Creating Underwater Value: The Economic Value of Artificial Reefs For Recreational Diving

by

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December 12, 2004

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Prepared for:
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Executive Summary

Ships, planes and other large structures are finding their way to the bottom of the sea along coasts in North America, Europe, Australia, and elsewhere. More and more, coastal communities are turning to these structures as a means of protecting shoreline, creating habitat for fish and sea life, and providing new destinations for recreational fishing and scuba diving tourists (Baine 2001). In Florida, over 380 existing vessels have been sunk to create artificial reefs. To date, over 700 ships serve as artificial reefs in the waters off the continental U.S. coastline. The majority of these ships are found off the coast of Florida (380), New Jersey (129), South Carolina (100), and New York (65). Other states lag far behind in the creation of artificial reef structures. For instance, while steps have been made to increase the use of artificial reefs in California, the state has only ten ships currently in place as artificial reefs intended for recreational diving.

Creating an artificial reef can be costly. The cost to prepare a ship for reefing can range from $46,000 to $2 million, depending on the size of the vessel (Hess et al. 2001). While estimating the costs of preparing and sinking a vessel for placement as an artificial reef is a straightforward task, predicting the benefits from these reefs is more difficult. The beneficiaries of artificial reefs are many; artificial reef users include divers, anglers, and even homeowners that enjoy shoreline protection from artificial reefs. The benefits these users derive may not be apparent in the market and include the value of additional recreational opportunities and improved quality of these experiences (these are often called non-market benefits). Further, the market benefits produced by artificial reefs, including increased local expenditures and tax revenues, often are hard to identify.

Scuba diving at artificial reefs generates market impacts (Table 1) that help to sustain local economies and provide new tax revenues, especially in areas where scuba diving tourism draws out-of-town visitors. Much of the literature on artificial reef uses focuses on the expenditures of recreational diving and fishing to oilrigs. In these studies, the economic expenditures (per person-day) by recreational divers range from $64 in Southern California to $119 for rigs in the Gulf of Mexico. Only one study, by Hess et al. (2001) has attempted to estimate the expenditures by recreational divers diving exclusively on ship-based artificial reefs in the United States. While Hess et al. (2001) do not provide per person expenditures, the authors do find that artificial reef sites based on sunken ships generate an average of $3.4 million in gross revenues annually. The expenditures of divers visiting a variety of artificial reefs were as high as $193 for non-residents visiting artificial reefs in Texas and $223 per person-day for visitors to reefs in Florida.

Scuba diving at artificial reefs can help enhance local economies!

Table 1: Market Value (Expenditure) Estimates for Diving at Artificial Reefs

AUTHOR	LOCATION	HABITAT TYPE	MARKET VALUE Per Person-Day ($2004)
Hiett & Milon (2002)	Gulf of Mexico	Oil and Gas Structures	$119
McGinnis *et al*. (2001)	So. California	Platform Grace (Oil Rig)	$64
Ditton and Baker (1999) Ditton et al. (2001)	Texas	Various types of artificial reefs	$184.68 for residents $193.80 for non-residents
Bell *et al.* (1998)	North West Florida	Ships, reef balls, and other private and public artificial reefs	$120.07
Johns et al. (2003)	South East Florida	Ships, reef balls, and other private and public artificial reefs	$223.26
Wilhelmsson *et al.* (1998)	Eliat, Israel	Navy Ship	$28
Brock (1994)	Waikiki	Surplus yard oiler	$26-$60

Table 2: Non-Market Value Estimates for Diving at Artificial Reefs

AUTHOR	METHOD	LOCATION	HABITAT TYPE	NON-MARKET VALUE Mean Per Person-Day ($2004)
STUDIES OF DIVING ON ARTIFICIAL REEFS				
Ditton and Baker (1999) Ditton et al. (2001)	Contingent Valuation: 1.dichotomous choice 2. open-ended	Texas	Various types of artificial reefs	1. $74.93 2. $44.46
Bell *et al.* (1998)	Travel Cost	N. West Florida	Ships, reef balls, and other structures	$10.71
Roberts *et al.* (1985)	Contingent Valuation	Gulf of Mexico	Petroleum Structures	($339.04 annually per diver)
STUDIES OF DIVING AND FISHING ON ARTIFICIAL REEFS				
Johns, *et al*. (2003)	Contingent Valuation	S. East Florida	Ships, reef balls, and other private and public artificial reefs	$5.45 (new artificial reefs) $15.73 (to maintain existing artificial reefs)
Milon (1988)	Contingent Valuation	Florida	Network of 7 different reefs from various materials	$29.04 to $42.77 per year
Milon (1989)	Contingent Valuation	Florida	Ships and steel debris	$4.48 to 127.56 per year

Artificial reefs also represent a potentially large economic resource, even in areas where most users are likely to live nearby. Local users, especially local divers, benefit from the recreational opportunities provided by artificial reefs. Even though recreational users don't generate expenditures at the level of out-of-town visitors and tourists, the value they place upon these resources is real. The studies surveyed here estimate the per-person day non-market value of recreational diving at artificial reefs (Table 2). The units of reef value vary from study to study and cannot always be made comparable. Estimates include an estimate of $5 per person-day for reef diving in Florida to an estimate of $339 annually per diver for diving at oilrigs in the Gulf of Mexico.

The potential economic value of a ship-based artificial reef depends both on the value of a reef to the individual diver (which is a function of diver interest, the quality of the artificial reef, and substitute dive sites) and the number of divers that are expected to use an artificial reef. Individual value, individual expenditures, and the numbers of visitors will vary by region. In Southern California, for instance, the San Diego Oceans Foundation estimates that 10,000 divers made 26,000 visits to the Yukon artificial reef site between August 2002 and August 2003. How do the values from the above studies transfer to the experience of the Yukon or other new and proposed ship-based artificial reefs? Based on the studies surveyed here, we could expect the Yukon to generate anywhere from $600,000 to over $2 million in local expenditures annually. The non-market value of the Yukon could cover a similar range of values.

I. Introduction:

Ships, planes and other large structures are finding their way to the bottom of the sea along coasts in North America, Europe, Australia and elsewhere. While many purists see the scuttling of ships and planes in coastal waters as something akin to dumping, more and more coastal communities are turning to these structures as a means of protecting shoreline, creating habitat for fish and sea life, and providing new destinations for recreational fishing and scuba diving tourists (Baine 2001).

Concrete rubble is often used to make artificial reefs. This pile was placed by the San Diego Oceans Foundation off the coast of Mission Beach in 1998.

The scale and pace of sinking ships to create artificial reefs, especially reefs designed for recreational diving, is increasing rapidly. In Florida, over 380 existing vessels have been sunk to create artificial reefs. In 2004 the U.S.S. Spiegel, a 510-foot naval vessel, was sunk in the Florida Keys National Marine Sanctuary. To date, over 700 ships serve as artificial reefs in the waters off the continental U.S. coastline. The majority of these ships are found off the coast of Florida (380), New Jersey (129), South Carolina (100), and New York (65). Other states lag far behind in the creation of artificial reef structures. For instance, while steps have been made to increase the use of artificial reefs in California, the state has only ten ships currently

in place as artificial reefs intended for recreational diving.

While the attention paid to artificial reef development has increased dramatically in the past decade, artificial reefs are not a modern development. Two thousand years ago, the Greek geographer Strabo recorded that the Persian Kingdoms built reefs across the Tigris River (Hess et al. 2001). In the US, artificial reefs have been around for over 150 years; as long ago as 1830 log huts were sunk off the coast of South Carolina to improve fishing (Hess et al. 2001). What differentiates modern artificial reefs from past reef making is the scale and cost of artificial reefs and the potential economic benefits that could be produced by the strategic placement and marketing of artificial reefs.

Creating an artificial reef can be a costly endeavor ,however the investment can be returned within just a few years.

Creating an artificial reef can be costly. The cost to prepare a ship for reefing can range from $46,000 to $2 million, depending on the size of the vessel (Hess et al. 2001). While estimating the costs of preparing and sinking a vessel for placement as an artificial reef is a straightforward task, predicting the benefits from these reefs is more difficult. The beneficiaries of artificial reefs are many; artificial reef users include divers, anglers, and even homeowners that enjoy shoreline protection from artificial reefs. The benefits these users derive may not be apparent in the market and include the value of additional recreational opportunities and improved quality of these experiences (these are often called non-market benefits). Further, the market benefits produced by artificial reefs, including increased local expenditures and tax revenues, often are hard to identify.

To better understand the potential economic benefits of artificial reefs, a number of studies have been undertaken to estimate both the market and non-market values of artificial reefs. In the late 1970s, studies began to quantify the economic benefit of recreational fishing and diving on artificial reefs (Daniel 1976). Over time, the accuracy and comprehensiveness of these studies have grown to provide a more complete picture of the potential economic benefit of artificial reefs.

In the paper that follows, I review the literature and assess the state of the art in the quantification of the recreational values of artificial reefs, especially the use of artificial reefs by recreational divers. Recreational diving is a rapidly growing industry and increasingly artificial reefs are being prepared, sunk, and maintained for the express use of recreational diving.

II. Economic Values

Artificial reefs offer economic benefits through the enhancement of shoreline protection, fishery resources, and recreational fishing and diving opportunities. The values of these benefits are difficult to quantify because they involve both

market and non-market values. The market impact of a reef resource usually is assessed by examining how much money artificial reef users contribute to the local economy by spending money to participate in activities on the reef (such as recreational fishing and diving). Commonly, the focus of market-based studies is on gross expenditures with fewer studies focusing on profits or taxes. While gross expenditures do not represent total benefits to the economy, gross expenditures do capture the magnitude of importance that artificial reefs may have in the overall local economy. Further, gross expenditures represent the base upon which tax revenues can be generated.

The non-market value of reef use is more difficult to determine than market values. Non-market values represent the value reef users place on a reef, beyond what they have to pay to use the reef. Non-market values are often associated with outdoor recreational resources, especially those resources that local users can enjoy with relatively little out of pocket expenses. Beaches, parks, and even natural dive sites have been shown to generate substantial economic value to local communities beyond the expenditures generated by these resources (see Cesar 2000 and Pendleton 1995). The National Ocean Economics Project (www.oceaneconomics.org) now lists over one hundred forty studies that provide estimates for the non-market value of ocean and coastal resources in the United States. In the literature, two primary methods are used to estimate the non-market value of artificial reefs. Travel cost methods are used to estimate a demand curve for recreational diving to artificial reefs by modeling the influence of travel cost and travel time on the frequency of visitation by divers. Travel cost methods use real diver behavior to estimate the consumer surplus of recreational diving, but the method can only estimate the value of current uses by non-resident divers. When travel cost methods are inappropriate, authors have used contingent methods to place values on artificial reef maintenance or abundance. Specifically, several authors use contingent valuation methods to ask divers to place a value on their current recreational use of a) existing artificial reefs and/or b) proposed new artificial reefs. Contingent valuation methods can be applied to both resident and non-resident divers.

Below I summarize studies that provide estimates of both market values (expenditure) and non-market values associated with recreational uses of artificial reefs. Most of the studies focus on sunken ships or oilrigs. It is important for the reader to note that the methods for finding these market and non-market values often differ between studies. In the following I provide these estimates (all converted to US$ in 2004) with brief explanations of the basic methods. Further, when possible, I break down the value estimates based on the value per visitor per day. By doing so, I hope the reader will be able to better understand how these values may compare to the values generated by artificial reefs beyond those in the studies.

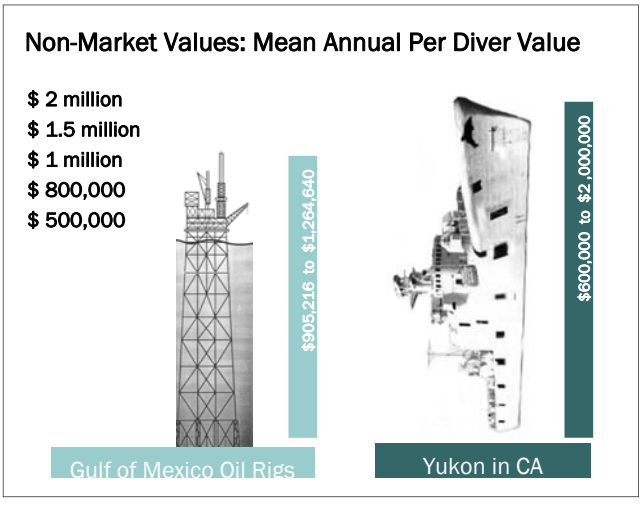
The Economic Value of Recreational Diving At Artificial Reefs

While much of the literature focuses on the economic value of recreational angling and diving combined, many of these studies also

provide data on the independent value of artificial reefs for recreational diving. Two studies estimate the expenditures associated with recreational scuba diving at oilrigs. Hiett & Milon (2002) surveyed divers visiting offshore oil and gas structures in the Gulf of Mexico; the authors calculate that the average per person-day expenditures at artificial reefs in Alabama, Mississippi, and Louisiana was $119, and total annual value for the three states combined was over $7.4 million. Following a similar approach in California, McGinnis et al. (2001) calculate the average per person-day expenditures of divers visiting oil rigs to be $64, with a total annual value of $10,700.

Expenditures by divers visiting artificial reefs are similar to divers visiting oilrigs (see Table 1). Hess et al. (2001) provide gross revenue estimates for a variety of artificial reef sites made from sunken ships. The authors find that these reef sites, located around the world, generate an average of $3.4 million annually. Ditton et al. (2001) and Ditton and Baker (1999) find that non-resident divers who visited an artificial reef on at least one dive trip each year spent just over $193 per person-day on their last trip to a dive site in coastal Texas waters; residents spent over $184 per person-day. Brock (1994) surveyed a dive-tour operator in Hawaii who conducted trips exclusively on a surplus yard oiler and calculated the total gross annual income generated by these trips to be $494,840. Bell et al. (1998) also provide a break down of expenditures per person-day for divers visiting artificial reefs in Northwest Florida. The authors find that divers spend $120.07 per person-day, a value that lies within the range of the other studies; together, resident and non-resident divers visiting artificial reefs spend more than $14 million in Northwest Florida. Johns et al. find even higher levels of expenditures by scuba divers and snorkelers visiting artificial reefs in South East Florida. On average across the four southern counties in Florida, the authors estimate the per person-day expenditures at $223.26 for a total of $118 million.

Artificial reefs also generate substantial non-market values (Table 2). Roberts et al. (1985) use contingent valuation methods to estimate the mean annual per diver non-market value of oilrig diving in the Gulf of Mexico to be $339, with a total annual value ranging from $905,216 to $1,264,640. Other studies provide estimates of per person-day non-market values. Bell et al. (1998) use both travel cost and contingent valuation methods (specifically Turnbull and Dichotomous Choice analyses) to estimate a per person-day non-market value of $10.07. Ditton and Baker (1999) estimate the non-market value of diving in Texas waters, for divers that visited at least one artificial reef in the past year, to be between $44.46 and $74.93 per person-day for non-residents. The values estimated by Ditton and Baker, however, are not exclusively for artificial reef divers.



In many cases, recreational divers also are recreational anglers or spearfishers; so it is difficult to apportion the value of a reef visit to either use. Three studies, focusing on two major regions in Florida, provide estimates for the non-market values for recreational fishing and diving at artificial reefs; all studies focus primarily on artificial reefs generally, including reefs created by sinking ships, reef balls, and other types of non-native structures. Table 2 includes non-market value estimates for the major studies that estimate economic values for combined recreational angling and diving uses at artificial reefs.

Johns et al. (2003), and Milon (1988 and 1989) estimate values for recreational diving and fishing in Florida ranging from $5.45 to $46.76 per person-day. The Johns et al. study estimates the value of maintaining artificial reefs and creating new artificial reefs; the authors conclude that the non-market use value per-person day for maintaining artificial reefs was $15.73, while the expected use value for creating new artificial reefs was only $5.45; the finding suggests that there are declining marginal returns to increasing the supply of reefs in an area in which both natural and artificial reefs already were abundant. Milon (1989) also estimates the economic value of new artificial reefs, what the author calls "option" values." Milon finds that estimates for the option value of new artificial reefs range from $4.48 to $127.56 per visitor per year, depending on the method used.

At least two studies find that artificial reefs are not perfect recreational substitutes for natural reefs. Johns found a preference among boaters, fishers, and divers for natural reefs; the use value for natural reefs was $18.58 compared to the value for artificial reefs that was $15.73. In addition to the higher willingness to pay for natural reefs, the Johns et al. study also shows that in most counties in Florida, the percent of dives conducted on natural reefs was much higher than that of dives conducted on artificial reefs. In an unpublished manuscript (personal communication), Ditton also finds that artificial reefs are not as highly valued as natural reefs; Ditton estimates the per trip value for artificial reefs is $76 lower than that of natural reefs ($114 and $190 respectively). It should be noted the studies by Johns et al. and Ditton were conducted in the waters off the coast of Florida where divers may chose from both natural and artificial reefs. In these cases, reef diving opportunities are not as scarce as in other locations (e.g. Southern California or the Mid-Atlantic United States). Where reef diving opportunities are scarce, it is likely that the non-market value of artificial reefs will be relatively higher. To date, however, there are few studies that examine the non-market value for artificial reefs in areas where natural reefs are limited or completely absent.

III. Conclusion

The economic value of recreational diving at artificial reefs is substantial. Scuba diving at artificial reefs generates market impacts that help to sustain local economies and provide new tax revenues, especially in areas where scuba diving tourism draws out-of-town visitors. Much of the literature on artificial reef uses focuses on the expenditures of recreational diving and fishing to oilrigs. In these studies, the economic expenditures (per person-day) by

recreational divers range from $64 in Southern California to $119 for rigs in the Gulf of Mexico. Only one study, by Hess et al. (2001) has attempted to estimate the expenditures by recreational divers diving exclusively on ship-based artificial reefs in the United States. While Hess et al. (2001) do not provide per person expenditures, the authors do find that artificial reef sites based on sunken ships generate an average of $3.4 million in gross revenues annually. The expenditures of divers visiting a variety of artificial reefs were as high has $223 per person-day for visitors to reefs in Florida.

Artificial reefs also represent a potentially large economic resource, even in areas where most users are likely to live nearby. Local users, especially local divers, benefit from the recreational opportunities provided by artificial reefs. Even though recreational users don't generate expenditures at the level of out-of-town visitors and tourists, the value they place upon these resources is real. The studies surveyed here estimate the per-person day non-market value of recreational diving at artificial reefs ranges from $5 per person-day in Florida to $339 annually per diver for diving at oilrigs in the Gulf of Mexico. The non-market value of artificial reefs to local divers may explain the increasing role of diver-based "not for profit" organizations in the creation of new artificial reefs.

Admittedly, our base of knowledge regarding the economic value of dive recreation at ship-based artificial reefs is still immature. In the published literature, only a handful of studies examine the economic impacts of ship-based artificial reefs and most of those studies focus on ship-based artificial reefs in coastal Florida. Clearly there is a need to know more about the economic impacts of the more than 300 ship-based artificial reefs in place around North America, but outside of Florida. The potential economic value of a ship-based artificial reef depends both on the value of a reef to the individual diver (which is a function of diver interest, the quality of the artificial reef, and substitute dive sites) and the total number of divers that are expected to use an artificial reef site. Individual value, individual expenditures, and the total numbers of visitors will vary from region to region. In Southern California, for instance, the San Diego Oceans Foundation estimates that 10,000 divers made 26,000 visits to the Yukon artificial reef site between August 2002 and August 2003. The Yukon cost more than $400,000 to acquire, prepare and sink and costs more than $1,000 annually for basic maintenance. Was it worth it? How do the values from the above studies transfer to the experience of the Yukon or other new and proposed ship-based artificial reefs? Based on the studies surveyed here, we could expect the Yukon to generate anywhere from $600,000 to over $2 million in local expenditures annually. The non-market value of the Yukon could cover a similar range of values.

The findings of Johns et al. suggest that while the value of existing artificial reefs is large, the value of additional artificial reefs will decline as artificial reefs become more common. Conversely, the value of new reefs in areas where natural reefs are scarce could be substantially higher than the values estimated for reefs in Florida and Texas. In the short-term, new artificial reefs will yield the highest values in places where scuba diving tourism is

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