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Coastal Management, Volume 19, pp. 205–218
Printed in the UK.

0892-0753/91 $3.00 + .00

Land Use Implications of Sea Level Rise: A Case Study at Myrtle Beach, South Carolina

JAMES B. LONDON

Department of Planning Studies
Clemson University
Clemson, SC 29634

CLAUDIO R. VOLONTÉ

Organization of American States
Washington, DC 20006

Abstract *The prospect of global warming and consequent sea level rise will have important implications for coastal communities. This article examines the land use implications of alternate sea level rise scenarios on the city of Myrtle Beach, South Carolina. Current trends as well as high and low sea level rise scenarios are superimposed on the city's beach profile and near shore contours to estimate the type and value of land development likely to be impacted.*

It is found that losses associated with accelerated sea level rise would be particularly high in the city's hotel district and that overall property loss could range from 21 to 60% of the city's total property value. To lessen these potential losses, coastal communities such as Myrtle Beach must choose among one of three policy options including: (1) barricade the beach, (2) raise the land, and (3) implement a strategic retreat. Specific alternatives within each of these options are explored in turn. The article concludes that successful development plans will incorporate ground rules sensitive to and consistent with dynamic coastal processes.

Keywords sea level rise, land use, coastal planning.

Introduction

In recent years, leading researchers in the atmospheric science community have reached a virtual concensus that concentrations of carbon dioxide and other trace gases in the atmosphere are increasing and that these concentrations may be impacting global climate. Although considerable uncertainty exists as to the magnitude of change that may be occurring, it is estimated that a continuation of present emissions patterns will increase global temperature by 3 +/− 1.5°C within the next century (NAS 1979).

Among the consequences of global warming is the probable rise in sea level associated with thermal expansion of water and the melting of snow and ice on both land and sea. Again, the magnitude of this impact is difficult to predict with certainty, but the most reliable estimates compiled to date predict sea level rise of between 0.3 and 0.64 ft by the year 2025 and between 2 and 11 ft by the year 2100 (Hoffman 1986). According to EPA, the long-term implications of sea level rise will include

Table 1
Sea Level Rise Scenarios at Myrtle Beach, SC Based on Current and Accelerated Sea Level Rise Scenarios

Year	Current Trends ft	Current Trends cm	Low S.L.R. ft	Low S.L.R. cm	High S.L.R. ft	High S.L.R. cm
2025	0.43	13.10	0.61	18.58	0.97	28.58
2050	1.16	35.55	1.12	34.08	2.26	12.92
2100	2.07	63.33	2.69	82.08	12.92	393.08

Note. Global sea level rise is based on Hoffman et al. (1986). Base year = 1986; current trends (1940–1980) 0.3355 cm/yr = 0.011 ft/yr; local subsidence = 0.22 cm/yr = 0.0072 ft/yr.

(1) Inundation of low-lying areas
(2) Erosion of beaches
(3) Increased flooding and storm damage
(4) Increased salinity of surface and ground water
(5) Higher water tables (Titus et al. 1989).

Earlier studies have focused on the implications of sea level rise at Galveston, Texas (Leatherman 1984); Ocean City, Maryland (Titus 1985); Sea Bright, New Jersey (Kyper and Sorenson 1985); and Charleston, South Carolina (Davidson and Kana 1988). The present study focuses on the impact of sea level rise at Myrtle Beach, South Carolina, among the more popular and densely developed beachfront communities along the South Atlantic coast. Particular attention is given to the land use implications of sea level rise and to the land use options available to beachfront communities affected by accelerated sea level rise.

Shoreline Change

Historical erosion rates at Myrtle Beach have been estimated in a number of recent studies including: Hayes et al. (1977), London et al. (1981), U.S. Army Corps of Engineers (1983), and Kana et al. (1984a). Along the city's 21 stations, shoreline recession rates of 0.6 to 0.8 ft/yr are typical. The arcuate strand characteristics of the reach with little inlet interruption make long-term erosion trends more predictable than in most oceanfront areas.

Sea level rise scenarios estimated at Myrtle Beach are shown in Table 1 for the years 2025, 2050, and 2100. Current trends are determined by extrapolating the past trend of sea level rise (0.011 ft/yr) from the base year 1986 to the target year. Also included is the cumulative subsidence effect at Myrtle Beach, adjusted from estimates for Charleston and Wilmington by Hicks (1983). Accelerated sea level rise scenarios are calculated by adding global sea level rise estimates by Hoffman (1986) to the target year. By the year 2100, sea level rise is projected to rise from 2.07 ft under current trends to 12.92 ft under the high sea level rise scenario.

Based on the sea level rise scenarios in Table 1, shoreline erosion rates along the city's 10-mile beachfront were projected. Three different shoreline retreat techniques employed in this study: the drowned valley concept (Kana et al. 1984b), extrapola-

tion of historical trends (Leatherman 1984) and Bruun's Rule (Bruun 1962 and Hands 1981.) The model is based on the contention that sea level rise will cause two main events: inundation and erosion, resulting in horizontal displacement of the beach.

The drowned valley approach considers the preexisting topography along the shoreline as fixed with slope as the controlling variable. Steep-sloped areas will experience little horizontal shoreline displacement with each increment of water level rise, while gently sloping shoreline stretches will undergo a much broader area of flooding for a given sea level rise. Extrapolation of historical trends techniques are calibrated using historical shoreline data. The underlying assumption of the analysis is that shorelines will respond in similar ways in the future as they have in the past, since sea level rise is the predominant driving function and all other parameters remain essentially constant or can be explained within the analysis. After establishing a feet-per-year relationship for different shoreline types and wave exposures, the method develops a new annual erosion rate or rule of thumb on which to project further effects of sea level rise on shoreline movement.

The Bruun Rule was the first method to formulate the relationship between rising sea levels and the rate of shoreline erosion. Bruun's argument is based largely on the concept of an equilibrium beach profile. The term *equilibrium profile* is a statistical average profile that maintains that form apart from small fluctuations. It provides for a profile at equilibrium in that the volume of material removed during shoreline retreat is transferred onto the adjacent inner shelf, thus maintaining the original beach profile and near shore shallow water conditions (only farther inland). Hands (1981) modified the so-called Bruun rule to account for the loss of suspended load into the formula, which is a more general and practical variation.[1]

Therefore, these three techniques are combined to develop the following three-step model, depicted in Figure 1:

(1) Current erosion and inundation trends are applied to the present shoreline. This step does not consider accelerated sea level rise.
(2) Under conditions of accelerated sea level rise, the shoreline is further inundated and eroded. The additional displacement is calculated using Hands' equation.
(3) The total horizontal displacement is the sum of (1) and (2) for each scenario.

Table 2 depicts projected shoreline retreat for the city of Myrtle Beach to the years 2025, 2050, and 2100 based on current erosion trends and accelerated by alternate sea level rise scenarios. Projections are made along three sections of the beach to estimate the relative position of Mean Sea Level (MSL), the baseline (the position of the ideal dune line) and the mandated setback line. As shown in Table 2, for the year 2025, the mean sea level line moved inland between 39 and 64 ft under the low sea level rise scenario and from 64 to 89 ft under the high sea level rise scenario. By the year 2100, it is projected that the shoreline will be 182 to 253 ft farther inland under the low scenario and from 896 to 960 ft farther inland under the high sea level rise scenario.

Figure 2 depicts mean sea level and delineations at the present time and projected to the year 2100 under both low and high sea level rise scenarios. Here, the disparity between the low and high sea level rise scenarios clearly is evident. Numbers also were run for the projected baseline and setback line as mandated in the city's zoning ordinance and the state's 1988 Beachfront Management Law (Table 2). The baseline represents the ideal dune line, while the setback line incorporates a 50-year erosion rate. Both baseline and setback lines were left off of Figure 2 to make it more readable.

The findings suggest an accelerated rate of erosion and inundation through the next

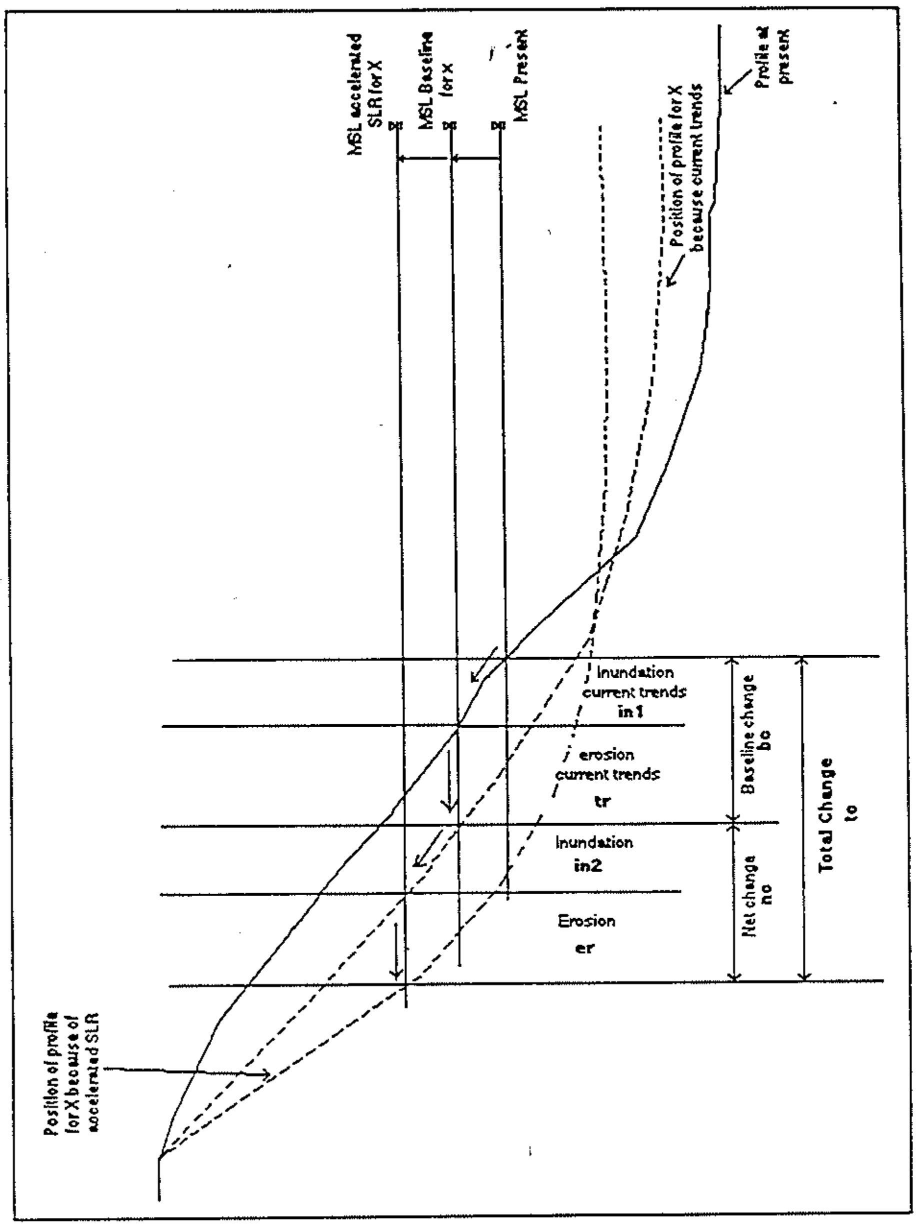

Figure 1. Shoreline retreat model.

Table 2
Horizontal Retreat Scenarios at Myrtle Beach, SC (ft)

Year	Scenario	Line	Northern Region	Central Region	South Region
2025		MSL	−22	−1	4
	Current	Baseline	−232	−211	−206
		Setback	−253	−232	−206
		MSL	−64	−44	−39
	Low	Baseline	−274	−254	−249
		Setback	−301	−281	−276
		MSL	−89	−65	−64
	High	Baseline	−299	−275	−274
		Setback	−342	−318	−317
2050		MSL	−41	−8	0
	Current	Baseline	−251	−218	−210
		Setback	−272	−239	−231
		MSL	−117	−87	−77
	Low	Baseline	−327	−297	−287
		Setback	−357	−327	−317
		MSL	−197	−169	−157
	High	Baseline	−407	−379	−367
		Setback	−468	−440	−428
2100		MSL	−73	−14	1
	Current	Baseline	−283	−224	−209
		Setback	−304	−245	−230
		MSL	−253	−201	−182
	Low	Baseline	−463	−411	−392
		Setback	−503	−451	−432
		MSL	−960	−931	−896
	High	Baseline	−1170	−1141	−1106
		Setback	−1365	−1336	−1301

Note. Negative numbers denote shoreline retreat, positive numbers denote shoreline accretion.

century. Although some uncertainty remains as to the level of sea level rise and commensurate inundation of beachfront land, the current trends and high and low sea-level rise scenarios help to bracket the possible impacts on ocean-based tourism communities such as Myrtle Beach.

Land Use Implications

The land area projected to be lost to inundation under alternative sea level rise scenarios is summarized in Table 3. The figures represent the projected location of mean sea level, baseline, and setback lines relative to represent mean sea level. Using baseline numbers, by the year 2025, the city is projected to lose between 3.3 and 4.0% of its total land area. By the year 2100, the area lost through sea level rise is projected to be between 412 and 1231 acres or between 7.2 and 21.3% of the total land area of the city.

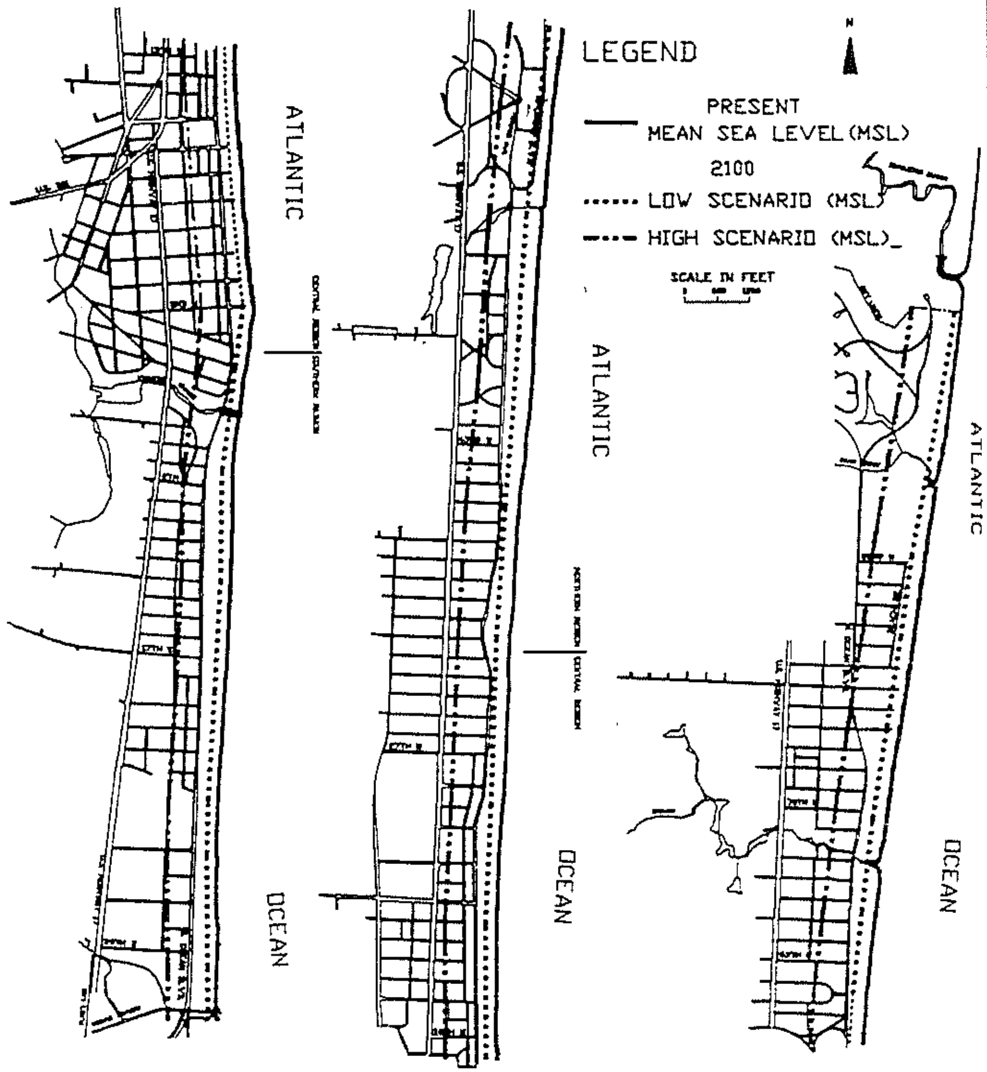

Figure 2. Position of mean sea level, baseline, and setback (2100).

Although the land area lost to inundation becomes sizeable by the end of next century, the significance of the loss becomes still greater when related to existing land use patterns in the city. Superimposing baseline figures on the city's land use map, particularly large losses are projected for properties classified as Transient Accommodation Use, which includes the majority of the city's hotel district (Figure 3). The loss of Transient Accommodation property is projected to range from 15 to 18% in the year 2025 to 31 to 84% in the year 2100. Accommodation/commercial property loss (especially in and around the Central Business District) is projected to range from 11 to 25%

Table 3
Land Use Lost to Shoreline Retreat (2025, 2050, and 2100)

		2025				2050				2100			
	1989	Low		High		Low		High		Low		High	
Land use	Acres	Acres	% Lost	Acres	% Lost	Acres	% Lost	Acres	% Lost	Acres	% Lost	Acres	% Lost
Transient accommodation	718	111	15	129	18	132	18	196	27	221	31	604	84
Residential	3499	67	2	86	3	90	3	117	3	143	4	495	14
Commercial	1127	0	0	0	0	0	0	0	0	1	0	29	3
Accommodation/ Commercial	441	15	4	18	5	14	3	25	6	47	11	103	25
Medical	61	0	0	0	0	0	0	0	0	0	0	0	0
Total	5816	193	33	233	4	236	4	338	6	412	7	1231	21

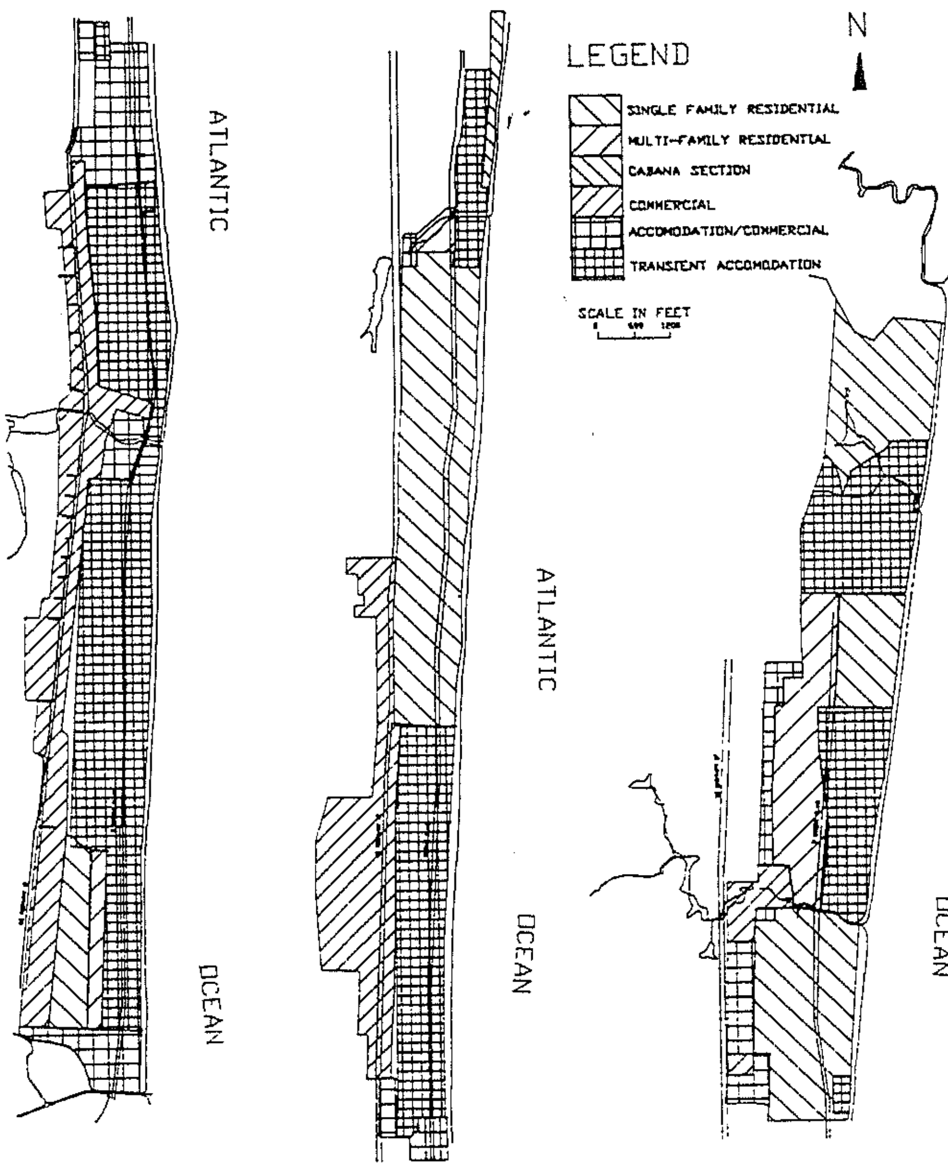

Figure 3. Current land use for the city of Myrtle Beach.

by the year 2100, while residential property loss (especially in the northern beachfront areas) is projected to range from 4 to 14%.

Because of the amenity value associated with locations at or in close proximity to the ocean, the inundation of oceanfront and near oceanfront property will have a disproportionate effect in terms of property loss. To simulate property loss associated with sea level rise, shoreline retreat as projected earlier was superimposed onto footprints taken from aerial photographs and tax maps for the city. Figure 4 depicts a planimetric view taken along the northern area of the city. This map provides some insight into the projected movement of baseline and setback lines under alternate sea level rise scenarios. In this case shoreline movement is not parallel to the ocean as a swash is found the right center of this map. Figure 5 depicts a cross section of this same profile. This section of the beachfront is particularly hard hit by the year 2100 under the high sea level rise scenario.

Again, using baseline numbers, property loss is projected to range from 285 to $361 million (9.5 to 12.0% of the total) by the year 2025. By the year 2100, losses of between 636 million and $1.8 billion are projected with relative shares ranging from 21 to 60% of present land value. The projected losses are in present dollar terms and reflect present development patterns. Changes in future development patterns or engineering solutions to ameliorate the impacts of rising sea level certainly will alter these relative property losses. The options available to coastal communities to deal with sea level rise are the focus of the following section.

Options to Deal With Sea Level Rise

In essence, the land use implications of sea level rise for beachfront communities are similar to those of long-term erosional trends for which considerable planning and policy thought has been given. The major differences between the two occurrences relate to the magnitude and certainty of change. Although many of the questions remain the same, the stakes certainly have increased.

The ability of coastal communities to deal with the land use implications of sea level rise are dependent to a large extent on the ground rules that are established now and into the near future. Among the options available to communities to deal with long-term sea level rise are

(1) Construct walls to hold back the sea
(2) Raise the land
(3) The incorporation of presumed mobility on the part of property owners as a premise for building in coastal areas

Each of these options has its place in adapting to the long-term effects of sea level rise.

The first approach embodies traditional land zoning. As a response to long-term erosion trends, setback lines have provided a major breakthrough forcing new development off of the immediate beachfront to accommodate beach dynamics. Although based on various criteria, setbacks require good information and perhaps better information than is currently available with respect to innundation caused by long-term sea level rise. In that environment, setback programs will be forced to err on the side of caution to prevent future conflicts between public and private interest along the beach. The application of a static planning tool in a dynamic beachfront environment alternately will result in conflict in the case of more rapid than expected erosion rates and the preclusion of higher land uses in the event of slower than projected erosion rates.

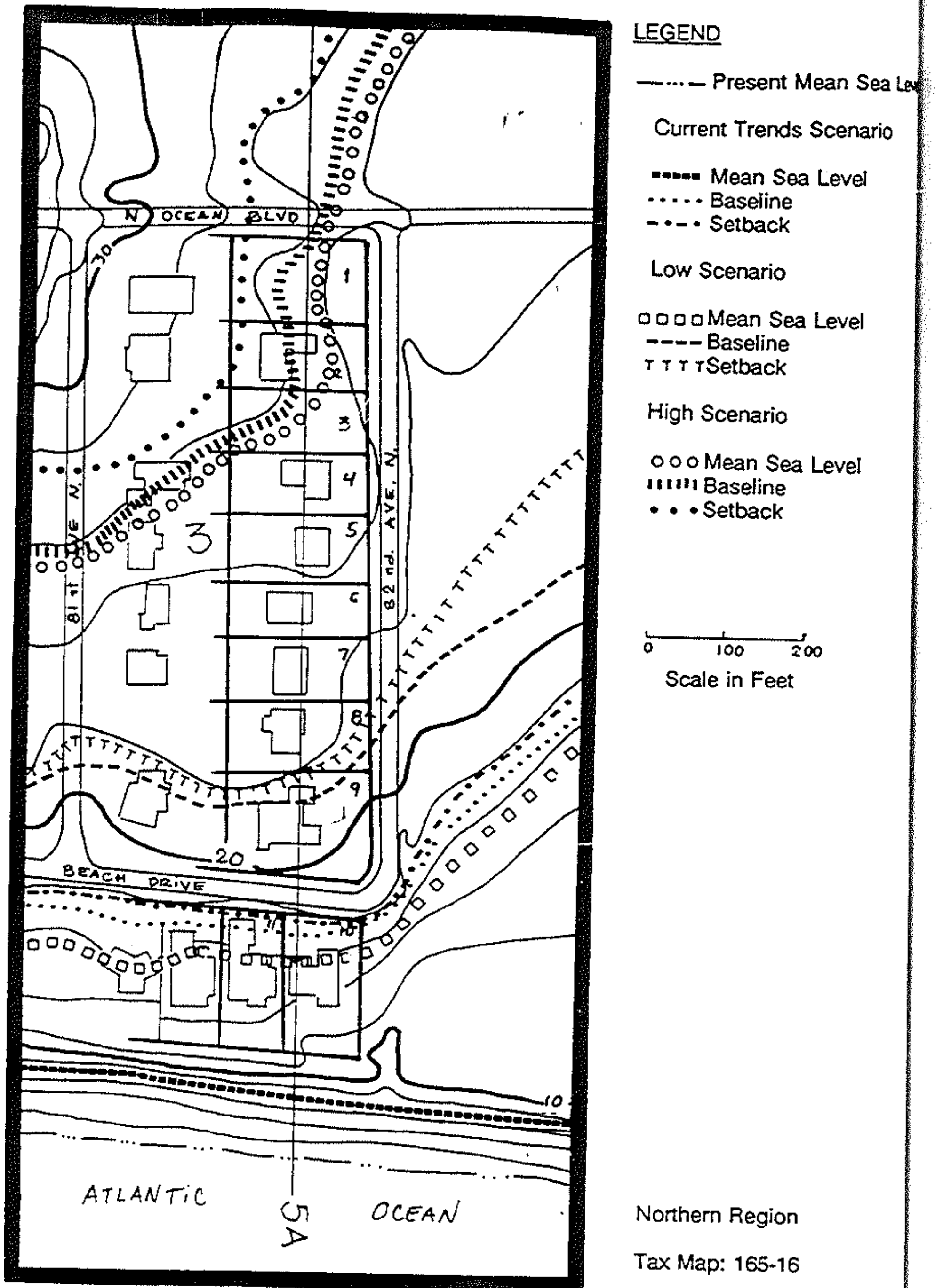

Figure 4. Planimetric view of Sector 5A.

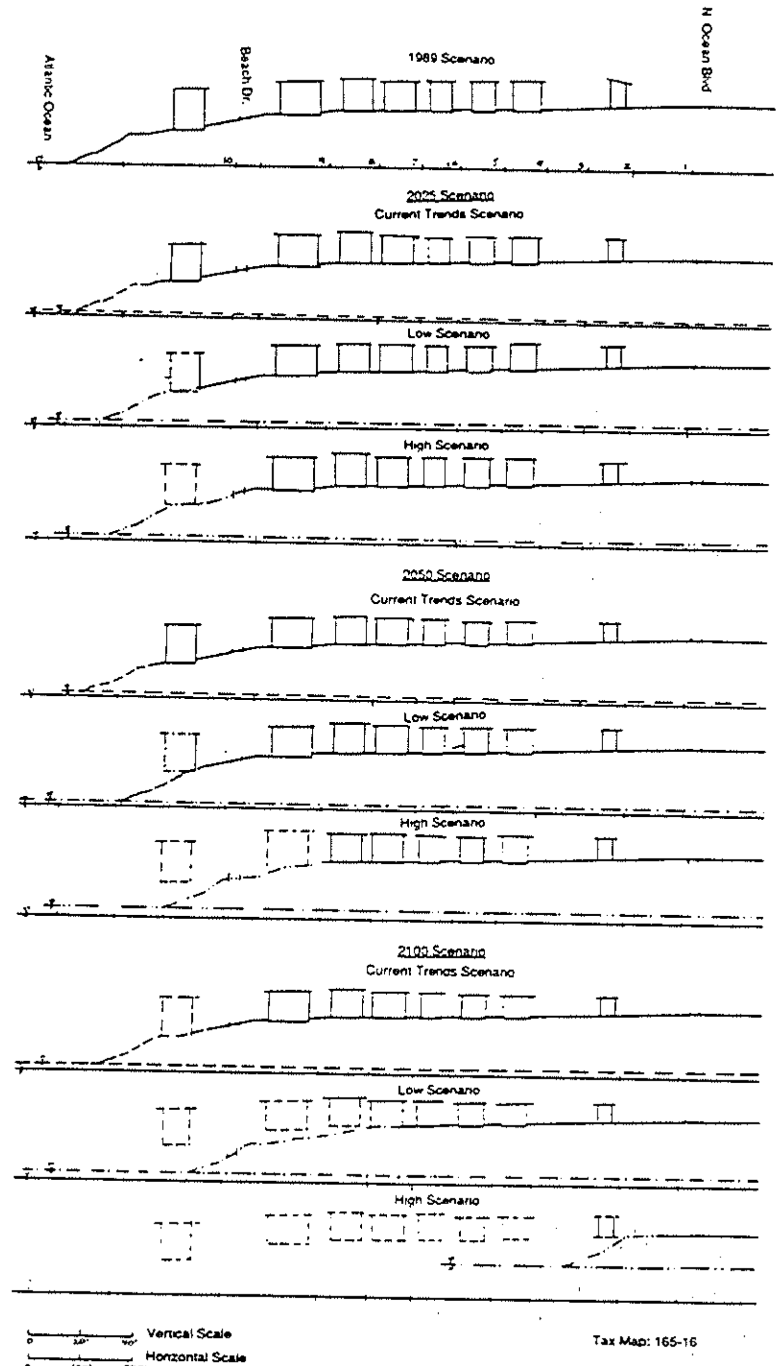

Figure 5. Cross section of shoreline retreat of Sector 5A.

In particular locations especially around inlets and other environmentally sensitive areas, the establishment of conservation districts has considerable appeal. Well-placed conservation zones contribute to the maintenance of public beach and to public beach access. Were we to start from scratch, a broad conservation zone to accommodate shoreline fluctuation and public beach maintenance would have obvious merit.

Where past mistakes have been made either due to a lack of information or poor planning, financial incentives should be targeted to remove damaged or threatened properties from hazard areas. The inappropriate incentives of past flood insurance programs have been well-documented, while the buy-out provisions of Federal Emergency Management Agency (FEMA) emergency programs remain inadequate to induce major retreat in the face of natural disasters. Financial incentives combined with restrictions on reconstruction in the event of natural disasters offer long-term solutions. In the interim, compensation for perceived takings in the light of institutional change that further restricts private property rights may be necessary.

The final approach bears still greater attention as communities begin to construct their long-run planning apparatus. An important issue to be resolved is the relative risk bearing to be assumed by public and private interests. The term *presumed mobility*, first used by Titus (1989), is based on the premise let the buyer beware. Property owners are allowed to build with the condition that they must move their structures when the shoreline laps at their door or more appropriately comes within a predetermined distance of the structure.

Ideally, presumed mobility would be introduced in conjunction with the above approaches. Setbacks would provide a minimum assurance that careless investments and near-term conflicts could be avoided. Still more flexibility remains to allow potentially advantageous investments with the developer assuming full risk for accelerated shoreline retreat. A period of transition would be required to accommodate present development where investment was made under previous institutional arrangements. A period of 15 years after construction (a common depreciation schedule of commercial structures) or the year 2000 (or some target date), whichever date is sooner, might serve as an appropriate period of transition. Beyond that point, the rules of the game have changed. Private (and public) development along the beachfront must account for dynamic shoreline conditions. Ultimately, conflicts that surface between private development and the public beach must be decided in favor of the public beach.

Implications for Oceanfront Communities

Densely developed oceanfront communities, like Myrtle Beach, stand to lose disproportionately under accelerated sea level rise scenarios. Yet, these same communities have often frustrated past planning efforts including coastal zone management programs and shoreline management plans with opposition to tighter development controls. Understandably, these communities stood the greatest potential for financial loss where institutional change was imposed.

Still, a number of communities have come around in recent years realizing that their economy is amenity-based and that the protection of that amenity is crucial to long-term commercial viability. The city of Myrtle Beach, for instance, established a building setback based on 50-year erosion rates which is more restrictive and was enacted at an earlier date than South Carolina's Beachfront Management Act mandating setbacks on a statewide basis. The City Council and the Planning Commission convened a special workshop to discuss the findings of this study and were overwhelmingly supportive in a way that would have seemed impossible a few years ago. Information from this study is being incorporated in the city's long-range plan.

Studies of sea level rise that focus on the inherent conflict between private interests and the public beach may help to emphasize the need for creative and effective land use planning alternatives in oceanfront communities. The challenge to the scientific community is to provide timely and realistic information to the public and to public officials.

Conclusion

Accelerated rates of sea level rise will have serious implications on beachfront communities. In the case of Myrtle Beach, SC, it is estimated that property losses could range from 636 million to $1.8 billion by the year 2100. Those losses represent 21 to 60% of the present property value of the city. Although the range is wide reflecting some uncertainty as to relative rates of shoreline erosion and inundation, the potential for property loss is still extremely large.

The extent to which property loss is actually experienced will depend on the ground rules that are established in the intervening years. Coastal communities must begin to factor long-term coastal dynamics into their planning process. A failure to adapt to a rapidly changing shoreline profile will result in frequent conflicts between human development interests and the natural beach system.

Acknowledgments

Funding for this project was provided by the South Carolina Sea Grant Consortium and the Strom Thurmond Institute at Clemson University. The authors wish to thank the city of Myrtle Beach, the South Carolina Coastal Council, Tim Kana, Margaret Davidson, Danny McElmurray, and the anonymous reviewers of this paper for their assistance.

Notes

1. The modified Bruun Rule as defined by Hands (1981) is expressed as $x = sbR_A/e + d$, where x = shoreline recession; e = shoreline elevation; d = limiting depth between predominant nearshore and offshore material and littoral drift characteristics; s = sea level rise; b = width of shelf or distance to limiting depth from shore; and R_A = overall ratio to account for loss of suspended load from the eroded material.

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Coastal Management, Volume 19, pp. 219–238
Printed in the UK.

0892-0753/91 $3.00 + .00

Demographic Indicators of the Relative Need for Artificial Reefs in Florida

STEPHEN M. HOLLAND

Department of Recreation, Parks and Tourism
University of Florida
Gainesville, FL 32611-2034

Abstract *Artificial reef development involves planning from a number of perspectives including biological, oceanographic, engineering, and social. This article reviews previous studies and identifies demographic variables that affect the use of artificial reefs by recreational anglers. An index of relative demand was created employing eight components: number of coastal county resident boat anglers, nonresident boat anglers, tourist boat anglers, nonboat anglers, number of fishing clubs, number of charter/party boats, number of registered pleasure boats, and the rate of county population growth. By comparing the magnitude of the index to the number of existing artificial reefs off of Florida's 35 coastal counties, an estimate of relative need was graphically portrayed on a state map. Indian River county on the Atlantic coast and Hernando, Hillsborough, Pasco, Citrus, Levy, Lee, and Charlotte counties on the central Gulf coast are the areas with the greatest demand relative to existing reef supply.*

Keywords artificial reefs, recreational demand, recreational fishing, demographic variables, Florida.

Introduction

Marine artificial reef development has expanded notably in the last 20 years. These include manmade structures placed on the seafloor or floating in the water column that attract and facilitate the growth of many marine organisms and fish. Artificial reefs are constructed from construction debris, sunken ships, oil platforms, P.V.C. tubing, specially designed reef structures, and various other materials. The evolution and acceptance of a technology to increase the abundance of accessible fisheries resource has accelerated due to the steady decline in marine fisheries stocks,[1] the steady increase in marine recreational boat fishing,[2] and an interest in decreasing costs associated with offshore access to marine fisheries by both recreational and commercial sectors. Leadership on the part of the Japanese government in subsidizing the design, construction, and deployment of artificial reefs has also focused attention on artificial reefs (Sheehy and Vik 1982; Reeff 1987). Interested groups range from federal, state, and local government agencies; oil companies, commercial and recreational fishing associations; and local businesses interested in low cost solid waste disposal solutions.

Artificial reef deployment should involve oceanographic, biological, geological engineering, national defense, and social aspects of reef siting (Ditton and Burke 1985). While there has been a variety of planning strategies reported based on the physical, biological, and engineering components of the problem, there have been comparatively few published attempts to integrate social aspects into the siting of artificial reefs. The purpose of this study was to identify demographic factors that affect the use of artificial reefs and to develop an approach leading to a relative ranking of higher and lower priority zones for siting reefs based on demographic variables.

Background on Artificial Reef Planning

During the 1980s, artificial reefs became an increasingly important tool for fishery managers. Though they have been utilized along the U.S. shoreline since the nineteenth Century (Stone 1974), only in the last 15 years, have artificial reefs been the subject of coordinated planning and research.[3] With increasing fishing pressure, environmental degradation, and declining fishing stocks (Fernald 1985; Gissendanner 1982; Pearce 1983; Seaman 1985), and an interest in increasing harvest efficiency, methods of increasing the efficiency of fishing or enhancing the stock have received more attention (Stone et al. 1979).

Historically, the placement of artificial reefs has been primarily based on accidental ship wrecks, convenient scuttling, petroleum resource sites, or the availability of disposable scrap materials (Stone 1974). In the last decade there have been increasing calls for regional research, planning, and consideration of multiple factors in placement of reefs (Bohnsack and Sutherland 1985; Gordon and Ditton 1986; Myatt 1981). Factors that need to be addressed in reef placement include permitting (Christian 1984; Goode 1981); biological aspects (Ranasinghe 1981; Stone et al 1979); economic (Bockstael, et al. 1985; Hanni and Matthews 1977; Milon 1988 and 1989); legal liability (Hayes 1981), social dimensions (Ditton 1981); naval defense concerns (NRC 1985); and engineering considerations (McAllister 1981). General suggestions regarding reef placement include suggestions such as locating the reef offshore from a channel or small boat inlet, selecting a low current area, placing some reef sites within sight of land, others in 30 to 40 meter depths and placement in a previously nonproductive area with a solid bottom (Mathews 1979).

The move toward comprehensive artificial reef planning received impetus with the passage of the National Fishing Enhancement Act of 1984 (P.L. 98–623). This act established a planning procedure which called for the coordination of the multiple information dimensions in deploying artificial reefs. The National Artificial Reef Plan (DOC 1985) provides a framework to develop site-specific plans that take into consideration the marine environment condition and the local resource use demands.[4] The Sport Fishing Institute also published an extended planning guide for artificial reefs for recreational fishing (Ditton and Burke 1985).[5]

In Florida, comprehensive mapping of existing reef locations has been coordinated and published by the Florida Sea Grant College Program (Aska and Pybas 1983; Seaman and Aska 1983). However, the executive director of the Florida Marine Fisheries Commission has acknowledged that the state has no comprehensive artificial reef plan (Hardie 1987).[6] The marine artificial reef development process in Florida is decentralized (Murray 1989) and, as are many coastal actions (Guy 1983), initiated at the local level. Of the 210 state-permitted reefs authorized between 1960 and 1987, 54% were submitted by county governments, 5% by city governments, 21% by fishing and diving clubs, 5% by reef associations, 6% by private individuals, and 4% by businesses and 5% by others (Pybas and Seaman 1987).

The permit process is coordinated by the Department of Environmental Regulation (DER) at the regional level.[7] The Division of Marine Resources within DNR has an Aid to Local Government: Artificial Reef Program that makes use of Wallop-Breaux monies and state general revenue funds.[8] The program will give grants to local coastal governments to assist in offsetting the engineering, advertising, and transportation costs of placing marine reefs. The Department of Transportation disposes of some old bridges on reef sites in coordination with local governments and the Division of Marine Resources (Murray 1989).

According to some charter boat captains with whom this author has spoken, there are also numerous unpermitted reefs, built by captains themselves as "private" fishing locations.[9] Finally, artificial reefs are used by commercial fishermen when not specifically banned from commercial utilization (Ditton and Auyong 1984; Harrington 1972; Phillips 1989; Samples 1989; Samples and Sproul 1985).[10] However, the focus of this article is recreational use.

Social Factors in Artificial Reef Planning

Artificial reef planning guidelines (Ditton and Burke 1985), as well as basic outdoor recreation demand planning (Clawson and Knetsch 1966; DOI 1975) indicate that factors such as population demand, access to the marine resource, and degree of social organization will influence the degree of demand for artificial reefs. Several studies provide empirical evidence about who uses artificial reefs and which factors effect the decision to fish artificial reefs.

A fundamental demographic demand variable is resident population (Loomis and Ditton 1988). Larger numbers of proximal residents mean that artificial reef resources are available to serve more of the public. Siting facilities to provide the greatest good for the greatest number of people is a well established planning principle. For most coastal areas, anglers can be either residents or tourists (Miller and Ditton 1986). About 2.5 million tourists a year come to Florida for the purpose of going saltwater fishing during their visit.[11] A survey of Florida boat customers (Holland 1988a) reported that 78% of charter boat customers and 55% of party boat customers in Florida were tourists. Thus, resident and tourist population gives an initial indication of the pool of individuals that is available to use an artificial reef.

A more relevant population demand factor that would influence artificial reef use is the number of anglers in the adjacent area. The Marine Recreational Fishery Statistics Survey in 1986 (NMFS 1987) found that approximately 8% of all households contacted in a telephone survey reported marine fishing activity. Because of statewide proximity to the resource[12] and fair weather, it is estimated that there are about 3.5 million Florida resident saltwater anglers (28% of state population) (Florida DNR 1989; FWS 1982).

Access to artificial reefs are primarily obtained through the use of a private or for-hire boat.[13] Ditton and Graefe (1978) surveyed boat owners in Texas. About 70% of all small boat (less than 26 ft) and 48% of large boat owners were anglers. For boat anglers with boats less than 26 ft, 6% fished offshore, and of those with boats greater than 25 ft, 60% fished offshore. About 70% of the surveyed Texas offshore anglers fished near artificial reefs or oil platforms. This group of anglers traveled 18 and 25 mi offshore on their average and farthest ships, respectively.

Witzig (1986) reported that the Marine Recreational Fishery Statistics Survey conducted by the National Marine Fisheries Service (1986) indicated that 37% of all saltwater fishing trips by coastal Louisiana residents, and 20% of such trips by Texas residents were within 200 ft of an oil or gas structure. Furthermore he reported that 70% of all fishing trips greater than 3 mi off the Texas-Louisiana shore were to waters near an oil or gas structure. Survey results (NMFS, 1987) further revealed that private boats had the highest catch rate (14.5 fish per trip) compared to shore anglers at 4 fish per trip. Approximately 71% of the total number of fish caught by recreational anglers in the Gulf of Mexico was taken by private boat anglers.

Milon (1988) surveyed about 1200 boat (greater than 16 ft) owners in Dade County. About 75% were anglers and 28% of those fishermen reported fishing at artificial reefs. Seventy-eight percent of the respondents indicated that the "better chance of catching fish" was very important in their decision to locate a reef. Twenty-six percent of boat anglers were willing to travel up to 30 min and another 26% were willing to travel at least an hour to fish at a reef.

Ditton and Auyong (1984) analyzed nearly 20,000 observations from oil platforms in the Louisiana Gulf of Mexico of adjacent fishing activity. Of the 11,911 boats observed between April 1980 and March 1981, 9% were commercial, 2% scuba, 14% charter/party boats, and 75% were private boats. There was variation in the distance traveled offshore depending on location, with the average distance for private boats ranging from 12 to 19 mi (with the majority of boats nearer the 12-mi zone) and for charter/party boats extending from 16 to 41 mi. Other indications of charter/party boat use of artificial reefs is primarily anecdotal (Abbas 1978; Ditton et al. 1978a; Putnam 1981).

The amount of social organization into advocacy clubs can be an indication of commitment or involvement in fishing (Buchanan 1985; Bryan 1979). Many artificial reefs are built by, planned by, and/or publicized by angler organizations (Ditton and Burke 1985).[14] The number of active fishing clubs in a county can also indicate a greater interest in reefs (Pybas 1987).

The degree of understanding of social factors has increased. The next challenge is to develop an approach to utilize information that will assist the site selection for reef placement. The following section describes the utilization of population, access, and social organization variables in the creation of an index of relative need for artificial reefs in Florida.

Methods

The technique utilized was the creation of a relative demand index (Babbie 1989) based on indicators of fishing demand.[15] An index is a composite measure where more than two indices are combined into a single measurement through some procedural rules (Smith 1975). It is a relative index because the index values are meaningful only in a comparative sense among the 35 index values computed for this study. Indexes have been widely used to quantify complex phenomena in basic terms (Campbell et al. 1976; Keyfitz 1976; Kerlinger 1973; Rives and Serow 1984). Combined indices should be employed when an investigator lacks a precise theory to predict with a single test (Webb et al. 1966). By combining several indicators into a composite measure, a better overall representation of the concept results and errors tend to cancel each other out, yielding a more reliable measure (Singleton et al 1988). In addition, validity tends to increase by using more items (Smith 1975). Since there have been few, if any, attempts to assemble and quantify demographic variables associated with the demand for artificial reefs, an index approach to initiate study of the topic is appropriate.

As previous studies have indicated, the primary demand factors are resident and tourist populations, number of boat anglers, number of boats, and number of nonboat anglers who might utilize charter boats for access. Specifically, the basic items included in creating the demographic demand index for this study were: (1) an estimate of the number of resident saltwater boat anglers in coastal counties, (2) an estimate of the number of Florida saltwater boat anglers from outside the coastal counties (nonresidents), (3) an estimate of number of tourist saltwater boat anglers from out-of-state using the coast in each county, (4) an estimate of number of nonboat saltwater anglers in each county, (5) the number of saltwater fishing clubs in each coastal county, (6) number of charter/headboat services by county, (7) the number of registered pleasure boats (>15 ft in length) per county, and (8) the estimated rate of coastal county population growth. The population growth rate was added to include a future demand indicator in the index.

All data were available from existing sources. Similar data should be available in many states. Specific sources for the data include the "Vessels Registered in Florida" census from the Florida Department of Natural Resources, Division of Law Enforcement, Office of Vessel Titling and Registration; the "Florida Resident and Tourist Outdoor Recreation Participation Survey" data (of 7000 residents and 9000 tourists) from the Florida Department of Natural Resources, Division of Recreation and Parks; the official "Florida Population and Demographic Forecast" data from the State Office of the Secretary of the Senate (FEC 1987); "Charter and Party Boat Vessel Canvas" data from the National Marine Fisheries Service; the Sport Fishing Institute's mailing list of Florida fishing associations available from the Sport Fishing Institute, Washington, DC, and the Florida Game and Freshwater Fish Commission "Florida Sportsmen and Conservation Clubs Directory" (which does include saltwater organizations). Data on other potential variables such as reef productivity, average number of trips to reefs, distance offshore, number of access points per county, etc. were either unavailable or too complex to incorporate in this basic index.

The data for the eight items in the index were arrayed by coastal county. Each variable was sorted by magnitude and the counties ordered from low to high value. Then, the ordered distribution of each variable was divided into quartiles with a score of 4 points being assigned to those counties in the top quartile, 3 points to those in the next quartile, and so on. The points for each county were summed across the eight variables to serve as an unweighted estimate of relative artificial reef recreational fishing demand for each coastal county (Table 1).

Whereas, the eight separate factors were weighted equally, four of the eight items were based on estimates of the number of private boat anglers or number of private boats. Therefore, the private boat access aspects of demand accounted for one-half of the index magnitude that is similar in effect to private boat factors receiving a heavier weighting than other items. This is appropriate since boat access is a crucial aspect of reef access. The sum of the scores was divided by the reef supply (i.e., number of permitted artificial reefs) offshore of each county to generate a relative need estimate (Table 2).

The eight demand variables are graphically portrayed for coastal counties in Figures 1 through 8. The index score or sum of item points is portrayed in Figure 9. This graphically depicts the relative location of offshore fishing demographic demand in the coastal counties of Florida based on 1985–1987 information.

The number of permitted artificial reefs adjacent to each county is illustrated in Figure 10. The relative need for artificial reefs in the offshore waters adjacent to each of Florida's 35 coastal counties was computed and portrayed graphically on a state map (Figure 11). Five counties with relatively low population and demand appeared near the top of the need list because there was no or little supply of reefs.[16] Since a demand numerator divided by zero supply is undefined, which results in an infinitely large need

Table 1
Quartile Ranking and Points Assigned for Eight Factors for Florida Coastal Counties

County	Resident Boat Anglers	Non-resident Boat Anglers	Tourist Boat Anglers	Non-boat Anglers	Pleasure Boats < 15 ft	Charter and Headboats	Saltwater Fishing Clubs	Population Growth Rate	Total Demand Points[a]
Bay	2	3	4	2	2	4	1	4	22
Brevard	4	4	3	4	4	2	3	4	28
Broward	4	3	4	4	4	4	4	2	29
Charlotte	3	3	3	2	3	3	1	4	22
Citrus	2	3	3	2	2	2	1	4	19
Collier	4	1	4	3	3	4	3	4	26
Dade	4	4	4	4	4	4	4	1	29
Dixie	1	2	1	1	1	1	1	3	11
Duval	3	2	2	3	4	3	4	3	24
Escambia	3	4	2	4	3	3	2	3	24
Flagler	1	1	1	1	2	1	1	4	12
Franklin	1	2	1	1	1	2	1	2	11
Gulf	1	1	1	2	1	1	1	2	10
Hernando	2	1	1	1	2	2	2	4	15
Hillsborough	4	4	3	4	4	1	3	3	26
Indian River	3	2	3	3	2	3	1	4	21
Jefferson	1	1	1	1	1	1	1	2	9
Lee	4	3	4	4	4	4	4	4	31
Levy	2	2	2	2	1	1	1	3	14
Manatee	2	4	3	3	3	3	1	3	22
Martin	4	4	2	4	3	4	4	3	28
Monroe	4	4	4	3	4	4	4	3	30
Nassau	3	2	2	2	2	3	1	4	19
Okaloosa	4	3	3	3	3	4	1	4	25
Palm Beach	4	3	4	4	4	4	4	4	31
Pasco	3	4	4	3	3	2	1	3	23
Pinellas	4	4	4	4	4	4	4	2	30
Santa Rosa	1	3	1	2	2	2	1	3	15
Sarasota	3	2	4	4	4	4	2	3	26
St. Johns	2	4	2	3	4	2	2	4	23
St. Lucie	4	1	3	2	2	3	2	4	21
Taylor	1	2	2	1	1	1	1	2	11
Volusia	3	4	4	4	3	3	4	3	28
Wakulla	1	2	2	1	1	2	1	4	14
Walton	2	1	1	1	1	1	2	3	12

Note. Numbers are quartile rankings of each county for each factor.
[a]Total Demand Points are the sum of the eight point scores.

index, an alternative adjusted ranking was created to give higher priority to counties with higher population" (Figure 12).

Starting with the offshore fishing demographic demand depiction (Figure 9), the areas of greatest demand are the southern peninsula from Martin County south through Palm Beach, Broward, Dade counties (Palm Beach, Ft. Lauderdale, Miami) and along the Gulf shore from Monroe through Collier and Lee counties (the Keys, Naples, and Cape Coral-Ft. Myers area). Pinellas, Hillsborough, Sarasota, Volusia, and Brevard Counties (Tampa-St. Petersburg, Sarasota, Melbourne, Daytona Beach, and Titusville) also experienced high demand.

In estimating relative need (demand estimates divided by existing reef supply), the

Table 2
Ratio of Demand Points to Number of Reefs, Relative Need for Reefs Raw and Adjusted

County	Demand pnts/ # of reefs raw	Demand pnts/ # of reefs adjusted*[a]
Indian River	21.0	21.0
Hernando	15.0	15.0
Levy	14.0	14.0
Hillsborough	13.0	13.0
Pasco	11.5	11.5
Lee	10.3	10.3
Citrus	9.5	9.5
Charlotte	7.3	7.3
Martin	7.0	7.0
Wakulla	7.0	7.0
Nassau	6.3	6.3
Brevard	4.7	4.7
Volusia	4.7	4.7
Broward	4.1	4.1
Santa Rosa	3.8	3.8
St. Lucie	3.5	3.5
Okaloosa	3.1	3.1
Palm Beach	3.1	3.1
Pinellas	3.0	3.0
Manatee	2.8	2.8
Collier	2.6	2.6
Escambia	2.4	2.4
St. Johns	2.3	2.3
Sarasota	2.2	2.2
Bay	2.0	2.0
Monroe	1.8	1.8
Dade	1.7	1.7
Duval	1.0	1.0
Flagler	24.0	[a]
Dixie	22.0	[a]
Jefferson	18.0	[a]
Taylor	11.0	[a]
Gulf	5.0	[a]
Walton	3.0	[a]
Franklin	1.0	[a]

[a]The seven counties with the lowest saltwater fishing demand were designated with a lower priority to give a higher ranking to those counties with greater fishing pressure.

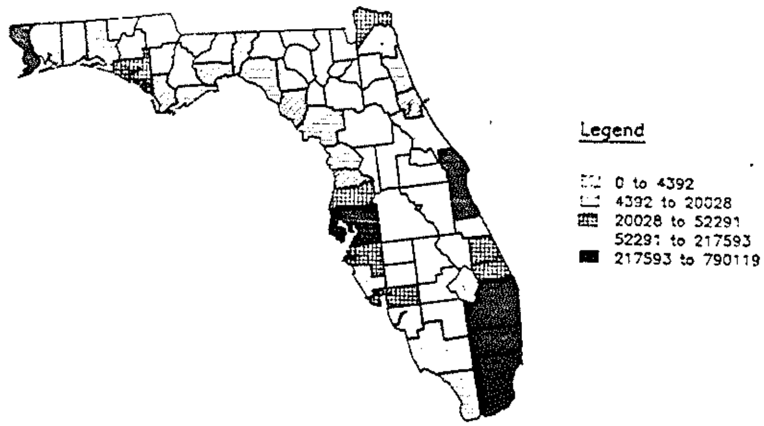

Figure 1. Number of resident saltwater boat anglers per Florida coastal county.

demand in the southern counties (Collier, Monroe, and Dade) is ameliorated somewhat and the areas of greatest relative need emerge along the central counties of both coasts (Figures 11 and 12). Indian River county on the Atlantic coast and Hernando, Hillsborough, Pasco, Citrus, Levy, Lee, and Charlotte counties on the central Gulf coast are the areas with the greatest demand relative to existing reef supply (i.e., relative need). Wakulla, Martin, Volusia, Brevard, Broward, Nassau, and Okaloosa counties also have a moderate degree of relative need though lower than those above. Figure 13 presents a map indicating 1990 estimated population for comparison with Figures 11 and 12.

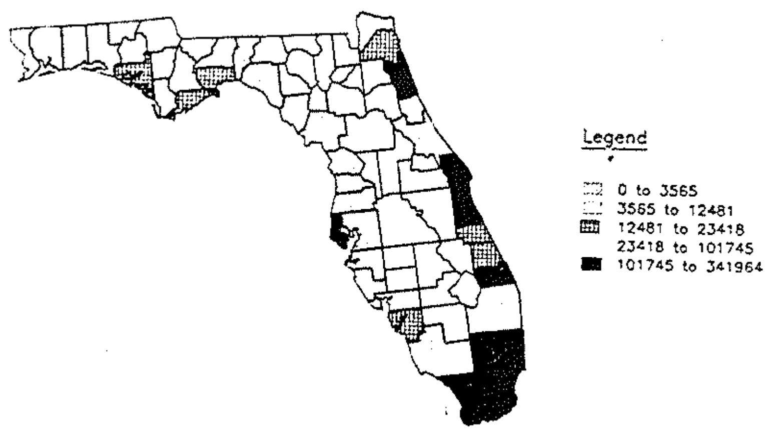

Figure 2. Number of in-state nonresident saltwater boat anglers per Florida coastal county.

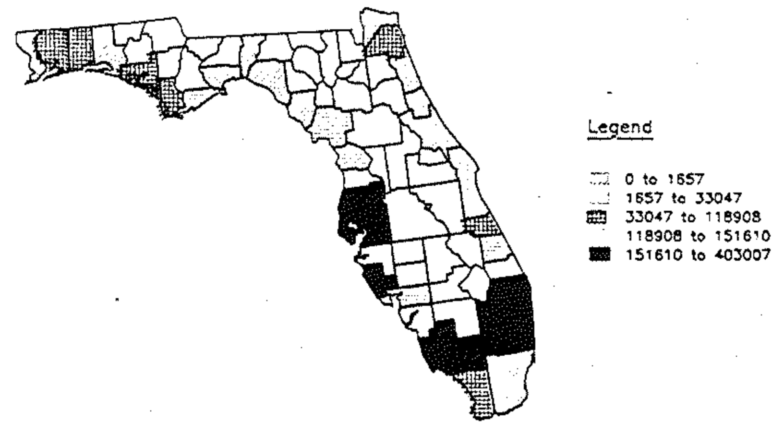

Figure 3. Number of out-of-state tourist saltwater boat anglers per Florida coastal county.

Conclusions

The procedure identified a relative priority of counties that have greater and lesser need for offshore reef fishing opportunities. The waters off of the identified counties constitute the priority zones for maximum relative recreational fishing demand where the placement of new reefs is likely to benefit the most number of anglers.[18] A similar need indicator could be utilized for the placement of piers (modifying the index by emphasizing land based anglers over boat angler). There are no "use standards" (Holland 1988b; Lancaster 1983) to estimate actual unmet demand. However, it is likely that additional reefs will be utilized if past behavior is an indication. To maximize reef utilization, a relative need estimate based on offshore fishing demand indicators is a useful tool for macro-planning of reef development. By comparing the adjusted ratio of demand points to reef supply graphic (Figure 12) with a map of estimated population (Figure 13), it is

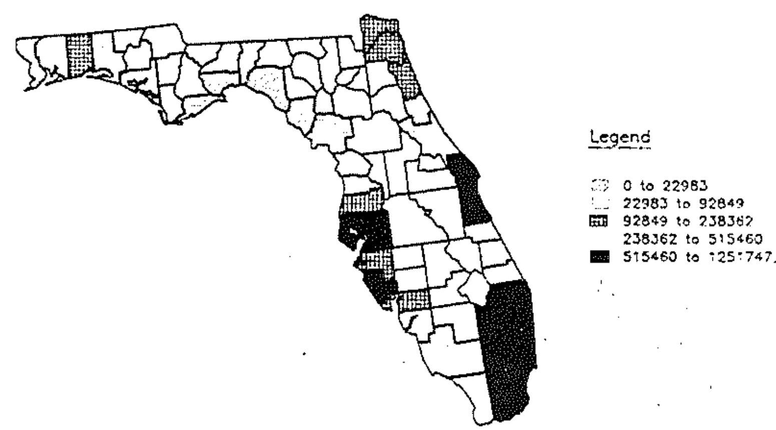

Figure 4. Number of non-boat saltwater anglers per Florida coastal county.

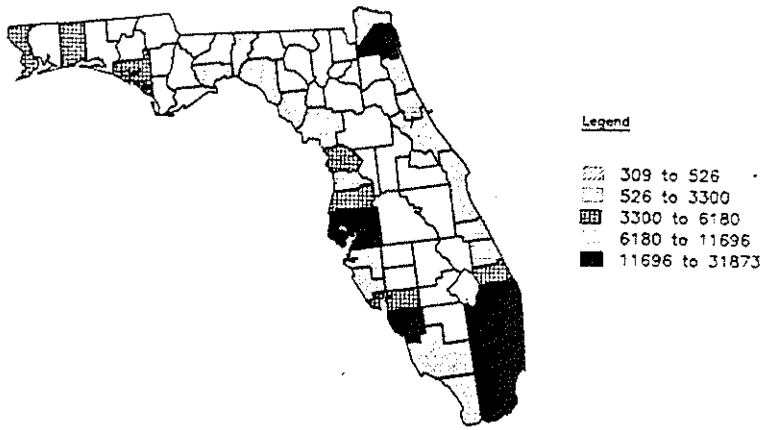

Figure 5. Number of registered recreational boats (>15 ft) per Florida coastal county.

apparent there are differences. A composite demand/supply index provides information for fishery or coastal managers that is based on proven offshore fishing demographic demand variables that leads to conclusions disparate with simple population demand projections.

The approach utilized here is intended as a first step in understanding demographic demand for artificial reefs. Policy makers should understand it as such and utilize additional social information in making siting decisions. In future refinements of this approach, weighted indexes could be developed based on theoretical or empirical justifications.[19] It also appears that the number of nonboat anglers is highly correlated with the number of charter and headboats and thus contains redundant information. Significant overlap of information among variables diminishes the usefulness and additivity of these items and redundant items should be excluded. Other variables such as number of non-

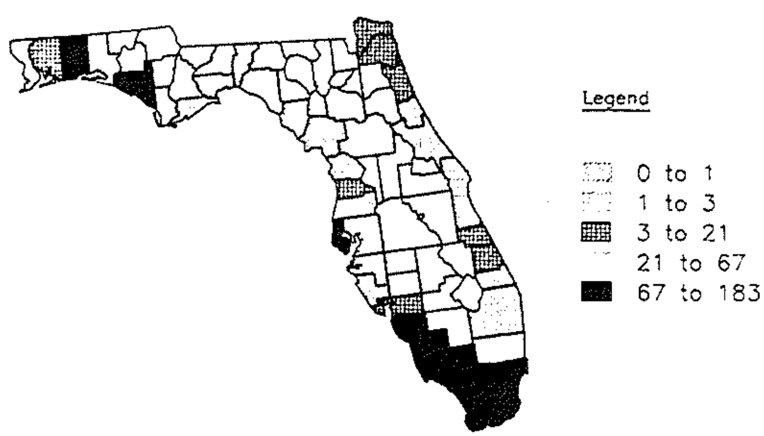

Figure 6. Number of charter and party boats per Florida coastal county.

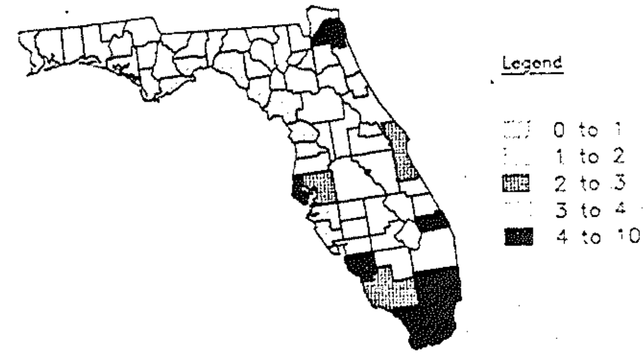

Figure 7. Number of saltwater fishing associations per Florida coastal county.

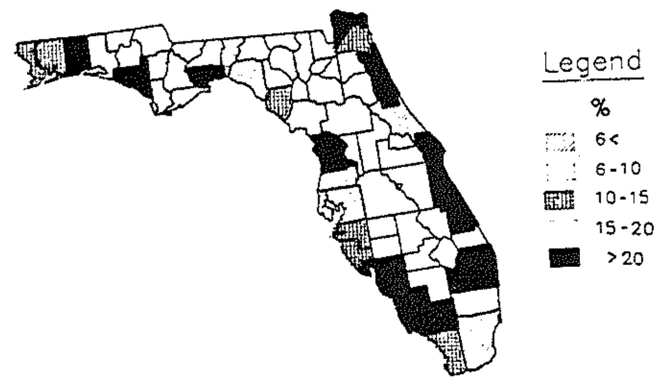

Figure 8. Estimated rate of 1985–1990 population growth per Florida coastal county.

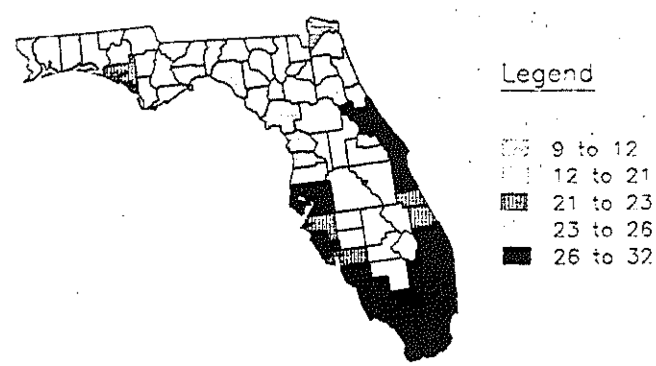

Figure 9. Total of demand index points per Florida coastal county.

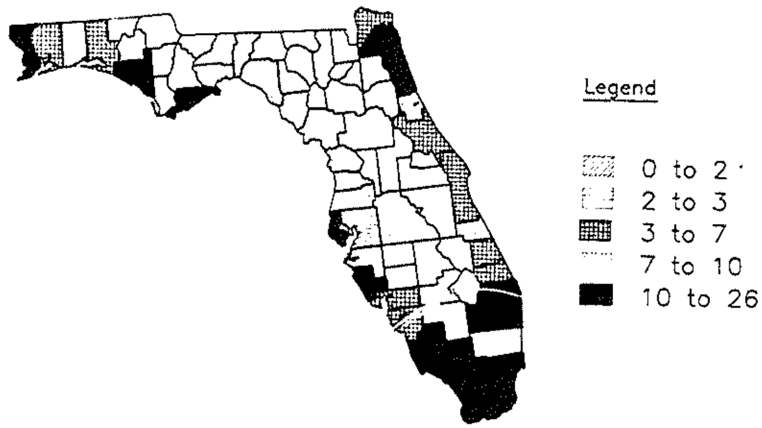

Figure 10. Number of permitted saltwater artificial reefs per Florida coastal county.

storm or high seas days, boat ramps, marinas, highway access points, distance from shore, reef productivity, or variation in targeted species could be included in index computations. For example, relative productivity of reefs by county could be used to adjust the number of permitted artificial reefs by county. Another demand item that could be included is the number of fishing trips taken from different ports (counties) of origin. The number of trips made to respective reef sites could also be an indication of demand.

It should be remembered that the inclusion of estimated demand or relative need information does not totally meet the requirement for the inclusion of social information in artificial reef planning.[20] Issues of access (shoreline and marine), economics, and

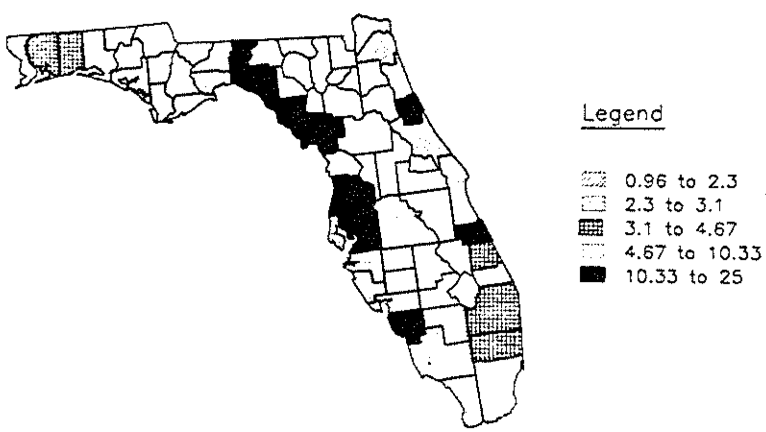

Figure 11. Ratio of demand index point totals to number of permitted saltwater artificial reefs per Florida coastal county.

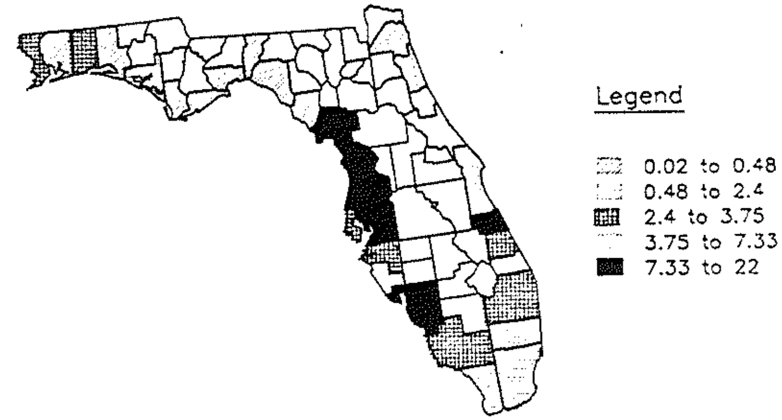

Figure 12. Adjusted ratio of demand index point totals to number of permitted saltwater artificial reefs per Florida coastal county (7 counties with lowest demand adjusted to lower priority).

equity concerns (i.e., who will benefit from an expenditure of public monies)[21] are also important components of understanding the social dynamics of artificial reef utilization.

Finally, although the direction of this article has been to focus on indicators and estimates to enhance allocation of artificial reef developments, concerns about overfishing of aggregated stocks leave open the possibility of using this same approach with the reverse goal of placing artificial reefs or fishery reserves/sanctuaries (Green 1985; NMFS 1990) in areas of minimum demand or need as identified through this approach.[22]

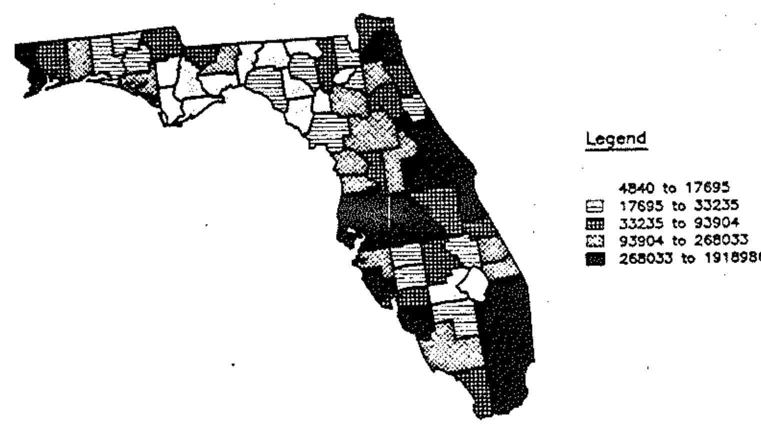

Figure 13. Estimated population (1990) per Florida county.

Acknowledgments

The author acknowledges the constructive comments and suggestions of Dr. Robert Ditton, Mr. Don Pybas, and the anonymous reviewers who all substantially improved the paper with their input.

Notes

1. For example, the Reef Fish Fishery Management Plan Amendment (Gulf of Mexico FMC 1983) estimates that annual harvest of Red Snapper has declined from about 15 million pounds in 1981, 1982, and 1983 to 4.7 million pounds in 1987 and 5.9 million pounds in 1988. The Coastal Pelagic Fishery Management Plan Amendment 3 report indicates that landings of Florida East Coast King Mackerel declined from 2.6 million pounds to 836,000 pounds in 1987. The Redfish Fishery Management Plan reports that Gulf of Mexico Landings declined from 4.1 million pounds to 2.3 million pounds between 1979 and 1985. Some of this decline is due to management actions but the general trend is also indicative of declining stocks. See Brown and Parrock 1985; Conser 1985; Goodyear and Phares 1990.

2. Results from the Marine Recreational Fishery Statistics Survey (NMFS 1985) indicates that the number of fishing trips by private or rental boat anglers increased from 6,150,000 (Gulf) or 4,997,000 (South Atlantic) in 1982 to 7,943,000 (Gulf) and 5,899,000 (South Atlantic) in 1986, increases of 29% and 18% respectively in four years. The Florida Outdoor Recreation Demand Survey (Florida DNR 1989) indicates that the percentage of residents utilizing salt water boat ramps increased from 9% to 15% between 1985 and 1989.

3. The first International Conference on Artificial Reefs was held in March 1974 in College Station, TX. A second national conference was held in Daytona Beach, Florida in September 1979. Of the 198 citations in Bohnsack and Sutherland (1985) only 34 (17%) are pre-1970 (with many of these based on freshwater reefs), while 81 (41%) were published in 1970–1979. The first Artificial Reef Development Center was established by the Sport Fishing Institute in 1983 to promote planning of reefs. The National Fishing Enhancement Act (P.L. 98–623, Title II), the first congressional act to focus on artificial reefs, was passed by Congress in 1984. An Artificial Reef Plan Development Workshop was convened in February 1985 at Vicksburg, MS.

4. Section 204 of the National Fishing Enhancement Act (P.L. 98-623) specifies that ". . . the Secretary of Commerce . . . shall develop and publish a long term plan (that) *must include*-geographic, hydrographic, geologic, biological, ecological, *social*, economic and other criteria for siting artificial reefs . . ." (emphasis added). Section IIIA1a of the National Artificial Reef Plan (U.S. DOC 1985) guidelines states "Prospective reef builders should understand the nature and extent of recreational fishing in the area. . . . Particular attention should be given to assessing the relative importance of, *and demand for*, shore-based and boat-based fishing activity, . . . target species . . . shoreline access points (e.g. ramps, piers, marinas, bridges, charterboats, headboats) . . ." (emphasis added). Section IIIA2 states ". . . artificial reef development should be in geographic areas of *greatest user need, demand, and constituency support*. . . . Poorly sited reefs often do not produce desired social and economic benefits and may preclude reef developers from securing future artificial reef funding commitments from government and private sponsors" (emphasis added).

5. Basic concepts on which the plan is based include: "Reefs are for people; most of the time for recreational fishermen. It is imperative that artificial reefs be sited where they will be used by a diversity of fishermen. . . . Artificial reef development is an interdisciplinary effort. . . . Artificial reef development needs to be planned from the outset. . . . Previous artificial reef guides have focused largely on how to build artificial reefs. In too many instances, it is simply assumed that reefs are in the public interest. These matters need to be addressed directly by reef development committees. . . . Artificial reef development will not generally be successful without constituency support."

6. Quoting from a newspaper account of the decision of the South Atlantic Fishery Management Council not to ban commercial fish traps from an artificial reef off of Key Biscayne, "Greg McIntosh of Fort Lauderdale who voted in favor of the special management zone, said wider planning is needed to protect the reef. 'Dade County is paying the price for the failure of the state to have a comprehensive artificial reef policy and program,' McIntosh said. 'There needs to be a statewide reef plan rather than these parochial attempts.' Conner Davis of Tallahassee, executive director of the Florida Marine Fisheries Commission, acknowledged that the state has no comprehensive artificial reef plan. 'It's a subject we will probably deal with before long,' he said."

7. To receive a permit, a Dredge and Fill Permit application must be approved by the DER (state waters) or Corps of Engineers (federal waters) and a consent of use approval form attained from the Department of Natural Resources (DNR) (state waters only) to secure permission to use publicly owned state (submerged) land.

8. Founded in 1950 through the Dingell-Johnson Act, the Federal Aid in Sport Fish Restoration Program was amended and expanded through the Wallop-Breaux Amendment to the Act in 1984. The Wallop-Breaux Amendment established a trust fund that more than quadrupled the amount of money going back to the states for sport fish restoration projects. The funds were increased by taxing a greater array of sport fishing equipment and by capturing existing motorboat fuel taxes and import duties on tackle and boats. The fund has two accounts, a sport fish restoration account and a boat safety account. Monies from the sport fish restoration account are available to carry out the purposes of the Dingell-Johnson Act. It is under this authority that monies are eligible for artificial reef planning, development, and deployment. Disbursed monies to the states have totaled about $100 million dollars a year in recent years (Source: *Sport Fishing Institute Bulletin* 1990).

9. These "pirate reefs" are a negative aspect of artificial reef development. These are illegal, unpermitted reefs that are in the public water column but are "hidden" for private use. These reefs are not part of the planning process proposed in this article.

10. As recounted in Gordon and Ditton (1986, 385), the state of South Carolina has faced a jurisdictional conflict (also see Phillips 1989) in the use of artificial reefs. The executive director of the South Atlantic Fisheries Council received a letter from the Director of South Carolina's Marine Resources Division pointing out the benefits derived from recreational sport fishermen. The letter questioned whether the economic benefits derived from commercial use of the reefs as compared to recreational use would justify reef maintenance costs. The South Carolina Marine Resources Division Director then requested, on behalf of the state, that the South Atlantic Fisheries Management Council declare these reefs as special management zones to be used exclusively by recreational fishermen. The National Marine Fisheries Service then designated 19 artificial reefs off of Georgia and South Carolina as special management zones where only hand-held hook and line gear can be used and fishtraps, longlines, gillnets and trawls are prohibited (NMFS-SERO NR86-36). See note 6 for a similar example of conflict in Florida. Also see Marine Recreational Fisheries 7 published by the Sport Fishing Institute, Washington DC; the entire volume (180 pp.) is a set of collected articles on Conflicts with Marine Fishery Resources.

11. This is based on surveys of 8850 auto and airport tourists at 13 intercept locations in Florida (Florida Division of Tourism 1985).

12. No site in Florida is more than 100 mi from the coast.

13. In addition to boat anglers, 37% of observations of fishing occurring on or near Louisiana offshore oil platforms was initiated by personnel stationed on the platform (Ditton and Auyong 1984). These personnel can be ferried to the site by helicoptor or crewboat. In those regions where significant residential platform populations exist, this use may need to be factored in. This is not the case in Florida.

14. In Miami, the Dade Sportfishing Council has been very active in generating local support, promoting, and publicizing artificial reefs. The Florida Keys has an association named the Florida Keys Artificial Reef Association that has assisted in the establishment of local reefs. The Organization for Artificial Reefs in Tallahassee is a private organization of fishermen that has supported artificial reef development. Finally, the Jacksonville Offshore Sportfishing Club states

on their business card and advertising, right under their club logo, "Pioneers in Artificial Reef Building." Also see Aska (1984).

15. Demand is used in this article in a noneconomic sense, as a relative measure of the use pressure that the public's desire or intention to participate in using artificial reefs places upon that resource. There is no attempt to introduce pricing dynamics into this article. Recreation demand is a phrase commonly used to express a volume of outdoor recreation activity likely to arise from a specified population and is often used in estimating the facilities that may be needed to satisfy the recreational pursuits of that population. See Lancaster (1983), Florida DNR (1989), or U.S. DOI (1975).

16. Flagler, Dixie, and Jefferson counties had 0 permitted artificial reefs; Taylor and Gulf counties 1, Walton 4, and Franklin County 11 artificial reefs. In addition, these seven counties ranked in the lowest quartile (with total demand points between 9 and 15 in a distribution that ranged from 9 to 31 points) of demand scores (see Table 1, last column).

17. The seven counties (lowest 20%) with the lowest saltwater fishing demand score were forced to the bottom of the relative need list as an adjustment (Figure 12) to facilitate more efficient utilization of artificial reef resources by favoring counties with greater demand and greater potential use of future reef. If policy makers do not agree with this adjustment, the original ranking is also available in Table 2 and Figure 11.

18. When utilizing public natural resources and tax revenues, an equity issue of providing for the public interest often practically translates into providing the greatest good for the greatest number. See Ditton et al. (1978b); Clawson and Knetsch (1966), especially sections on public provision and public benefit (265–272); and, Crompton and Lamb (1986), especially Chapter 7, Allocation Decisions: The Equity Issue (149–175).

19. For example, given more information, the magnitude ratio of the number of offshore anglers on private boats to offshore anglers on charter and headboats might allow a weighting different from that used in this article to actually reflect the relative impact attributable to these two sources. Given the increasing trend toward constituency politics (Matlock 1982; Matlock et al. 1988), factors such as population growth rate might be weighted less and an indicator of political activism by local anglers weighted more in more situations. Another issue, might be the inclusion of driving distance and gasoline prices (Ellis 1989) from major noncoastal cities, more important factors for states other than Florida.

20. See note 4.

21. See note 18.

22. The concept of marine sanctuaries, parks, and reserves essentially parallels the development of similar resource protection strategies on terrestrial resources. It is interesting to note that there is about 100-year delay between the first national parks on land and the first marine park/preserves. There are 15 national marine sanctuaries and five underwater parks in U.S. coastal waters with an accelerating trend toward creating more. The arguments for both kinds of reserves are similar, e.g., preserving wildlife, maintaining ecosystem balance, perpetuating gene pools for promoting genetic diversity, preserving scenic areas for appreciative recreation, conserving resources for future generations, etc.

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Coastal Management, Volume 19, pp. 239-252
Printed in the UK.

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ROBERT G. PATER
Center for Urban and R
University of North Car
Chapel Hill, NC 27599-

RAYMOND J. BUR
Department of City and
University of North Car
Chapel Hill, NC 27599-

ARTHUR C. NELS
City Planning Program
Georgia Institute of Tech
Atlanta, GA 30332

Abstract *Local waste
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