Since the USS *Vandenberg* was sunk on May 27, 2009, the post deployment monitoring was purposely delayed one month to avoid the “newness effect” or the demand by those who might have come only to be the first to dive the site. This is important because in interpreting results, the assumption is that the post deployment use estimated will be representative of future use.

Number of Dive Operators. The number of dive operators in the Key West District of the Florida Keys was eight (8) during the pre-deployment period, but doubled to 16 in the post deployment period. Five of the eight dive operators provided logbook data during the pre-deployment period, while 10 of the 16 dive operators provided logbook data for the post deployment period. As the on-water data revealed, the dive operators that provided logbook data accounted for the overwhelming amount of total dive operator use, so the logbook data is close to the census of dive operator use that was anticipated. Thus, the extrapolation factors for estimating total dive operator use are relatively small.

Method of Estimating Economic Impact

The method of estimating economic impact requires first converting estimates of use stated in the number of dives or dive equivalents (e.g. fishing) to person-days of use. Next the distribution of person-days by visitors versus residents of the area is required. Then person-days by visitors and residents are multiplied by the profiles of expenditures per person-day for residents and visitors, respectively. Total expenditures are then run through the Monroe County economic impact model to estimate total sales/output, income and employment impacts, including multiplier impacts. The details of this estimation can be found in the technical appendix to this report (Leeworthy 2011).

RESULTS

Local Environment/Ecology (User Pressure)

From the pre- to post- USS *Vandenberg* deployment period, there was a 40.1% increase in the total number of users (SCUBA divers, snorkelers, and others) on the surrounding natural reefs (Table 2). A 23.5% increase in recreational SCUBA diving use occurred on the natural reefs representing 5,214 dives, which is in contrast to a 442% increase (34,394 dives) in the share of recreational SCUBA diving that occurred on artificial reefs. However, the share of total use on natural reefs did decline from 67% in the pre-deployment period to 46.5% in the post-deployment period. However, the increase in total demand effect dominated the substitution effect of switching from natural to artificial reefs resulting in an increase in total use on the surrounding natural reefs. See the technical appendix to this report for more detailed and complete tables (Leeworthy 2011). Thus, the hypothesis that introduction of the USS *Vandenberg* as an artificial reef would reduce use (pressure) on the surrounding natural reefs is not supported.

Table 2. Net changes in total reef use following the deployment of the USS *Vandenberg*

Reef Type	Absolute and Percent Changes							
	Dives SCUBA	%	Dives Snorkelers	%	All Others*	%	Total	%
Natural Reefs	+5,214	+23.5	+748	+22.0	+18,270	+52.3	+24,232	+40.0
Artificial Reefs	+34,394	+442.0	+493	+252.9	+32,806	+150.5	+67,693	+227.3
Total	+39,608	+132.3	+1,241	+34.5	+51,076	+90.1	+91,925	+101.9

* This includes those that went out on charter or other boats, but who did not participate in any further activity, as well as those who participate in fishing.

Local Dive Charter Business

When considering the potential benefits to the dive charter industry, the study compared absolute number of dives made by SCUBA divers and snorkelers and other non-diving boat passengers (those onboard but not snorkeling or diving pre- and post- USS *Vandenberg* sinking. Data collection took into account that many customers participate in multiple dives and pricing is based on the number of dives per trip. From the pre-deployment to the post-deployment period, the results show an increase of 64.4% or 9,007 dives by SCUBA divers; an increase of 22% or 748 dives by snorkelers; and an increase of 567 non-diving passengers, or a 94.7% increase in business by these customers (Table 3). In total, there was an increase of 49,073 in the number of dives with paying customers, or a 188.9% increase in business. See the technical appendix for more detailed and complete tables (Leeworthy 2011).

Table 3. Net changes in dive charter operation business following deployment of the USS *Vandenberg*

Reef Type	Absolute and Percent Changes							
	Dives SCUBA	%	Dives Snorkelers	%	All Others*	%	Total	%
Natural Reefs	+9,007	+64.4	+748	+22.0	+567	+94.7	+10,322	+57.4
Artificial Reefs	+28,959	+501.3	+483	+247.7	-1,214	-59.9	+38,751	+484.4
Total	+37,966	+92.1	+1,231	+34.2	-446	-17.0	+49,073	+188.9

* This includes those that went out on the charter, but who did not participate in any further activity.

Local Economy

The net changes in total recreational expenditures from the pre- to post-deployment period indicate that there was an increase of \$6.5 million in total recreational expenditures, which generated a total impact on sales/output of \$7.29 million, about \$3.2 million in income, and the creation of 105 new jobs (Table 4). As expected, visitors accounted for a much larger share of this growth than residents (86.4% vs. 13.6% respectively). For more detailed results and to see the breakdown by artificial and natural reefs, please see the technical appendix to this report (Leeworthy 2011).

Table 4. Net economic impacts of the deployment of the USS *Vandenberg*

	Visitors	Residents*	Total
Expenditures	\$5,624,686	\$884,578	\$6,509,264
Sales/Output	\$6,299,652	\$990,726	\$7,290,378
Income	\$2,830,525	\$357,382	\$3,187,907
Employment	93	12	105

* Only export sector of resident spending included and all spending includes multiplier impacts. See Leeworthy (2011) for details.

State and Local Tax Revenues Generated and Return on Investment

Costs of the USS *Vandenberg*. The total cost of the cleaning, towing, sinking and monitoring the USS *Vandenberg* was \$8.6 million. The State of Florida invested \$2.8 million, while Monroe County invested \$4.3 million, for a total state and local government investment of \$7.1 million. The U.S. Maritime Administration invested \$1.25 million with the remaining \$0.25 million from private sources.

Additional Tax Revenues Generated to State & Local Governments. The USS *Vandenberg* generated an annual increase in state and local tax revenues of approximately \$618 thousand; about \$379 thousand in state sales tax revenue and almost \$240 thousand in local sales and lodging tax revenues (Table 5).

Table 5. Additional Annual State and Local Sales and Lodging Tax Revenues from the USS *Vandenberg*

State Sales Tax Revenue (5.5%)	\$378,920
Local Sales Tax Revenue (2.0%)	\$142,892
Local Lodging Tax Revenue (5%)	\$96,756
sub-total Local Tax Revenues	\$239,649
<hr/>	
Total State & Local Revenue	\$618,569

1. State sales tax is 6%, but 0.5% is returned to local governments.
2. Local sales tax is 1.5%, but 0.5% of state sales tax is returned to local governments.
3. Local lodging tax is 5%, the 7.5% of sales tax on lodging is counted in the state and local sales taxes.

Net Present Value of Tax Revenues and Return on Investment. Using lower-bound conservative assumptions that the annual additional state and local tax revenues from the USS *Vandenberg* will remain constant (net of inflation); that the life of the USS *Vandenberg* will range from 20 to 40 years; and the real interest rate (net of inflation) used to discount future tax revenues to their net present values ranges from 3 to 5%, we can calculate the net present value of the future flow of the tax revenues and compare these to the net costs to the state and local governments that invested in the USS *Vandenberg* to support economic development and tourism.

Table 6. Net Present Value of Additional State and Local Tax Revenue from the USS *Vandenberg*

Tax	3% Interest Rate (Millions \$) ¹			5% Interest Rate (Millions \$) ¹		
	20 years	30 years	40 years	20 years	30 years	40 years
State Sales Tax Revenue	\$5.64	\$7.43	\$8.75	\$4.72	\$5.82	\$6.50
Local Sales Tax Revenue	\$2.12	\$2.80	\$3.30	\$1.78	\$2.20	\$2.45
Local Lodging Tax Revenue	\$1.44	\$1.90	\$2.24	\$1.21	\$1.49	\$1.66
sub-total Local Tax Revenue	\$3.56	\$4.70	\$5.54	\$2.99	\$3.69	\$4.11
<hr/>						
Total State & Local Tax Revenue	\$9.20	\$12.13	\$14.29	\$7.71	\$9.51	\$10.61

1. Interest rates are net of inflation, since tax revenues are also net of inflation. Assumption is that additional tax revenue is constant over time.

Using the annual tax revenues and the above assumptions, the net present value of tax revenues to state and local governments ranged from a low of \$7.71 million assuming the USS *Vandenberg* has a useful life of only 20 years and the discount rate is 5% to a high of \$14.29 million assuming a useful life of 40 years and a discount rate of 3% (Table 6). With a total state and local government investment of \$7.1 million, there is a net return to state and local government even under the most conservative (lower) estimate.

State government would receive a return on their investment under all assumptions, while local government would receive a return on its investment only under two of the six assumptions (useful lives of 30 and 40 years and an interest rate of 3%). However, if the state and local government pooled their investments and paid the full cost of the USS *Vandenberg* (\$8.6 million), they would have received a return on their investment under all but one of the assumptions (20 year useful life and 5% interest rate).

Given what we know about other large ships as artificial reefs, the 40 year life span seems to be a reasonable assumption. Under this assumption, state and local governments could have paid the entire cost of the USS *Vandenberg* and earned a net return on their investment.

DISCUSSION

It was hypothesized that introducing an artificial reef by sinking a decommissioned ship would benefit the local environment, the local dive charter industry, and the larger local economy. Results from this case study are not consistent with the first hypothesis that placing an artificial reef in an area with natural reefs reduces the pressure on natural reefs, which could potentially provide benefits to the natural environment. The latter two hypotheses are supported. The study demonstrated large increases in local dive charter business and the greater local economy grew in terms of sales/output, income and employment.

There are several caveats that should be noted when considering these results. The increased recreational use (pressure) on the natural reefs may or may not be negative ecologically. It has not been established that all the natural reefs have reached either their ecological or socioeconomic carrying capacity. Also, the ecological effects of introducing new habitat in the form of an artificial reef have not been assessed. Still, the exclusion of habitat impacts from the analysis should be considered when interpreting the results. The ecological monitoring being conducted by the FKNMS and FFWCC will give a more complete answer as to the ecological impacts of the USS *Vandenberg*.

Use and economic impacts were calculated for the pre- and post-deployment periods to derive our conclusions. The state of the larger economy is important to consider. If the baseline economy (pre-deployment) had been in recession, while the post-deployment economy had recovered from recession, part of the increase in use and economic impact might just be attributed to an increase in general economic activity and not attributable to the USS *Vandenberg*. However, gross sales reported by the Florida Department of Revenue for the pre- and post-deployment Monroe County economy show an 11.85% decrease from pre- to post-deployment. Thus, the USS *Vandenberg* provided an important boost to the local economy in a time of general decline.

It is important to note that the results of this study depend heavily upon the attributes of the local marine ecosystem, its individual reef sites, and the USS *Vandenberg* reef site. Consequently, the conclusion may apply to other locations only inasmuch as those locations have similar attributes. The Key West area is a mature dive market with many different artificial and natural reefs. For Key Largo, in the case of the USS *Spiegel Grove*, the dive industry is larger than the dive market

in Key West and consequently there was a smaller impact in the total market when measured as a percent increase. In absolute terms, the numbers were very similar. Also in the case of the USS *Spiegel Grove*, the hypothesis that introducing an artificial reef would decrease use on the surrounding natural reefs was supported, while it was not supported in the case of the USS *Vandenberg*. However, in both cases both the dive charter industry and the local economies benefited from the introduction of decommissioned navy ships as artificial reefs.

It was not possible to estimate changes in net economic user value or consumer's surplus. In Johns et al. (2003), it was found that the net economic user value per person-day was higher, on average, for natural reefs than artificial reefs. However, one cannot simply apply an average for artificial reefs and natural reefs and assess the net economic gain or loss from the introduction of the USS *Vandenberg*. Economic theory would suggest that the observation that people chose to use the USS *Vandenberg* rather than a natural reef indicates the USS *Vandenberg* was the highest value alternative. What is needed is a model to estimate the value of recreational use based on reef attributes, controlling for user characteristics. Such a model would yield estimates of economic user value that would allow for differentiating artificial and natural reefs with different attributes. Newness may be an attribute and the novelty of the USS *Vandenberg* could wear off and user patterns could revert back to pre-deployment. To answer this question will require future monitoring.

Local, state and federal government agencies invested funds in the USS *Vandenberg* with the state and local agencies attempting to promote economic development and tourism, while the federal government was trying to dispose of a decommissioned ship. The case of the USS *Vandenberg* supports the idea that decommissioned ships converted to artificial reefs can be successful in promoting economic development and tourism and also yield a net return on investment.

REFERENCES

Code of Federal Regulations (CFR), 15 CFR Part 922, National Marine Sanctuaries Program Regulations, Commerce and Foreign Trade, Office of the Secretary of Commerce.

Florida Department of Revenue. 2011. Sales revenue for Monroe County, Florida by spending category and month. FL Dept. Revenue, Tallahassee. [Data set].

Johns, G. M., V. R. Leeworthy, F. W. Bell, and M. A. Bonn. 2003. Socioeconomic study of reefs in southeast Florida: Final Report. Hazen and Sawyer and Florida State University under contract to Broward County Florida. Partnership of Broward, Palm Beach, Miami-Dade and Monroe Counties; Florida Fish and Wildlife Conservation Commission; and National Oceanic and Atmospheric Administration, Florida Keys National Marine Sanctuary.
<http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/sereef2000.pdf>

Leeworthy, Vernon R. 2011. Technical Appendix: The Economic Impact of the USS *Vandenberg* on the Monroe County Economy. Silver Spring, MD: Office of National Marine Sanctuaries, National Ocean Service, National Oceanic and Atmospheric Administration.
<http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/teachappenvand.pdf>

Leeworthy, V.R., T. Maher, and E.A. Stone. 2006. Can Artificial Reefs Alter User Pressure on Adjacent Natural Reefs. *Bulletin of Marine Science*, 78 (1): 29-37.
<http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/bms.pdf>

Leeworthy, Vernon R. and Stone, Edward, A. 2005. The Impact of the USS *Spiegel Grove*: Technical Appendix: "Can Artificial Reefs Reduce or Alter Pressure on Adjacent Natural Reefs". Silver Spring, MD: National Oceanic and Atmospheric Administration.
<http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/techappen.pdf>