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The Economic Effects of a Five Year Nourishment Program for the Ocean Beaches of Delaware

Work Order No. 873726

Final Report

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CONTENTS

LIST OF EXHIBITS

Exhibit **Page**

CHAPTER 1: INTRODUCTION AND SUMMARY

This research effort was designed for Delaware's Department of Natural Resourees and Environmental Control (DNREC) to provide the State with information on the economic effects that are associated with beach nourishment. In DNREC's ongoing shoreline management efforts, the State devotes resources to the maintenancc of Delaware's ocean beaches. In order to provide accountability for the resources utilized in beach maintenance, the State funded this research effort to provide a basis for understanding the benefits of beach nourishment.

Since 1988, DNREC has been managing the ocean shoreline of Delaware through nourishment efforts. The nourishment efforts havc been sufficient to maintain beach widths in all communities and tourism revenues, real estate values, and recreational use have all flourished during this period. The cost of nourishment has been shared by the federal and local governments, and the annual cost of nourishment funded by the State has been under $2 million. Residents, business owners, property owners and visitors alike have come to rely on nourishment to maintain the State's beaches and their expectations are reflected in dccisions to purchase property, make business investments and plan vacations at the State's ocean beaches. While Delaware's thriving coastal communities clearly demonstrate the positive value of nourishment, this research begins the process of examining and measuring the economic benefits of nourishment, and identifying the economic beneficiaries of nourishment activities.

To define the economic value of beach nourishment, economic benefits and economic activity are estimated for two scenarios: the <u>baseline</u> scenario, a continuation of Statewide nourishment that maintains the existing shoreline; and the <u>without nourishment</u> scenario, wherein the shoreline is allowed to diminish according to the expected annual erosion rate over the next five years. Economic benefits of nourishment are dollars that would be lost to the economy in the absence of nourishment. If fewer people visit the beaches, the economy loses the recreational value (in excess of costs) of those visits, measured as consumers' surplus. If property values fall because of narrower beaches, the economy loses the reduction in value of the housing stock. Losses in economic activity, as defined herein, are those losses that are transferred to other areas as the Delaware beaches become less desirable. Thus, if fewer tourists visit thc beaches, restaurant, lodging and retail receipts in the area will drop. However, since the visitors who do not come to Delaware beaches will spend those dollars elsewhere, the loss in revenues is referred to as a decline in economic activity in the beach area (that will be offset by an increase in economic activity elsewhere). The difference in the level of economic benefits and activity five years hence with and without nourishment are the economic effects of nourishment activity.

As competition for Statc funding is intense, the State must consider how to finance continued beach nourishment. The most desirable cost allocation will reflect the incidence and magnitude of local, regional and statewide economic benefits and as well as the economic gains from the stimulation of economic activity within Delaware vis a vie other states. To aid the State in cost allocation decisions, the geographic distribution of those impacted by nourishment, including visitors, property owners, business owners and employees is considered.

ECONOMIC BENEFITS AND CHANGES IN ECONOMIC ACTIVITY

The economic benefits of beach nourishment can be thought of as the avoidance of economic losses that will occur without nourishment. Two major categories of economic benefits were measured and correlated with beach nourishment: the **consumers' surplus** for the recreation value of the beach (the actual visit and the value of future maintenance) and the component of **housing prices** that is influenced by beach width. The loss in consumers' surplus associated with beach width is measured by the loss in the consumers' surplus for visitors who may cease to visit Delaware if the beach size is reduced. The loss in consumers' surplus for each visitor was measured based on the willingness-to-pay of visitors for both daily recreational use and long-term existence value[1]. The total loss in consumers' surplus is measured by the consumers' surplus of visitors who are 'squeezed out' as the beach becomes narrower and congestion is held constant.[2] A set of behavioral assumptions define the timing of the loss as visitors react to the narrower beaches.

The loss in property value is the decrease in the value of the housing stock associated with a narrower beach area. This decrease is assumed to start in the second year of a no-nourishment policy, wherein the effects of one year without nourishment will be evidenced (though the evidence, within the backdrop of usual seasonal variations, may be slight) and more importantly, the market will react to the knowledge that future nourishment is not forthcoming. As part of this study, a hedonic model was developed to estimate the effect of beach width on residential property values along the Delaware ocean shoreline. The model results were translated into price effects per foot of beach width lost and used to calculate the reduced value of the housing inventory with each year's erosion loss.

Other losses to the State associated with a diminished shoreline include lost revenues from tourists who chose not to return to Delaware beaches. The loss in tourist purchases will reduce business profits, result in fewer jobs and decrease state and local taxes and fees that are linked to tourist spending. Though the reduction in property values would, in most U.S. regions, result in a reduction in property taxes, the algorithm used to levy property taxes in Sussex County is not sensitive to market fluctuations in price. Note that losses of tourism revenues, taxes, and local wages are

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[1]Based upon the results of a survey undertaken by Falk et. al and reported in "Recreational Benefits of Delaware's Public Beaches: Attitudes and Perceptions of Beach Users and Residents of the Mid-Atlantic Region", for DNREC.

[2]Another approach would be to measure the reduction in recreation value if the number of visitors is held constant and beaches are allowed to become more crowded. A lack of empirical measures of the correlation of recreation value to beach width precluded this approach. The actual result of a cessation of nourishment is likely to be a combination of the two occurrences, i.e., the beach will become more crowded and some visitors will not return because of the increased congestion.

economic transfers, in many cases to other states, as the monies previously spent on vacations in Delaware will be spent elsewhere.

SUMMARY OF FINDINGS

The research effort provides information on the economic benefits and activities, as well as the beneficiaries, associated with Delaware's ocean beaches. The findings indicate:

1996 Baseline Scenario, as shown in Exhibit 1-1:

1. An estimated 21,335 people live in the Delaware beach communities and neighboring areas.

2. An estimated 202,069 additional Delaware residents live within day-use traveling distance.

3. An estimated 171,718 Maryland residents live within day-use traveling distance.

4. There are an estimated 14,561 housing units in the beach communities, valued at $3.5 billion.

5. There are an estimated 5.1 million person trips to the Delaware beaches each year and the consumers' surplus for these visitors exceeds $380 million.

6. Visitors spend more than $573 million in beach trip-related expenditures each year.

7. Trip-related expenditures create jobs, profits and state and local receipts within the beach communities and the State.

8. The average annual erosion rate in the beach eommunities varies from 2 to 4 feet per year.

9. Current policies provide beach nourishment to the ocean beaches at a cost of approximately $1.8 million per year, thereby mitigating the effects of long term erosion and sustaining the ability to attract and accommodate beach visitors. The State plays the lead role in nourishment activities.

EXHIBIT 1-1	
BASELINE INFORMATION, DELAWARE OCEAN BEACHES	
POPULATION	
RESIDENT BEACH POPULATION:	21,335
OTHER DELAWARE RESIDENTS, WITHIN DAY-USE DISTANCE	185,725
DELAWARE POPULATION	666,168
SUSSEX COUNTY	113,229
KENT COUNTY	110,993
NEW CASTLE COUNTY	441,946
MARYLAND RESIDENTS, WITHIN DAY-USE DISTANCE	157,829
HOUSING	
HOUSING UNITS	14,561
PROPERTY VALUE	$3,350,154,922
TOURISM (ANNUAL)	
VISITORS (excludes day visitors travelling less than 50 miles)	5,096,908
VISITOR EXPENDITURES AT THE BEACH	$573,222,171
CONSUMER'S SURPLUS, BEACH VISITORS	$381,763,326
EROSION (ANNUAL)	
AVERAGE ANNUAL EROSION RATE	2-4 Feet
ON-GOING SHORELINE MAINTENANCE	300,000 cu.yds.
NET LONG-TERM EROSION	0

No Nourishment Scenario as shown in Exhibit 1-2:

1. Without ongoing nourishment efforts, the ocean beaches in Delaware can be expected to erode at the rate of 2 to 4 feet per year.

2. A reduction in the size of the beaches will reduce the holding capacity of the beaches, most notably during peak use periods.

3. Beach visitors will find future beach conditions more crowded, and some visitors will choose to vacation elsewhere during the peak season.

4. The economic effects of the reduction in beach size can be estimated, using a number of assumptions, based on the reduced holding capacity of heavily-used public beach areas along the shoreline. In this report, beach congestion is held constant (after allowing for one year of on-site mitigation by changing vacation dates and locations) at heavily-used beaches so that as the beach width narrows, visitors are reduced accordingly.

5. In a five year period of analysis without beach nourishment, property values begin to decrease in year two, when the first year of erosion is not mitigated by nourishment.

6. For the five year period, the following economic losses are predicted without nourishment:

-More than 268,000 visitors will chose other vacation locations.

-More than $20.1 million of consumer's surplus (a quantification of the value of beach visits to visitors) will be lost for those who no longer vacation on Delaware's beaches.

-Tourist related revenues will decrease by more than $30.2 million. This reduction in revenues will cause the loss of 625 beach area jobs, reduce wages and salaries by $11.5 million, profits by $1.6 million, and state and local revenues by $2.3 million.

-Beach area properties will drop nearly $43.3 million in value.

-The state will have avoided $9 million in costs for nourishment.

EXHIBIT 1-2

FIVE YEAR ECONOMIC LOSSES WITHOUT NOURISHMENT

POPULATION	
NO ESTIMATED REDUCTION	---
HOUSING	
HOUSING UNITS (NO ESTIMATED REDUCTION)	---
LOSS IN PROPERTY VALUE TO EXISTING HOUSING STOCK	$43,330,541
TOURISM	
REDUCTION IN VISITORS (excludes day visitors travelling less than 50 miles)	268,537
REDUCTION IN VISITOR EXPENDITURES AT THE BEACH	$30,200,904
REDUCTION IN CONSUMER'S SURPLUS, BEACH VISITORS	$20,113,663
REDUCTION IN LOCAL BUSINESS PROFITS	$1,556,246
JOBS AND WAGES & SALARIES	
REDUCTION IN THE NUMBER OF JOBS	625
REDUCTION IN WAGES AND SALARIES	$11,534,621
STATE GOVERNMENT	
REDUCTION IN PERSONAL INCOME TAX RECEIPTS	$210,052
REDUCTION IN OCCUPANCY TAX RECEIPTS	$15,750
REDUCTION IN CORPORATE INC. TAX RECEIPTS	$135,393
REDUCTION IN GROSS RECEIPTS TAX	$1,631,166
LOCAL GOVERNMENT	
REDUCTION IN PARKING RECEIPTS	$291,888
EROSION	
AVERAGE ANNUAL EROSION RATE	2-4 Ft/Yr
ON-GOING SHORELINE MAINTENANCE	NONE
NET LONG-TERM EROSION	8-16 Feet

Geographic Distribution of Economic Effects

Most of the benefits of shoreline nourishment accrue to those outside of Delaware because most of the visitors and property owners reside in other states. The following benefits for five years of nourishment are allocated to those who reside in Delaware:

1. $17.3 million in property value, distributed by county as follows:
   - -Kent $1.0 million
   - -New Castle $4.4 million
   - -Sussex $11.9 million

2. $1.7 million in consumers' surplus for visitors traveling more than 50 miles or remaining overnight.

2. 250 jobs

3. $4.6 million in wages and salaries

4. $622,782 in business profits

5. $2 million in State receipts for Income, Occupancy and Gross Receipts Tax

6. $300,000 in local revenue for parking fees.

7. Extrapolating recent annual nourishment costs, state and local expenditures for beach nourishment will be $6.7 million and $0.9 million, respectively.

Limitations

1. The measure of visitors and consumer's surplus exclude visitors who live outside the beach communities but within 50 travel miles and visit the beaches without spending the night.

The number of beach visitors was measured based on survey information from the United States Travel Data Center's TravelScope series. These data include only those visitors who travel more than 50 miles or remain overnight in the area. No corresponding measures are available for visitors who travel less than 50 miles and do not remain overnight. Thus, the number of visitors does not reflect these local visits and the measures of consumer's surplus with nourishment do not include values for local beach visits. Note that estimates of beach visits by residents of the beach communities were possible, though values of consumer's surplus for these resident beach visits were not. The lack of data for local day visitors did not affect the estimation of loss of consumer's surplus because in the five year period of analysis the loss is expected to result from visitors who travel further and spend more thereby having a wider range of choices available. In a longer time frame without nourishment, at some point all those who visit the beaeh would be impacted by erosion.

2. Actual behavioral responses may vary from assumed hehavioral responses.

The loss in consumer's surplus measured herein is based upon the assumption that with a reduction in beach width visitors will select other activities over a visit to Delaware beaches (not visit the beach) up to the point that congestion remains at approximately the same level evideneed in 1995. If instead visitors return to the beaches in the same numbers as in 1995, thereby increasing the congestion on the public beaches, the consumer's surplus for each beach visitor would be expected to deerease, though no estimates of the decrease based on higher levels of congestion are available. However, if the decrease is linear, i.e., the consumer's surplus for those visiting the beach deereases in aeeord with the decrease in beach size, the estimate of the loss in consumer's surplus would be the same as presented herein, though the incidence of the loss in consumer's surplus would change.

CHAPTER 2: THE RESEARCH FRAMEWORK

The research framework consists of the baseline (on-going nourishment) in comparison to five years without nourishment, wherein the beach narrows by the average annual erosion rate beginning in year two. The baseline represents the status quo, a continuation of shoreline maintenance that has been on-going since the 1980's. With nourishment, the baseline level of economic benefits and activity, as estimated in 1996 dollars, is sustained in year two through year five. Without nourishment, the shoreline narrows beginning in year two and the economic effects of no nourishment affect first property values and then the number of visitors over the five year period.

The next sections below describe the **Shoreline Condition, Economic Benefits**, and **Economic Activity** in each scenario. The **Cost of Nourishment** is included as the last section of this Chapter. The difference in the level of benefits and economic activity between the baseline and the without nourishment scenario represent those that may be attributed to beach nourishment.

SHORELINE CONDITION

The baseline condition is described, by reach, according to 1992 aerial photography in combination with site visits. As shown in Exhibit 2-1, seven reaches of shoreline were divided into twenty-four subreaches to reflect shoreline erosion characteristics in combination with economic development and political boundaries. Analysis of historic shoreline changes along Delaware's ocean coast were carried out as part of a Coastal Vulnerability and Mapping Study (Dewberry & Davis, 1997). The long-term average annual shoreline recession rates calculated during that study were used in the economic analyses described herein. The future condition with a project is based on long term erosion rates in combination with expected levels of nourishment over the next five years. It should be noted that short-term shoreline recession rates can sometimes be substantially greater or less than the average long-term rates shown in Exhibit 2-1, depending upon the frequency and intensity of storms affecting the coast. However, for the purposes of estimating economic aspects of beach use and shoreline management, use of average rates is appropriate. To correlate the beach condition to levels of economic benefit and economic activity, the shoreline condition in the base year is characterized further by several parameters that reflect the width of beach with respect to the erosion reference feature (ERF), herein defined as the ocean edge of the vegetation line or the base of the dune where a dune is present but vegetation is lacking. In some cases the ERF goes through structures, where the structures were built on what was previously the dune line. In some cases the ERF is landward of houses, i.e., the houses were constructed on the ocean side of the existing or previous dune line. Separate measurements also were made to examine the width from the building line. Appendix B provides the measurements by station that characterize the shoreline.

Exhibit 2-1: Shoreline Recession Rates Used in Economic Analyses				
Reach	**Length (ft)**	**Sub-Reach**	**Length (ft)**	**Long-Term Shoreline Recession Rate (ft/yr)**
1. Fenwick Island	20,900	Unincorporated Fenwick	1,900	4.0
		Incorporated Fenwick	4,000	4.0
		Fenwick Island State Park	3,600	4.0
		Fenwick Acres	600	4.0
		Uninc. Sussex County	2,800	4.0
		Fenwick Island State Park	6,600	4.0
		York Beach	1,400	4.0
2. South Bethany	6,000	South Bethany	3,600	4.0
		South Bethany, N.	500	4.0
		Middlesex	1,900	4.0
3. Sea Colony Unit	2,300	Sea Colony	2,300	4.0
4. Bethany Beach	5,100	Bethany Beach	5,100	4.0
5. North Bethany	22,500	Uninc. Sussex County	16,200	3.0
		Delaware Seashore St. Park	6,300	2.0
Indian River Inlet				
6. Dewey Beach	35,100	Delaware Seashore St. Park	26,900	2.5
		Indian/N. Indian Beach	2,500	2.5
		Dewey Beach	5,700	2.0
		Silver Lake	1,000	1.5
7. Rehoboth Unit	11,500	Rehoboth (S residential)	2,400	1.5
		Rehoboth (commercial)	3,800	2.0
		Rehoboth (Surf Avenue)	1,900	2.5
		Henlopen Acres	1,300	3.5
		North Shores	2,100	4.0

Economic Benefits: Economic benefit categories include the shoreline condition's contribution to land value and the consumers' surplus associated with recreation (willingness to pay). The contribution to land value is estimated using a hedonic approach. The model correlates property values with the condition of beaches (using the parameters described above), by reach. The model results indicate a reduction in property value per foot of reduction in beach width. The reduction in consumers' surplus measuring the recreation value of the beach is estimated based on a reduction of visitors due to narrow beach widths in already congested public beach areas.

BEHAVIORAL ASSUMPTIONS

To predict the effect of narrower beaches on Delaware's economy, it is neeessary to speculate how visitors will react to increasingly narrower beaches. The economic benefit, consumers' surplus, measures the recreation/aesthetic value of the beach as revealed by beach visitors. Tourists pay a myriad of costs to come to the beach, for transportation, lodging, food, recreation, sundry purchases, etc. but research indicates that they receive a level of enjoyment that exceeds the costs paid, measured as consumer's surplus. The consumer's surplus is linked to the condition of the beach, though empirical measures of the link to beach condition are not available.

In the second year after a no-nourishment policy is in place, the public beach areas along the Delaware shoreline will be two - four feet narrower. As the beach narrows, visitors will first attempt to mitigate crowding by spreading out beach use over areas which may be less crowded and selecting vacation days that are less popular. It is assumed that changes in on-site visitor behavior can mitigate the erosion evidenced in year two. In years three through five, the decrease in consumers' surplus was estimated based on a theory of constant congestion. Accordingly, it is assumed that visitors will choose other activities (not vacation at Delaware beaches) up to the point that the overcrowding (induced by erosion) is mitigated. Thus, in the without nourishment scenario, the level of each individual's consumer's surplus is held constant while the total level of consumers' surplus is reduced by a reduction in the number of visitors. The consumer's surplus in this study was measured according to two additive components, the amount consumers are willing to pay (in addition to those expenses already incurred by visiting the beach) for a day at the beach and the amount consumers are willing to contribute annually to an ongoing beach maintenance program that will maintain the beach for future generations. For more information on the calculation of consumer's surplus, refer to Chapter 3.

ECONOMIC ACTIVITY

Tourist spending results in revenues to local businesses, associated employment and indirect activity (stimulated by the purchases of inputs to the goods and services sold). The direct economic activity levels of interest are those which result from tourist expenditures, those caused by tourist visits and expenditures to attract tourist business. Economic activity includes traditional categories of expenditures by tourists, costs to maintain tourist areas (lifeguards, public and private beach infrastructure such as boardwalks, piers, parking lots and bathhouses) and monies spent by businesses to attract tourists to their location (advertisement via radio, television, skywriting, billboards, newspapers, etc.) This economic activity may be reduced with a reduction in the number of visitors. Within the five-year period analyzed herein, the reduction in visitors is not expected to reduce related beach maintenance or area advertising costs.

Losses in expenditures mean losses in total revenue to businesses. These losses translate into a reduced work force, reduced purchases of nonlabor inputs, and reduced profits. In addition to direct expenditures, indirect losses will result from the reduction in purchases of inputs (labor and materials). Indirect losses are based on ratios developed for Delaware in 1990.[3] State tax revenues from income taxes also decrease according to the loss of jobs by Delaware residents. Other State revenues are lost in proportion to the loss in visitor expenditures. Further information on losses in economic activity are provided in Chapter 5.

THE COST OF NOURISHMENT

Data obtained from DNREC were used to calculate total and average annual beach nourishment volumes and expenditures for each community along the ocean coast. These data are summarized in Exhibit 2-2. The results of the calculations show during the period 1988-1996, developed portions (5.1 miles) of the ocean coast have seen total volumes of beach nourishment ranging from approximately 33 to 177 cubic yards per foot of shoreline frontage (33 - 177 cy/ft), with an average total placement of 102 cy/ft. Average annual placement volumes during the nine-year period have ranged from 3.7 cy/ft-yr to 19.6 cy/ft-yr, with an average of 11.4 cy/ft-yr. A total of approximately 2.7 million cubic yards were placed along developed portions of the ocean shoreline during the period (note that this total, and the cost totals cited below, do not include the volumes or costs associated with sand bypassing at Indian River Inlet).

Calculations show that the total cost of beach nourishment construction along Delaware's developed shoreline has been $15.4 million ($1996) during the nine-year period ($1.7 million/year). The average cost of ocean beach nourishment between 1988 and 1996 has been $5.63/cy, or $575/ft ($64/ft-yr). Approximately 71% of the total cost has been borne by the State of Delaware, approximately 10% of the total cost has been borne by FEMA, approximately 10% of the total cost has been borne by upland property owners (private beach areas) or local governments, and approximately 8% of the total cost has been paid for by the others (the U.S. Army Corps of Engineers, the State of Maryland, and Ocean City), for beachfill tapers placed in unincorporated Fenwick Island as part of the Ocean City beach nourishment project.

[3] "The Economic Impact of Expenditures by Tourists on Delaware Beaches: 1990," Davidson-Peterson Associates, Inc. 1991.

Exhibit 2-2: Summary of Delaware Open Coast Beach Nourishment Projects, 1988-1996

Location					Current $	Constant $96		
Projects	Project Year	Volume (Cu. Yds)	Linear Feet	Cu. Yds /Linear Ft	Total Cost Current $	Total Cost $96	Cost/ Cu. Yd	Cost/ Linear Ft
Fenwick (Unincorp.)	1988	102,830	1,850	55.6	$485,006	$643,258	$6.26	$347.71
	1989							
	1990							
	1991	126,800	1,600	79.3	$443,603	$511,023	$4.03	$319.39
	1992	37,000	1,600	23.1	$269,234	$301,089	$8.14	$188.18
	1993							
	1994	60,000	1,800	33.3	$336,873	$356,649	$5.94	$198.14
	Total	326,630	1,850	176.6	$1,534,716	$1,812,019	$5.55	$979.47
Annual Average		36,292		19.6		$201,335		$108.83
Fenwick (Incorp.)	1988	230,670	4,150	55.6	$1,087,987	$1,442,985	$6.26	$347.71
	1989							
	1990							
	1991							
	1992	144,900	4,150	34.9	$716,915	$801,739	$5.53	$193.19
	1993							
	1994	8,236	500	16.5	$32,396	$34,298	$4.16	$68.60
	Total	383,806	4,150	92.5	$1,837,298	$2,279,022	$5.94	$549.16
Annual Average		42,645		10.3	$204,144	$253,225		$61.02
South Bethany	1988							
	1989	231,600	4,158	55.7	$1,307,849	$1,654,851	$7.15	$397.99
	1990							
	1991							
	1992	192,749	4,850	39.7	$905,786	$1,012,957	$5.26	$208.86
	1993							
	1994	98,419	2,550	38.6	$452,165	$478,709	$4.86	$187.73
	Total	522,768	4,850	107.8	$2,665,800	$3,146,517	$6.02	$648.77
Annual Average		58,085		12.0	$296,200	$349,613		$72.09
Middlesex Beach	1988							
	1989	63,700	1,909	33.4	$357,905	$452,865	$7.11	$237.23
	1990							
	1991							
	1992							
	1993							
	1994							
	Total	63,700	1,909	33.4	$357,905	$452,865	$7.11	$237.23
Annual Average		7,078		3.7	$39,767	$50,318		$26.36

Exhibit 2-2: Summary of Delaware Open Coast Beach Nourishment Projects, 1988-1996								
Location					**Current $**	**Constant $96**		
Projects	**Project Year**	**Volume (Cu. Yds)**	**Linear Feet**	**Cu. Yds /Linear Ft**	**Total Cost Current $**	**Total Cost $96**	**Cost/ Cu. Yd**	**Cost/ Linear Ft**
Sea Colony	1988							
	1989	132,600	2,378	55.8	$770,058	$974,372	$7.35	$409.74
	1990							
	1991							
	1992							
	1993							
	1994							
	Total	132,600	2,378	55.8	$770,058	$974,372	$7.35	$409.74
	Annual Average	14,733		6.2	$85,562	$108,264		$45.53
Bethany Beach	1988							
	1989	284,500	5,138	55.4	$1,630,241	$2,062,781	$7.25	$401.48
	1990							
	1991							
	1992	219,735	5,138	42.8	$1,037,303	$1,160,035	$5.28	$225.78
	1993							
	1994	184,452	4,150	44.4	$838,953	$888,203	$4.82	$214.02
	Total	688,687	5,138	134.0	$3,506,497	$4,111,019	$5.97	$800.12
	Annual Average	76,521		14.9	$389,611	$456,780		$88.90
Indian Beach	1988							
	1989							
	1990							
	1991							
	1992							
	1993							
	1994	25,770	557	46.3	$81,835	$86,639	$3.36	$155.55
	Total	25,770	557	46.3	$81,835	$86,639	$3.36	$155.55
	Annual Average	2,863		5.1	$9,093	$9,627		$17.28
Dewey Beach	1988							
	1989							
	1990							
	1991							
	1992							
	1993	5,755	1,900	3.0	$30,210	$32,802	$5.70	$17.26
	1994	592,878	6,000	98.8	$2,402,230	$2,543,252	$4.29	$423.88
	Total	598,633	6,000	99.8	$2,432,440	$2,576,054	$4.30	$429.34
	Annual Average	66,515		11.1	$270,271	$286,228		$47.70
Shoreline Totals		2,742,594	26,832	102.2	$13,186,549	$15,438,506	$5.63	$575.38
	Annual Average	304,733		11.4	$1,465,172	$1,715,390		$63.93
Scheduled 1997		550,000	15,988	34.4		$2,937,000	$5.34	$183.70
Total 1988 - 1997		3,292,594	26,832	122.7		18,375,506	$5.58	$684.84
	Annual Average	329,259		12.3		$1,837,551		$68.48

At the bottom of Exhibit 2-2, these figures were modified to include beach nourishment projects scheduled at Dewey Beach, Bethany Beach and S. Bethany Beach during 1997. When these projects are included, the average beach nourishment volumes and costs are as follows:

1988-1997 DELAWARE Oeean Beach Nourishment Volumes and Costs($1996)*

Total Nourishment Volume	3.3 million cy
Total Nourishment Volume/ft	122.7 cy/ft
Average Annual Nourishment Volume	329,000 cy/yr
Average Annual Nourishment Volume/ft	12.3 cy/ft-yr
Total Nourishment Cost	$18.4 million
Total Nourishment Cost/ft	$685/ft
Average Annual Nourishment Cost	$1.8 million/yr
Average Annual Nourishment Cost/ft	$68/ft-yr
Average Nourishment Cost/cy	$5.58/cy

* Costs adjusted for inflation effects, including completed and planned (1997) projects (exclude sand bypassing at Indian River Inlet)

As a first approximation, the costs and volumes above can be used to project average future ocean beach nourishment requirements for Delaware's ocean coast.

CHAPTER 3: THE RECREATION VALUE OF BEACH NOURISHMENT

Consumer's surplus is the economic measure used herein to estimate the value of beach nourishment to beach visitors. Consumer's surplus is the difference between what a person is willing and able to pay for a good or service and what the person actually has to pay for a good or service. For beach visitors, consumers' surplus is the difference between the total willingness to pay for a recreation day at the beach and the cost of undertaking that recreation day at the beach.

The measure of consumer's surplus used to calculate the results presented herein is based on research by Falk in a study conducted in 1993 for Delaware's Department of Natural Resources.[4] Falk's values are price-updated using the consumer price index to 1996 dollars. Efforts to estimate consumer's surplus in other areas using various techniques have resulted in significantly different estimates of this value. The estimation of the willingness-to-pay for recreation has attracted considerable research over the past two decades as policy makers have required information to develop and/or protect natural resources in the face of growing demand and limited funding.[5] Walsh, et. al. reviewed almost 300 studies that included data from 225,000 visitor days and provided estimates of the willingness-to-pay for various recreation experiences above the actual out-of-pocket expenses of users. Estimates of daily willingness-to-pay in 1987 dollars ranged from less than four dollars to over $200 with a mean of about $34. Activities with high average willingness-to-pay included: nonmotorized boating ($49), big game hunting ($46) and Salt Water Fishing ($72). Activities with lower average willingness-to-pay included: camping ($20), swimming ($23) and picnicking ($17).

For this study of the willingness-to-pay for the use of the Delaware ocean beaches, data were utilized from surveys of visitors to Delaware beaches. These estimates are at the low end of those reported by Welsh and thus represent a conservative approach to the estimation of the consumer surplus enjoyed by these beach visitors. Had the results of other similar studies been transferred to this analysis, the estimates of consumer surplus could have been somewhat higher than estimated here.

The next section below, **The Measurement of Consumer's Surplus**, presents the estimates used by Falk and the price-updated values used to estimate consumer's surplus in this effort. The second section below, **The Number of Beach Visitors**, provides 1996 estimates of beach days and visitors to Delaware beaches. The third and final section below, **Consumer's Surplus With and Without**

[4] "Recreational Benefits of Delaware's Public Beaches: Attitudes and Perceptions of Beach Users and Residents of the Mid-Atlantic Region," by James Falk, Alan Graefe and Marc Suddleson for the Delaware Department of Natural Resources and Environmental Control and the U.S. Army Corps of Engineers, Philadelphia District; published August 1994 by the University of Delaware, Sea Grant College Program, Newark, DELAWARE.

[5] Walsh, Johnson and McKean, "Nonmarket Values From Two Decades of Research on Recreation Demand, Advances in Applied Micro-Economics", Volume 5, pages 167-193. 1990, JAI Press Inc.

Beach Nourishment, calculates the loss in consumer surplus based on the loss in beach visitors expected without nourishment in the five-year scenario.

THE MEASUREMENT OF CONSUMER'S SURPLUS

The survey conducted by Falk[6] included on-site interviews with 562 beach users at five Delaware Beach communities. Falk also conducted a mail survey of residents living within a five state regional area plus the District of Columbia, but these results differed significantly from the results of on-site beach visitors and were not used herein. Two questions were asked respondents of interest to this effort, (1) How much would visitors be willing to pay for a day's use of the beach, and (2) How much would users be willing to contribute [in additions to daily use fees] to a voluntary beach protection fund which would insure the beaches would be maintained for their use as well as that of future generations. The results are discussed below.

Visitors to the beach were asked if they would pay a certain amount (bid amounts varied randomly from $1 to $5) for a day's use of the beach. Seventy-seven percent of on-site respondents were willing to pay some amount per day to use the beach. The average amount (including those who responded that they were willing to pay nothing) was $3.01. Those who were not willing to pay cited the following reasons: they already paid by other means; they objected to the daily fee payment method; and they did not want to place a dollar value on the experience. When asked how much they were willing to pay into a voluntary annual beach protection fund to maintain the beaches for their use as well as future generations, 79 percent of visitors surveyed responded that they would contribute. The amount of contribution stated varied between $3 and $2,500, the average voluntary contribution was $63.69, including those who would contribute nothing. Respondents who were not willing to contribute to the voluntary fund mentioned the following reasons: they already paid through other means; there was not enough information for them to make a decision; and they objected to the annual contribution method of payment.

The 1993 dollar values collected by Falk were updated to 1996 dollars using the Consumer Price Index[7] from 1993 to 1996, the total adjustment being +8.58%. The consumer's surplus used to calculate the 1996 total consumer's surplus for beach visitors per day of beach use is $3.27, while the total amount that visitors would be willing to contribute to a voluntary annual beach maintenance fund is $69.16. The average length of stay for Delaware ocean beach visits was 1.755 days. Thus, the consumers' surplus per day is $41.27 ($3.27 plus $69.16 divided by 1.755 days).

[6]Ibid

[7]Consumer Price Index-All Urban Consumers, Series ID: CUUR0000SAO.

THE NUMBER OF BEACH VISITORS

The number of beach visitors and visitor days was estimated based on 1995 data obtained from the U.S. Travel Data Center's (USTDC) "Travelscope, 1995". The number of visitors in USTDC is estimated from survey respondents. Beach visitors were estimated according to the number of respondents who indicated that visiting the beaehes was an activity pursued while visiting Delaware. Nonrespondents (to the activity question) who visited the beach were estimated in the same proportion as respondents, after a review of the data did not reveal a significant bias among nonrespondents. Exhibit 3-1 provides the USTDC estimates by USTDC definitions of persons trips, adjusted to refleet nonrespondents, aecording to whether the visit included an overnight stay. Based on survey results in 1995, there were more than 5 million person trips to the beach for those traveling more than 50 miles and/or staying overnight. Of these visitors, 2.7 million were destination/overnight visitors (visitors whose destination was Delaware beaches and/or who stayed overnight) and 3.4 million were pass throughs (visitors whose destination was not Delaware beaches and who may or may not have spent the night). As shown, 3.4 million visitors did not spend the night, while 1.7 million remained overnight with an average stay of 3.24 days.

The USTDC estimates excludes visitors who travel less than 50 miles and do not stay (as a visitor) overnight. These nearby day visitors to the beaches can be divided into three categories:

8. Year round residents of the beach communities.
9. Second home owners within the beach communities i.e., those who own homes and use these homes (do not offer them for rental), during the peak season.
10. Residents of nearby communities who travel less than 50 miles to the beach and do not stay overnight. This would inelude residents of Delaware and Maryland who make day trips to the beach areas.

Estimates of visits by year round residents and those using summer homes were based on the population and housing units within 10 miles of Indian River Inlet as shown in Exhibit 3-2. The estimates of summer residents were based on the number of second homes times the average household size. As developed in Chapter Four, there are 14,561 housing units within the loeal area. The percent of residential units that are operated as second homes, i.e., the owners do not rent their properties to others during the peak season, is estimated as 30% of total housing units[8] or 4,368 housing units. Based on an average household size of 2.59,[9] the estimated number of second home (summer) residents is 11,313. The number of beach visits undertaken by both year round and summer residents were estimated according to research undertaken by the Marine Policy Center of

[8]Estimated by Delaware coastal real estate expert Bill Lingo of Jack Lingo Realty Co.

[9]Provided by the Delaware Economic Development Department for 1995.

EXHIBIT 3-1: ESTIMATED ANNUAL BEACH VISITORS and BEACH DAYS*

Based on 1995 U.S. Travel Data Center (USTDC) estimates with imputations for nonrespondents

	TOTAL	NO OVERNIGHT STAY**	WITH OVERNIGHT STAY***	PERSON DAYS AT THE BEACH****
ALL VISITORS TO DE				
Person Trips to DE	12,969,000	8,594,000	4,375,000	
Pass Throughs	7,123,000	6,113,000	1,010,000	
Dest/Overnight Trips	6,733,000	2,481,000	4,252,000	
BEACH VISITORS				
Total Person Trips**	1,967,000	1,303,447	663,553	
+ Adj for Nonrespond.	3,129,908	2,074,056	1,055,852	
Adj Total Person Trips	**5,096,908**	**3,377,502**	**1,719,406**	**8,948,376**
Pass Throughs**	483,000	414,513	68,487	
+Adj for Nonrespond.	2,298,252	1,972,373	325,879	
Adj Total Pass Throughs	2,781,252	2,386,887	394,365	3,664,631
Dest. Overnights**	1,753,000	645,952	1,107,048	
+Adj for Nonrespond.	941,122	346,788	594,334	
Adj Total Dest/Overnight	2,694,122	992,740	1,701,382	6,505,219

*Excludes visitors who traveled less than 50 miles and do not remain overnight.
**Based to those responding to question.
***By subtraction.
****Day visitors are allocated 1 day, overnight visitors are allocated 3.24 days (average length of stay)

Definitions:
Person Trips are the total projected person trips based on the number of raw trips in the sample
Pass Throughs are person trips whosa destination is not within DE
Dest/Overnight trips have a DE destination and/or persons remain overnight in DE.

Shaded entries are taken directly from USTDC totals.

EXHIBIT 3-2: LOCAL POPULATION and ANNUAL BEACH VISITS					
RADIUS, MILES	**AVG # VISITS***	**1990 POPULATION IN RING**	**POPULATION INCREASE 90-96**	**ESTIMATED 1996 POPULATION**	**TOTAL ANNUAL VISITS**
40-50	NA	121,462	1.088	132,151	NA
30-40	NA	109,390	1.088	119,016	NA
20-30	NA	66,772	1.088	72,648	NA
10-20	NA	45,930	1.088	49,972	NA
10	26.04	21,335	1.159	24,727	643,898
TOTAL:		**364,889**		**398,514**	**643,898**
VISITORS FROM 2ND HOMES*:					**335,657**
TOTAL VISITS FROM POPULATION WITH 10 MILES:					**979,555**

Source: Census of Population, Census of Housing, Delaware Economic Development Department
NA: Estimate Not Available
*"Recreation Benefits at State Beach on Martha's Vineyard," Woods Hole Oceanographic Institute, 1992.

the Woods Hole Oceanographic Institution [10] in a survey of tourists and local residents. In this survey, year round residents indicated that they visited the beach an average of 26.04 times per summer, while summer residents averaged 29.67 visits. Accordingly, beach residents visit the beach an estimated 398,514 times per season and second home owners are estimated to make an additional 335,657 visits. Estimates of day visits by those who reside outside of the local communities but within 50 miles of the beach are not available. The population in the 10 to 50 mile range, residing in Delaware and Maryland, is estimated at 373,787.

CONSUMER'S SURPLUS WITH AND WITHOUT BEACH NOURISHMENT

To determine the effect of erosion loss on consumer's surplus, it is necessary to anticipate how visitors will react to the loss in beach width. Since within a five-year time frame the nature and conditions of the Delaware beaches will change little, total willingness to pay for a beach visit, holding beach area constant, is not expected to change. However, since there is less beaeh area, the holding capacity of all the beaches will bc reduced. This effect will be most pronounced in the public beach areas that are typically crowded during high use periods. In Exhibit 3-3, the shoreline is divided according to park, public or private use. The public access beaches of the incorporated townships of Fenwick Island, South Bethany, Bcthany, Dewey and Rehoboth are those which can be accessed most conveniently by visitors who do not have acccss to the private beach areas (the majority of visitors). While all visitors have access to park beaeh areas, these beaches are usually not within easy access (walking distance) of lodging. Thus the reduction in holding capacity of the selected public beach areas during the in-season is used to estimate the visitor loss expected from erosion in a five year framework.

The Timing of Erosion

Erosion takes place over time, for convenience it is measured via an average annual rate. Note that actual year-to-year erosion follows no such pattern, i.e., the beach size in Delaware varies tremendously throughout the season and each year's gains or losses are conditioned by the severity of wcather events that occur within a given year. The average annual erosion rate is used in analysis to represent the long tcrm trend expected for the shoreline. For the purposes of this study, the erosion is considered to happcn over the course of each year but thc loss is not evidenced until the following year so that at the end of year one (beginning of year two) one year's worth of erosion will be in evidence. The erosion loss expected within a five year period is equal to four years of average annual erosion (at the beginning of the sixth year, five years of erosion loss will be in evidence.). Within the five-year period of analysis, the average annual erosion loss of two to four feet evidenced in the various reaches of the Delawarc shoreline will result in an eight to 16 foot loss in beach width.

[10] "Recreation Benefits at State Beach on Martha's Vineyard," by Yoshiaki Kaoru, Marine Policy Center, Woods Hole Oceanographic Institution, 1992.

Exhibit 3-3: Erosion Beach Loss by Reach and Community

Reach #	Name	Park/Public /Private	Length (Ft.)	Erosion Rate (Ft/Yr)	Loss (Sq.ft./Yr)	Sq Ft/Yr Public	Cum Loss, Five Yrs*
1	Uninc. Fenwick	Private	1,900	4	7,600		
2	Inc. Fenwick	Public	4,000	4	16,000	16,000	64,000
3	FISP	Park	3,600	4	14,400		57,600
4	Fenwick Acres	Private	600	4	2,400		9,600
5	Uninc. Sussex Cty	Private	2,800	4	11,200		44,800
6	Fenwick Isl. St. Pk.	Park	6,600	4	26,400		105,600
7	(York Beach w/o Rt 1)	Private	1,400	4	5,600		22,400
8	S. Bethany	Public	3,600	4	14,400	14,400	57,600
9	(S. Bethany, N)	Public	500	4	2,000	2,000	8,000
10	Middlesex	Private	1,900	4	7,600		30,400
11	Sea Colony	Private	2,300	4	9,200		36,800
12	Bethany	Public	5,100	4	20,400	20,400	81,600
13	Uninc Sussex	Private	16,200	3	48,600		194,400
14	DSSP (Ind River Inlet)	Park	6,300	2	12,600		50,400
15	DSSP	Park	26,900	3	67,250		269,000
16	Indian/N Indian Beach	Private	2,500	3	6,250		25,000
17	Dewey Beach	Public	5,700	2	11,400	11,400	45,600
18	Silver Lake	Private	1,000	2	1,500		6,000
19	Rehoboth (S resid)	Public	2,400	2	3,600	3,600	14,400
20	Rehoboth (comm)	Public	3,800	2	7,600	7,600	30,400
21	Rehoboth (Surf Ave)	Public	1,900	3	4,750	4,750	19,000
22	Henlopen Acres	Private	1,300	4	4,550		18,200
23	North Shores	Private	2,100	4	8,400		33,600
24	Cape Hen. St. Pk.	Park					
Total Park Shoreline			43,400		120,650		482,600
Total Private Shoreline			34,000		112,900		421,200
Total Public Shoreline			27,000		80,150		320,600
Total Shoreline			104,400		313,700	80,150	1,224,400

*The erosion evidenced in Year 5 is equal to the erosion occurring in the first 4 years.

The Behavioral Response

The shoreline of Delaware is divided among sections that are open to the public, areas that are privately owned and from which the public is restricted and park areas that offer beach access in less developed shoreline areas. Park areas are mostly accessed by car. Public reaches include open access townships and limited access outlying reaches. Visitors facing a reduced holding capacity of the already crowded public beach areas of the towns will first attempt to overcome the increased congestion by changing their vacation timing or daily routines while at the beach. Visitors may have flexiblility within the season to choose relatively less crowded days (early or late season, mid-week visits) and/or may choose shopping, visits to the State's park beaches or other pastimes on days of their vacation when the high-use public beaches are most crowded.

However, the responses by visitors to mitigate beach losses are limited. The timing of vacations often is locked, by workplace requirements or early reservations required to secure lodging. The willingness to pursue other activities or travel to another beach that is less crowded, e.g., a park beach, is less desirable than having access to the closest available public beach. In this study, visitors are predicted to offset one year of (average annual) erosion of the public beach areas, or 80,150 square feet of beach loss, by altering their vacation days or activities. Thus, no losses in consumer's surplus are predicted until the third year of a five year without nourishment scenario (note the first year of erosion is not in evidence until year two and visitors are able to mitigate the year two loss by a change in vacation timing or activities).

After year two, erosion will continue to diminish the beach width but visitors will no longer be able to compensate for the reduced beach with on-site strategies. From year three on, the holding capacity of the beach will be reduced. If the same number of visitors return to the beach in year three, beach congestion will occur resulting in a reduction of the consumer's surplus for all affected visitors. Alternatively, if visitors are not willing to accept a reduction in consumer's surplus (a measure of their enjoyment of a beach visit), visitors will choose other activities in place of a beach visit. To measure the loss of consumer's surplus in this study, beach congestion is held constant and the result of a diminished beach is translated into a reduction in the number of visitors, equivalent to the lost holding capacity of the public beach areas. Note that the loss would be the same if crowding occurred (the number of visitors did not decrease) and the consumer's surplus of each visitor was reduced proportional to the reduction in beach area).

To estimate the number of visitors who would decide not to visit to Delaware beaches because of the diminished beach size, the erosion loss in the already congested public beach areas is translated into the number of visitors who will no longer 'fit' on the beaches, holding beach congestion constant. The number of visitors electing to go elsewhere was estimated to be equal to the reduced 'holding power' of the diminished public beaches times the number of days during the peak season. According to the average annual erosion rates in the (selected) public beach areas, as shown in

Exhibit 3-4, 80,150 square feet of beach will be lost each year. The U.S. Army Corps of Engineers[11] estimates that 100 square feet is required per beach user. Assuming a 14-week season from Memorial Day to Labor Day, there are 98 beach days in the peak beach season. With an 80,150 square foot loss, the daily beach holding power in the congested public access beach communities is reduced each year by 801.5 visitors (average stay is @1.8 days /visitor). For the entire season, the beach capacity is reduced 78,547 beach visitor days or 44,756 visitors. As shown in Exhibit 3-4, in years three - five, a cumulative loss of 471,282 visitor days or 268,537 visitors is expected. This reduction in visitors assumes that visitors will remove themselves from the Delaware beach areas each day of the 98 day season up to the point that the congestion is no worse than experienced in the 1995 season, after adjusting for one year of erosion wherein visitors alter their plans to mitigate potential crowding. If the erosion continues unchecked after five years, an additional 44,756 visitors will be lost each year.

To estimate the dollar value of the loss in recreation value by year, the number of beach visitor days lost per year is multiplied by the average consumer's surplus for beach visitors in 1996 dollars, by year. In Exhibit 3-5, the number of beach visitors not returning to Delaware beaches is multiplied by the annual willingness to contribute to a voluntary beach fund to estimate the total reduction in contributions to the annual beach fund. A loss in consumers' surplus of $20.1 million is predicted for the five year period.

[11]Rehoboth Beach/Dewey Beach Interim Feasibility Study, April 1995, page 26.

Exhibit 3-4: Loss in Public Beach Size, Visitor-days and Visitors, by Year*

		Year Three		Year Four		Year Five		Cumulative	
Reach Name, Public Beach Areas	Annual Erosion	Loss in Visitor Days	Loss in Visitors**	Loss in Visitor Days	Loss in Visitors**	Loss in Visitor Days	Loss in Visitors**	Loss in Visitor Days	Loss in Visitors**
	(Sq Ft/Yr)	(Sq. ft loss/ 100 sq ft/ person/day*98 days)	(Visitor Days/1.755 Days per Visitor)	(Sq. ft loss/ 100 sq ft/ person/day*98 days)	(Visitor Days/1.755 Days per Visitor)	(Sq. ft loss/ 100 sq ft/ person/day*98 days)	(Visitor Days/1.755 Days per Visitor)	(Yrs 3-5)	(Yrs 3-5)
Inc. Fenwick	16,000	15,680	8,934	31,360	17,869	47,040	26,803	94,080	53,607
S. Bethany	14,400	14,112	8,041	28,224	16,082	42,336	24,123	84,672	48,246
S. Bethany, N	2,000	1,960	1,117	3,920	2,234	5,880	3,350	11,760	6,701
Bethany	20,400	19,992	11,391	39,984	22,783	59,976	34,174	119,952	68,349
Dewey Beach	11,400	11,172	6,366	22,344	12,732	33,516	19,097	67,032	38,195
Rehoboth (S resid)	3,600	3,528	2,010	7,056	4,021	10,584	6,031	21,168	12,062
Rehoboth (comm)	7,600	7,448	4,244	14,896	8,488	22,344	12,732	44,688	25,463
Rehoboth (Surf Ave)	4,750	4,655	2,652	9,310	5,305	13,965	7,957	27,930	15,915
Total	80,150	78,547	44,756	157,094	89,512	235,641	134,268	471,282	268,537

*The erosion evidenced in year two is mitigated by visitor behavior changes so that visitors do not decline until year three.

**Loss in visitors = Visitor days/(3.24 days per overnight visitor*33.73% overnight visitors+66.27% day visitors * one day per visitor)= Visitor days/1.76)

Exhibit 3-5, Loss in Consumers' Surplus from Beach Visitors, Cumulative for Five Years					
Reach Name, Public Beach Areas	Loss in Visitor Days*	Loss in Daily Visit Consumers' Surplus	Loss in Visitors**	Loss in Maintenance Fund Consumers' Surplus	Total Loss in Consumers' Surplus
	(Based on a 98 Day Season)	($3.27 per daily visit lost)	(Visitor Days/1.755 Days per Visitor)	(69.16/Visitor)	(Daily Visit +Maintenance)
Inc. Fenwick	94,080	$307,642	53,607	$3,707,449	$4,015,090
S. Bethany	84,672	$276,877	48,246	$3,336,704	$3,613,581
S. Bethany, N	11,760	$38,455	6,701	$463,431	$501,886
Bethany	119,952	$392,243	68,349	$4,726,997	$5,119,240
Dewey Beach	67,032	$219,195	38,195	$2,641,557	$2,860,752
Rehoboth (S resid)	21,168	$69,219	12,062	$834,176	$903,395
Rehoboth (comm)	44,688	$146,130	25,463	$1,761,038	$1,907,168
Rehoboth (Surf Ave)	27,930	$91,331	15,915	$1,100,649	$1,191,980
Total	471,282	$1,541,092	268,537	$18,572,002	$20,113,094

*The erosion evidenced in year two is mitigated by visitor behavior changes so that visitors do not decline until year three.

**Loss in visitors = Visitor days/(3.24 days per overnight visitor*33.73% overnight visitors+66.27% day visitors * one day per visitor)= Visitor days/1.76)

CHAPTER 4: THE PRICE EFFECT OF BEACH CONDITION ON BEACH COMMUNITY PROPERTIES

As the shoreline narrows with erosion, an important component of price in beach community properties, the contribution to property value from the nearby presence of a recreational beach, is reduced. The reduction in value can be traced to a reduction in the willingness-to-pay of beach owners and visitors for lodging/property near the beach. When properties are sold, this translates into a reduced price. When properties are held in rental, the rental value can be expected to decrease with a decrease in the quality of the beach, which in turn decreases the resale value of the property. The reduction in price related to the beach width, a proxy for beach condition, has been quantified in this study through the construct of a hedonic model. The model results are based on cross-sectional transactions data for about two years ending in March 1997 wherein the correlation between beach width and property price was observed.

OVERVIEW OF THE HEDONIC MODEL

A hedonic model was used to estimate the effects of beaeh erosion on beach community properties. The hedonic approach relates the price of a commodity to its attributes. It assumes that commodities are composites of numerous attributes that are not sold individually in the market but for which there are levels of demand. The price of a commodity, then, is determined by the various eombinations of these attributes as well as the different levels of supply and demand for each.

In this effort, the price of a piece of property is related to four property attributes: the number bedrooms, the number of bathrooms, how far the property was from the beach, and the width of the closest beach. In addition, community dummy variables were also included in the regressions to aceount for different price levels that may exist across communities.

The regressions were estimated using a semi-log functional form. This means that the estimated coefficients can be interpreted as growth rates: i.e., the percentage ehange in the property priee due to a one unit change in the independent variables. On average, it was found that a one foot change in beach width impacted property prices by approximately 0.1% (0.000981). In Exhibit 4-1 below, this percentage change has been eonverted into absolute changes for the average property value in each community. As can be seen, these absolute values range from $183 to $464. Assuming that property owners are willing to pay up to this amount to prevent each foot of erosion (thereby maintaining the value of their asset), the estimates can be inferred as representing the value of beach nourishment efforts to coastal property owners.

The model was estimated using the Multiple Listing Service (MLS) data on property transactions. The sample of data that was used spanned about two years, ending in March 1997, and included over 1,100 observations. For more information on the model framework and results, see Appendix A.

Exhibit 4-1: Property Value Lost per Foot of Beach Width, by Community

Community	Number of Units	Average 1990 Price	Estimated Average 1996 Price	Total 1996 Property Value	Change in Price/Foot of Beach Width	Total Property Loss/Foot of Beach Width
Incorporated Beach	8,576			$2,072,263,773		$2,032,891
Bethany Beach	2,175	$155,100	$186,191	$404,965,863	$183	$397,272
Dewey Beach	1,378	$225,000	$270,103	$372,202,334	$265	$365,130
Fenwick Island	691	$202,800	$243,453	$168,226,091	$239	$165,029
Rehoboth Beach	3,257	$205,400	$246,574	$803,092,470	$242	$787,834
South Bethany	888	$220,800	$265,061	$235,374,489	$260	$230,902
Henlopen Acres	187	$393,800	$472,741	$88,402,526	$464	$86,723
Unincorporated Beach	5,985	$201,276	$241,624	$1,446,117,241	$237	$1,418,641
Total	14,561			$3,518,381,013		$3,451,532

THE PROPERTY INVENTORY

To estimate the total impact of beaeh nourishment efforts on coastal property values, it was necessary to develop an inventory of affected properties. The per-unit-benefits estimated in the regression analysis were applied to all of the properties in the inventory to generate a total benefit estimate. The MLS data set was not adequate for this purpose since it only includes data on properties that were sold and excludes all other properties. Data from the Sussex County Courthouse also did not provide current price information, which is needed in the inventory. As a result, the inventory of housing units in the beach communities was developed from 1990 Census data for the beach communities, increased by the number of permits for new dwellings less demolitions for the 1990 - 1996 period. Census totals from U.S. Census Bureau tract numbers 511.98 and 512 were used to approximate the beach communities. In total, there were 13, 886 housing units in 1990. The eount increased by 679 between 1990 and 1996, for a total of 14,561 in 1996. The inventory was valued aeeording to Census values for housing units by (incorporated) place where available, or by the average of unincorporated places. Census values are based on 1990 prices and were updated to 1996 using the Consumer Price Index.

For each area, Exhibit 4-1 presents the number of units in the inventory, the average price of each unit, the per unit loss in property value due to a one foot loss in beach width, and the total loss in property values for all of the units in the inventory. As can be seen, the average 1996 price ranged from $186,191 to $472,741, depending on location. Each one foot loss in dry sand is shown to reduce the average property values by $183 in Bethany to $464 in Henlopen Acres. These estimates were developed by multiplying the average 1996 priees by 0.000981, the log coefficient estimated in the regressions. Multiplying these unit losses by the number of units yields estimates of the total property loss for each community. The total property loss per foot of erosion for the inventory is estimated to be just under 3.5 million dollars.

Since the State is interested in assessing how nourishment benefits accrue to various groups of property owners, the property inventory was segmented aeeording to the permanent geographic residence of the owner. This geographic distribution of beaeh property ownership was based on the distribution of ownership in the beach communities included within the two large tax map distriets, #1-34 and # 3-34. Within the two large tax districts, the beach communities were defined according to the tax maps that represented the geographic area covered by the Multiple Listing Service transactions used in the model. In total, 19,771 properties are included in these districts. Of these, 22 properties are owned by those residing in other countries, 11,837 are owned by residents of other states and 7,912 are owned by those residing in Delaware. By county, 2,028 owners reside in New Castle, 448 in Kent and 5,427 in Sussex County. Within the beach community, Bethany shows 526 property owners, Dewey 32, Rehoboth 2,272, South Bethany 145. Note that these numbers reflect property ownership, including commercial and undeveloped. Also note that one person may own multiple properties, as is clearly the case in Rehoboth, where properties owned by those whose address is Rehoboth outnumber the resident population of Rehoboth. More information on property ownership is provided in Chapter 6.

THE VALUE OF RESIDENTIAL HOUSING WITH AND WITHOUT BEACH NOURISHMENT

In the with-project (nourishment to continue as planned by the State) scenario, property values do not decrease as a result of erosion because while erosion does continue, the State maintains a management program that prevents the nourishment from having a price effect. In other words, with an ongoing State policy to protect the shoreline, the market knows that erosion will be offset by future State nourishment activity. In the without project scenario, it is assumed that owners, buyers and visitors understand that the State will not nourish the shoreline and the willingness to pay for properties is influenced according to the model estimates of the effect of beach loss on property values, beginning in Year 2. Exhibit 4-2 presents forecasts of the cumulative losses of property values that are predicted to occur over the time horizon if nourishment efforts are not undertaken. The estimates are given in constant 1996 dollars. These estimates are a function of the average annual rate of erosion expected to occur over the period. During this period, erosion is expected to reduce beach width from an average of 2 feet per year to 4 feet per year, depending on location. The loss in value was estimated based on the value of properties within each community times the beach loss expected in that community times .000981, the estimated log coefficient per foot of beach width. As shown in the table, after ten years the total property value of the coastal area is predicted to fall by 2.91% if no beach replenishment efforts are undertaken.

Exhibit 4-2: Property Value Lost Without Nourishment, by Year

			Property Value Loss as of:					
Community	Property Loss per Foot of Beach Width	Annual Erosion Rate (ft)	Year One	Year Two	Year Three	Year Four	Year Five	Year Ten
Incorporated Beach	$2,032,891		$0	$5,782,273	$11,564,546	$17,346,818	$23,129,091	$52,040,455
Bethany Beach	$397,272	4	$0	$1,589,088	$3,178,176	$4,767,264	$6,356,353	$14,301,793
Dewey Beach	$365,130	2	$0	$730,260	$1,460,521	$2,190,781	$2,921,041	$6,572,343
Fenwick Island	$165,029	4	$0	$660,118	$1,320,236	$1,980,354	$2,640,471	$5,941,061
Rehoboth Beach	$787,834	2	$0	$1,575,668	$3,151,337	$4,727,005	$6,302,674	$14,181,016
South Bethany	$230,902	4	$0	$923,608	$1,847,216	$2,770,825	$3,694,433	$8,312,474
Henlopen Acres	$86,723	3.5	$0	$303,530	$607,060	$910,590	$1,214,120	$2,731,769
Unincorporated Beach	$1,418,641	3.56	$0	$5,050,362	$10,100,725	$15,151,087	$20,201,450	$45,453,262
Total	$3,451,532		$0	$10,832,635	$21,665,270	$32,497,906	$43,330,541	$97,493,717
% of Total Property Value				0.32%	0.65%	0.97%	1.29%	2.91%

CHAPTER 5: LOSS IN BUSINESS REVENUE WITHOUT NOURISHMENT

As the shoreline erodes without nourishment, the shrinking beach forces out visitors, especially in the heavily-used public beach areas. In the constant congestion framework used here to estimate visitor losses, it is assumed that visitors will select other aetivities over a Delaware beach vacation in numbers sufficient to maintain the beach density at the level prior to erosion, less a one-year margin wherein visitors change their vaeation patterns to offset the loss in beach width. Thus it is assumed that the crowding will remain somewhat the same as with nourishment because timing changes followed by a reduction in the number of visitors will offset potential crowding.

As developed in Chapter 3, an estimated 45 thousand visitors will be lost in year three, nearly 90 thousand in year four and 134 thousand in year five, for a eumulative total of almost 269 thousand visitors. It is expected that visitors who do not return will be those with relatively higher financial investment in the beach visit, i.e., visitors who travel more than 50 miles and/or remain overnight. These visitors have more alternatives as they have the longest travel distances and largest travel budgets. Visitors lost are apportioned between overnight visitors and day visitors (traveling more than 50 miles) according to the relativc shares of total visitors to the Delaware shoreline.

According to the USTDC's TravelSeope, on average, each travel party has 1.84 household members over 18 and spends and spends $201 in Delaware. However, the USTDC data does not provide data whereby the expenditures for day versus overnight visitors (reference Exhibit 3-1) can be estimated separately. Therefore, data from the "Southern Delaware: Beach Region Visitor Profile Study" were used to apportion the average $201 expenditure according to day and overnight visitors. Based on a USTDC's 3.24 day average stay and the Southern Delaware study's avcrage daily expenditures, overnight visitors spend an estimated $475.79, while day visitors spend $70.10.

Expenditures from the Southern Delaware: Beach Region Visitor Profile Study[12] for visitors by typc of visitor and expenditure category are distributed as follows:

[12] "Southern Delaware: Beach Region Visitor Profile Study," conducted by the Delaware Public Administration Institute, University of Delaware for the Delaware Tourism Office, August 1995.

EXHIBIT 5-1: VISITOR EXPENDITURES BY CATEGORY

Category	Percent Overnight Visitors	Percent Day Visitors
Lodging	37.7%	0%
Restaurants	22.32%	28.46%
Entertainment	12.40%	13.24%
Food Shopping	9.52%	16.75%
Non-Food Shopping	14.33%	32.37%
Transportation	3.71%	9.19%

The $30.2 million loss in visitor expenditures that is expected in years three - five are shown in Exhibit 5-2, by expenditure category.

The relationship of expenditures to jobs, wages and salaries and profits, as evidenced in the Southern Delaware study, are shown in Exhibit 5-3. These percentages are used to estimate the jobs, income and profits shown in Exhibit 5-4.

Additional variables that are linked to expenditures include State receipts for income, occupancy, corporation and gross receipts taxes. The loss in State receipts for income taxes was based on an average rate of 4.53%. The reduction in occupancy taxes was based on the relative share of lodging receipts that are paid to hotels (according to USTDC) and taxed at 8 %. Corporate taxes are estimated at 8.7% of profits and gross receipts are estimated at the marginal rate by category as shown in Exhibit 5-4. Local parking revenue losses are estimated at two dollars per car.

The final column in Exhibit 5-4 provides an estimate, based on incremental values developed in this study, for the losses that would accrue after 10 years without nourishment. These values are provided for information only, and have not been evaluated in the research effort.

EXHIBIT 5-2: EXPENDITURES BY CATEGORY, BY YEAR						
	ANNUAL VALUES WITH NOURISHMENT	AVERAGE ANNUAL LOSS WITHOUT NOURISHMEN T YRS 3- 5+	LOSS, YR 3	LOSS, YR 4	LOSS, YR 5	CUMULATIVE, YRS 3-5
VISITORS	5,096,908	44,756	44,756	89,512	134,268	268,537
TRAVEL PARTIES (1.84 VISITORS/TRAVEL PARTY)	2,770,059	24,324	24,324	48,648	72,972	145,944
TOTAL	$573,222,171	$5,033,484	$5,033,484	$10,066,968	$15,100,452	$30,200,904
1996 EXPENDITURE/PARTY						
LODGING	$167,680,213	$1,472,406	$1,472,406	$2,944,812	$4,417,218	$8,834,435
RESTAURANTS	$135,861,298	$1,193,003	$1,193,003	$2,386,006	$3,579,008	$7,158,017
ENTERTAINMENT	$72,174,704	$633,769	$633,769	$1,267,537	$1,901,306	$3,802,612
FOOD SHOPPING	$63,873,837	$560,878	$560,878	$1,121,757	$1,682,635	$3,365,270
NON FOOD SHOPPING	$105,345,519	$925,043	$925,043	$1,850,085	$2,775,128	$5,550,256
TRANSPORTATION	$28,334,803	$248,809	$248,809	$497,618	$746,427	$1,492,853
TOTAL	$573,270,375	$5,033,907	$5,033,907	$10,067,815	$15,101,722	$30,203,444

Source: Breakdown of expenditures from Southern Delaware: Beach Region Visitor Profile Study, 1995
All other values based on U.S.T.O.C.'s TravelScope, 1995

Exhibit 5-3: TOURIST EXPENDITURES, by JOB, WAGES AND SALARIES and PROFITS

Expenditure Relationships, All Types of Business*

Economic Activity	1990	Expenditures, $1990 per Job or per $1 Income	Expenditures, $1996** per Job or per $1 Income
Tourist Expenditures	$165,000,000		
Direct Jobs	3,337	$49,445.61	$59,357.43
Wages and Salaries	$51,797,000	$3.19	$3.82
Indirect Jobs	759	$217,391.30	$260,969.36
Wages and Salaries	$23,854,000	$6.92	$8.30

Profit Margins, by Type of Business**

Industry	Profit
Lodging	6.47%
Restaurants	5.58%
Amusement	7.56%
Food Stores	1.79%
General Merchandise	3.30%
Auto Repair	3.67%

*Based on expenditure relationships described in "The Economic Impact of Expenditures by Tourists Delaware Beaches, 1990"

**Price updated by the Consumer Price Index 1996/1990, 156.9/130.7

***Based on Corporate Income Statistics, 1991

EXHIBIT 5-4: SUMMARY, ECONOMIC VARIABLES, BASELINE AND YEARS 2- 5 and Year 10, WITHOUT NOURISHMENT

(Based on reduction in tourism and property value from diminished beaches, $1996)

CATEGORY	BASELINE:	LOSS WITHOUT NOURISHMENT:				Cumulative	Expected Loss
	Year 1	Year 2	Year 3	Year 4	Year 5	5 Yr Loss	After 10 Yrs.
Total Visitors	5,096,908	0	44,756	89,512	134,268	268,537	2,282,562
Day Visitors (50+ Miles)	3,377,502	0	29,658	59,316	88,974	177,948	1,512,556
Overnight Visitors	1,719,406	0	15,098	30,196	45,294	90,589	770,006
ECONOMIC BENEFITS							
Consumer's Surplus: Total	$381,763,326	$0	$3,352,277	$6,704,554	$10,056,832	$20,113,663	$170,966,136
Daily Visits	$29,261,190	$0	$256,944	$513,887	$770,831	$1,541,661	$13,104,120
Annual Maintenance Fund	$352,502,136	$0	$3,095,334	$6,190,667	$9,286,001	$18,572,002	$157,862,015
Property Value	$3,350,154,922	$10,832,635	$21,665,270	$32,497,906	$43,330,541	$43,330,541	$97,493,717
Total Economic Benefits	$3,731,918,248	$10,832,635	$25,017,548	$39,202,460	$53,387,372	$63,444,204	$268,459,853
ECONOMIC TRANSFERS							
Tourism Revenues (total):	$573,222,171	$0	$5,033,484	$10,066,968	$15,100,452	$30,200,904	$256,707,684
Lodging	$167,680,213	$0	$1,472,406	$2,944,812	$4,417,218	$8,834,435	$75,092,698
Restaurants	$135,861,298	$0	$1,193,003	$2,386,006	$3,579,008	$7,158,017	$60,843,144
Entertainment	$72,174,704	$0	$633,769	$1,267,537	$1,901,306	$3,802,612	$32,322,199
Food Stores	$63,873,837	$0	$560,878	$1,121,757	$1,682,635	$3,365,270	$28,604,799
Non Food Stores	$105,345,519	$0	$925,043	$1,850,085	$2,775,128	$5,550,256	$47,177,178
Transportation	$28,334,803	$0	$248,809	$497,618	$746,427	$1,492,853	$12,689,254
Profits:	$29,538,005	$0	$259,374	$518,749	$778,123	$1,556,246	$13,228,087
Lodging	$10,850,281	$0	$95,277	$190,553	$285,830	$571,660	$4,859,112
Restaurants	$7,577,259	$0	$66,536	$133,072	$199,609	$399,217	$3,393,345
Entertainment	$5,453,681	$0	$47,889	$95,778	$143,667	$287,334	$2,442,337
Food Stores	$1,142,179	$0	$10,030	$20,059	$30,089	$60,177	$511,505
Non Food Stores	$3,475,908	$0	$30,522	$61,044	$91,566	$183,132	$1,556,626
Transportation	$1,038,696	$0	$9,121	$18,242	$27,362	$54,725	$465,162
Total Jobs:	11,854	0	104	208	312	625	5,308
Direct	9,657	0	85	170	254	509	4,325
Indirect	2,197	0	19	39	58	116	984
Wages and Salaries:	$218,930,542	$0	$1,922,437	$3,844,874	$5,767,310	$11,534,621	$98,044,275
Direct	$149,898,154	$0	$1,316,261	$2,632,522	$3,948,783	$7,897,566	$67,129,309
Indirect	$69,032,388	$0	$606,176	$1,212,352	$1,818,527	$3,637,055	$30,914,967
State Receipts		$0	$332,060	$664,121	$996,181	$1,992,362	$22,431,144
Income Tax (4.53% Avg.Rate)		$0	$35,009	$70,017	$105,026	$210,052	$7,281,508
Occupancy Tax (8% hotels)	$298,947	$0	$2,625	$5,250	$7,875	$15,750	$133,878
Corporate Income Tax (8.7%)	$2,569,806	$0	$22,566	$45,131	$67,697	$135,393	$1,150,844
Gross Receipts (Marginal Rate)		$0	$271,861	$543,722	$815,583	$1,631,166	$13,864,914
Retail (0.720%)		$0	$106,986	$213,973	$320,959	$641,918	$5,456,302
Restaurants (0.624%)		$0	$74,443	$148,887	$223,330	$446,660	$3,796,612
Services (0.384%)		$0	$90,431	$180,863	$271,294	$542,588	$4,611,999
Local Parking Fees ($2/party))		$0	$48,648	$97,296	$145,944	$291,888	$2,481,046

CHAPTER 6: GEOGRAPHIC DISTRIBUTIONS OF ECONOMIC BENEFITS AND ACTIVITIES

To assist policy-makers in understanding the incidence of losses in economic benefits and economic activity that is correlated with beach nourishment, the losses as estimated herein are allocated according to the geographic location of the residence of the beneficiary. Thus, property losses and losses in profits, jobs and salaries are allocated according to the residence of the owners of beach community properties while losses in consumer's surplus are estimated based on the residenee of visitors to the beach communities. The distribution assumes that the residence of beach area job holders is the same as that of beach area property owners.

Exhibit 6-1 presents the distribution of property owners based on owners in the beach communities. This distribution is used to estimate the incidence of losses in property value, profits, jobs and wages and salaries in the beach communities. As shown, 40% of properties in the beach communities are owned by Delaware residents. Of the 40 percent of beach properties owned by Delaware residents, about 69 percent reside in Sussex County, 26 percent in New Castle County and 6 percent in Kent County whereas by total population the county distribution is 17 percent, 66 percent and 17 percent respeetively. In Sussex County, 31 percent of the beach properties are owned by Sussex County residents who do not reside within the beach communities.

Exhibit 6-2 presents the distribution of the state of residence of visitors to the shoreline. This distribution is used to allocate losses in consumer's surplus. Accordingly, eight percent of the loss in consumer's surplus is from Delaware residents, whereas the remaining 92 percent is lost by residents of other states or countries. As shown, states with more visitors than Delaware are Maryland (23 percent), Pennsylvania (20 percent), New Jersey (19 percent), New York (10 percent) and Virginia (eight percent).

Exhibit 6-1: Distribution of Property Ownership in Beach Communities and Associated Distribution of Profits, Jobs and Wages & Salaries

Property Owneship:				5 YEAR LOSSES:			
		# of Properties	Percent	Property Value	Profits	Jobs	Wages & Salaries
Total		19,771	100.00%	$43,330,541	$1,556,246	625	$11,534,621
Distribution of Ownership:							
Out of Country		22	0.11%	$48,216	$1,732	1	$12,835
Out of State		11,837	59.87%	$25,942,219	$931,732	374	$6,905,837
	Maryland	5,806	29.37%	$12,724,552	$457,011	183	$3,387,285
	Virginia	2,127	10.76%	$4,661,578	$167,424	67	$1,240,915
	Pennsylvania	1,843	9.32%	$4,039,158	$145,069	58	$1,075,227
	District of Col.	741	3.75%	$1,623,991	$58,327	23	$432,308
	New Jersey	344	1.74%	$753,918	$27,077	11	$200,693
	Florida	262	1.33%	$574,205	$20,623	8	$152,854
	New York	184	0.93%	$403,258	$14,483	6	$107,348
	Connecticut	63	0.32%	$138,072	$4,959	2	$36,755
	California	54	0.27%	$118,348	$4,251	2	$31,504
	Ohio	34	0.17%	$74,515	$2,676	1	$19,836
	Others	379	1.92%	$830,624	$29,832	12	$221,113
Delaware		7,912	40.02%	$17,340,106	$622,782	250	$4,615,949
Counties:							
	Kent	448	2.27%	$981,846	$35,264	14	$261,368
	New Castle	2,028	10.26%	$4,444,608	$159,631	64	$1,183,158
	Sussex	5,427	27.45%	$11,893,928	$427,178	171	$3,166,172
Beach Communities:		3,731	18.87%	$8,176,938	$293,680	118	$2,176,707
	Bethany	1,055	5.34%	$2,312,160	$83,043	33	$615,499
	Dewey Beach	32	0.16%	$70,132	$2,519	1	$18,669
	Fenwick Island	216	1.09%	$473,390	$17,002	7	$126,017
	Henolopen Acres	2	0.01%	$4,383	$157	0	$1,167
	Rehoboth Beach	2,268	11.47%	$4,970,597	$178,522	72	$1,323,176
	South Bethany	157	0.79%	$344,085	$12,358	5	$91,596
	North Bethany	1	0.01%	$2,192	$79	0	$583

EXHIBIT 6-2: STATE OF RESIDENCE, BEACH VISITORS

(Based on all visitors to Delaware who travel more than 50 miles and/or remain overnight)

STATE OF RESIDENCE	VISITORS	PERCENT	LOSS, 5 YEARS WITHOUT NOURISHMENT	
			VISITORS	CONSUMER'S SURPLUS
Total	**12,969,000**	**100.00%**	471,282	$20,113,094
Maryland	2,931,000	22.60%	106,510	$4,545,569
Pennsylvania	2,540,000	19.59%	92,301	$3,939,183
New Jersey	2,500,000	19.28%	90,848	$3,877,148
New York	1,259,000	9.71%	45,751	$1,952,532
Virginia	1,077,000	8.30%	39,137	$1,670,275
Delaware	1,068,000	8.24%	38,810	$1,656,318
Connecticut	250,000	1.93%	9,085	$387,715
Massachusetts	199,000	1.53%	7,231	$308,621
Florida	136,000	1.05%	4,942	$210,917
West Virginia	135,000	1.04%	4,906	$209,366
Georgia	127,000	0.98%	4,615	$196,959
North Carolina	121,000	0.93%	4,397	$187,654
District of Col.	95,000	0.73%	3,452	$147,332
California	93,000	0.72%	3,380	$144,230
South Carolina	70,000	0.54%	2,544	$108,560
Missouri	65,000	0.50%	2,362	$100,806
Illinois	51,000	0.39%	1,853	$79,094
Ohio	51,000	0.39%	1,853	$79,094
Other	201,000	1.55%	7,304	$311,723

APPENDIX A: HEDONIC MODEL

I. THEORETICAL MODEL

To estimate the effects of beach nourishment efforts on property values, we used a hedonic modeling approach. The hedonic approach relates the value of a commodity to the attributes or characteristics of that commodity. It assumes that commodities sold in the market are composites of various goods (attributes) not sold individually in the market but for which there are individual levels of demand. The price of an aggregate (or composite) commodity is determined in part by the various combinations of attributes that form the aggregate and the different levels of demand for each.

The hedonic approach has been used in many studies to estimate the value of shore replenishment. In these studies, the aggregate commodity of interest is the housing market. In general, the price of a house is assumed to be a function of its structural attributes (number of bedrooms, etc.) and its neighborhood or location characteristics, e.g., quality of school district. In coastal areas, distance from the beach and the quality of the beach (neighborhood characteristics) are thought to be important determinants of housing prices and are, therefore, independent variables used in those beach value studies. These variables capture what may be called the recreational or esthetic benefit of the shoreline. Other important predictors include the erosion rate along the shore, the presence of a dune and/or beachhead, and beach width. These factors affect the flood sites associated with coastal properties and therefore these prices.

Our modeling effort started with a very general theoretical specification of the equations needed to assess the impact of nourishment projects on coastal housing prices. Three equations were considered. The first equation is the hedonic equation that relates the price of a given piece of property to its characteristics:

$$P = f(S, Dist2Bch, BQ, ONC) \qquad (1)$$

where P is the property price, S is a vector of structural characteristics (e.g., number of bedrooms, number of baths, etc.), *Dist2Bch* is the distance from the house to the beach, BQ refers to an index of beach quality, and ONC is a vector of other neighborhood characteristics (e.g., number of restaurants in close proximity). Notice that each property is associated with a particular beach. In actuality, many coastal properties are in proximity to many different beaches. We introduced this simplification to keep the model tractable. However, this required us to assign a beach area to each property. The southern Delaware coast was divided into twenty-four reaches and each property was associated with one of those reaches. Since beach access on some reaches is restricted by zoning and/or property ownership along the beach, the distance measure used in the model was estimated based on the route a person would have to take to reach the beach.

The second equation specifies beach quality as a function of beach characteristics; namely,

$$BQ = g(BW, C) \qquad (2)$$

where *BW* is beach width and *C* is congestion. Other beach characteristics, such as type of sand, could also be introduced into this equation.

Beach width for a given reach is then assumed to be a function of nourishment efforts and erosion rates not only on that reach but also on adjacent reaches.

$$BW_R = h(N_L, N_P, E, BW_{R,L}, Y1, Y2) \qquad (3)$$

where *R* refers to the reaeh, N_L refers to a vector of the last or most recent nourishment efforts on the given reach as well as on adjacent reaches, N_P refers to a vector of the latest prior nourishments undertaken on the given and adjacent reaches, *E* refers to a veetor of erosion rates on the given and adjacent reaches, BW_{RP} is thc beaeh width on reach *R* at the time of the prior nourishment project, Y1 is a vector of the number of years between the prior and latest nourishment projects on the given and adjacent reaches, and Y2 is a vector of the number of years since the last nourishment effort was undertaken - for the given and adjacent reaches.

II. DATA SOURCES AND LIMITATIONS ON VARIABLES USED

Before developing the empirical specification, we had to evaluate the available data to determine which variables could be included in regressions. Two data sources were considered for structural characteristics: the Multiple Listing Service (MLS) and data obtained from Sussex County.

The real estate industry maintains the Multiple Listing Service database to track information about properties sold. The electronic files we received included information on property type (e.g., condos vs. single family homes), number of bedrooms, number of baths, square footage, lot square footage, year built, transaction date, and selling price. The file contained much information that was not useful (e.g., name of agent), or could not be identified because it was not labeled. We had hoped that this file would provide us with information on the presence of a garage, the presence of an air conditioner, etc., but we were reluctant to guess which columns contained those variables since many fields were unlabeled. In addition, missing values made us uncertain about how missing values were treated in the logical fields (i.e., contained only zeros or ones).

Regarding the items that we could identify, many had considerable amounts of missing data. These included square footage, lot square footage, and year built. Almost no data were missing for the number of bedrooms, number of baths, transaction date, and selling price.

The file contained data primarily for two years (1995 and 1996) and included many duplicate records that had to be identified and eliminated before the data set could be used. After the file was processed and cleaned, it contained about 1,200 observations with complete data for the number of bedrooms, number of baths, transaction date, and sale price.

The Sussex County Courthouse data contain information on each piece of property in the state of Delaware. We evaluated this database, which contained approximately 40,000 records for coastal Delaware, to see if we could use it in place of the MLS data or to supplement it. While the file does mention a price, there is not a corresponding transaction date, which is needed to determine the property's current value. In addition, the prices in this file frequently appear to refer to the cost of additions or modifications made to the property. These things meant we could not use the courthouse data to determine property values and therefore had to rely on the MLS data for that information. We attempted to use the courthouse data for other information but ran into difficulties there as well. The file contains three description fields which were originally thought to contain useful information; however, those fields primarily consisted of location identifiers and were not consistently formatted—i.e., a very manually intensive process would have been required to retrieve any information out of them. The fields were dropped from further consideration and, instead, original courthouse records were used to fill in some missing MLS blanks on square footage, lot size, and year built. However, even that information was sparse and still left many gaps. In addition, there were significant discrepancies between some items (square footage and lot size) for which we had comparable courthouse and MLS data. In the end, we used only the additional "year built" courthouse data to supplement the MLS data set. Since we were trying to maximize the number of observations that could be used, we decided that we would not use the square footage and lot size variables. It is likely that these variables are strongly correlated with the number of bedrooms and number of baths and using them would have significantly reduced our sample size because of the large number of missing observations in those variables.

III. EMPIRICAL MODEL

Given the data availability and limitations cited above, we had to translate the general theoretical model into a working model that eould be estimated using regression analysis. The most significant change that had to be made entailed eliminating the seeond and third equation because it was not possible to estimate them. The second equation eould not be estimated because we do not have data on beach quality or eongestion. Estimating the third equation was not possible because we only have beach data for a single point in time, whereas we would need time series data to estimate that equation. An implication was that we needed to use a proxy for the beach quality variable in the hedonic equation. Two options were deemed possible; use beach width as proxy or use a combination of nourishment level and erosion rates as the proxy. The first approach is conceptually easier to estimate and the approach we chose to use. The second approach eould be attempted in future work and is discussed below.

Two things should be noted about using beach width as a proxy for beach quality. First, since we only have beach width data for one point in time, we had to estimate a cross-sectional regression using structural characteristic data for a similar period. The MLS data set consists mostly of transactions that occurred three to four years after the beach width measurement, but this was considered to be acceptable. Earlier data on property transactions that we had thought about including in the data set were considered too far away in time from the beach width measurement point and, therefore, were not included in the regressions. The second point is that we did not include a nourishment variable in the regressions, since the change in price due to the change in beach width captures the value of nourishment projects to property owners.

The following equation defines the core set of variables used in the regressions:

$$P = (Bedrooms,\ Baths,\ Dist2Bch,\ BW) \qquad (4)$$

In hedonic models such as these, a Box-Cox test (or specification) is often used to determine whether to use a linear or log-linear specification. However, signs of heteroscedasticity were evident in scatterplots of priee against number of bedrooms and price against distance to beach. Therefore, we used the log of price as the dependent variable to help mitigate this problem.[1]

[1] The variance in housing prices is negatively correlated with distance from the beach. The spread in prices is very large for properties close to the beach and is relatively smaller for properties further away from it. Using a logarithmic transformation of price helped mitigate this problem since the mapping had a relatively larger impact on the wider price spreads than it did on the more narrow spreads (e.g., ln(1) = 0 whereas ln(100) = 4.6). The result was to convert the larger prices into more narrow bands.

Scatterplots of *ln(P)* against number of bedrooms then revealed a linear relationship. A scatterplot of *ln(P)* against distance to beach indicated a squared relationship in which *ln(P)* declined as distance increased, and then reversed and started to increase at approximately 6,000 feet away from the beach. Therefore, we transformed *Dist2Bch* variable into the following variable: *Distance* = $(Dist2Bch-6000)^2$. Scatterplots of *ln(P)* against number of baths and beach width did not indicate any obvious relationship so we assumed both were linear. This led to the following regression equation:

$$ln(P) = A0 + \beta_1 \cdot Bedrooms + \beta_2 \cdot Baths + \beta_3 \cdot BeachWidth + \beta_4 \cdot Distance + e \qquad (5)$$

Given this specification, the interpretation of the coefficients needs some explanation. Here B_3 measures the change in *ln(P)* due to a one foot change in beach width. This implies that the change in price due to the change in beach width is equal to the following:

$$\beta_3 = \frac{\partial \ln(P)}{\partial BW} = \frac{\partial P}{\partial} BW \cdot \frac{1}{P} \rightarrow \frac{\partial P}{\partial BW} = \beta_3 \cdot P \qquad (6)$$

Since *P* occurs and is estimated for each record in the sample data used to run the regression, the change in price due to the change in beach width is similarly estimated for every data point. This means that to calculate the benefits of a nourishment project to the total community, we need an estimated price for each Delaware shore property affected by beach width. Since that price information is not available, we had to rely upon 1990 Census data which gives average property values for different areas.

We attempted to improve the model by accounting for differences in communities that exist along the coast. Two approaches were used: adding dummy variables or running the regressions separately for each community/reach. Overall, we did not see a significant improvement in the model results. There are a couple of possible reasons for this. First, when we used dummy variables, we did not include interaction terms. This means that the dummies only affected the intercept estimated in the regression, but not the slope coefficients. However, if communities are differentiated by various beach widths, then the marginal change in price due to a one foot change in *BW* could differ significantly across those communities. We did not capture this effect in the dummy variable approach and could introduce interaction dummies in future work in an attempt to do so. Why we did not see improved results when we estimated the regressions separately for each community could be because we applied the same overall model specification to each community. Developing separate specifications for each community might improve the results.

In addition to these possible improvements, there are several other efforts that could be undertaken that might lead to better results. First, it is likely that the impact of changes in beach width on property price is a function of how far away the property is located from the beach. Two approaches could be taken to incorporate this effect. For instance, separate regressions could be estimated for different groups of properties depending on their distance from the beach. The second approach would be somewhat easier to implement and would entail adding to the existing model an interaction term between distance and beach width. Even if better results were obtained from one of these approaches, we still might run into difficnlties in expanding the results to thc community. Inventories and priees would have to be developed for each property group defined by their proximity to the beach.

A more involvcd effort that might lead to better results would entail replacing the bcach width variable with the nourishment and erosion rate data. While more complicated (we would need to incorporate nourishment projeets and erosions rates on adjacent reaches, as indicated in equation 3), such an approach might allow us to cxpand our data set to include earlier data.

IV. MODEL RESULTS

The statistical results of the estimated regressions are presented below. The model fit is indicated by the Adjusted R2, which is 0.637. The model was found to be somewhat robust as few of the specifications we estimated generated R2s that were significantly different from this. Given that the model only included two structural characteristics and did not take into account things like maintenance on the property or general appearanee, the 0.637 R2 is considered to be fairly good. Note that eaeh of the core variables is significant at a 93% confidence level, while most of the community dummies (C2-C7) are insignificant.

Model: MODEL1
Dependent Variable: LNPRICE

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob
Model	10	192.92242	19.29224	205.780	0.00
Error	1157	108.47060	0.09375		
C Total	1167	301.39302			

Root MSE	0.30619	R-square	0.6401
Dep Mean	12.09558	Adj R-sq	0.6370
C.V.	2.53141		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	10.768199	0.05394216	199.625	0.0001
BEDROOMS	1	0.164970	0.01153275	14.304	0.0001
BATHS	1	0.243300	0.01505268	16.163	0.0001
DIST2BCH	1	0.014280	0.00076054	18.777	0.0001
ERF2DRY	1	0.000981	0.00046401	2.115	0.0346
C2	1	0.018665	0.04706171	0.397	0.6917
C3	1	-0.030122	0.04013791	-0.750	0.4531
C4	1	0.003307	0.04344525	0.076	0.9393
C5	1	-0.051814	0.04447674	-1.165	0.2443
C6	1	-0.128092	0.04014465	-3.191	0.0015
C7	1	0.136635	0.03917756	3.488	0.0005

C1 = Fenwick Island
C2 = South Bethany
C3 = Sea Cikibt
C4 = Bethany
C5 = North Bethanby
C6 = Dewey Beeh
C7 = Rehoboth

APPENDIX B: BEACH WIDTH BY STATION, 1992 AERIAL PHOTOGRAPHY

Location	Measurement Station (100 ft increments from MD border)	Reference Feature to Dry Sand (ft)	Reference Feature to Swash (ft)	Reference Feature to Building Set Back (ft)	Distance to Rt 1 Center Line (ft)	Distance to Alternate Center Line (ft)
State Line	0	-10	-240	60	610	-
Unincorp. Fenwick	5	-10	-230	50	600	-
"	10	-10	-220	50	610	-
"	15	-20	-200	40	600	-
Incorp. Fenwick	20	-40	-180	40	610	-
"	25	-40	-180	25	600	-
"	30	-40	-160	30	600	-
"	35	-30	-150	40	620	-
"	40	-30	-150	30	620	-
"	45	-40	-150	40	600	-
" (LRP 66)	50	-40	-160	25	560	-
"	55	-30	-140	20	550	-
Unincorp. Sussex	60	-30	-150		520	-
" (park)	65	-50	-200	-	440	-
"	70	-50	-200	-	400	-
"	75	-50	-190	-	400	-
"	80	-50	-210	-	400	-
"	85	-30	-220	-	420	-
"	90	-40	-230	-	400	-
Ocean Park Lane	95	-60	-230	30	400	-
Ocean Park La (LRP 65)	100	-60	-210	40	400	-
Unincorp Sussex	105	-60	-210	120	400	-
" (park)	110	-60	-200	50	390	-
"	115	-60	-200	60	380	-
"	120	-80	-160	190	400	-
"	125	-60	-180	220	460	-
"	130	-80	-190	220	500	-
"	135	-80	-190	-	550	-
"	140	-80	-190	-	610	-
"	145	-90	-190	-	660	-
"	150	-100	-210	-	700	-
"	155	-100	-200	-	740	-
"	160	-80	-170	-	770	-
"	165	-100	-200	-	820	-
"	170	-100	-200	-	820	-
"	175	-80	-180	-	790	-
"	180	-100	-180	-	720	-
"	185	-90	-190	-	640	-
"	190	-60	-180	-	580	-
"	195	-20	-190	-	500	-
" (LRP 63)	200	-20	-180	-	450	-
"	205	-20	-180	-	460	-
S. Bethany	210	0	-160	-90	460	-
"	215	0	-160	-90	460	-
"	220	0	-160	-90	450	-

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"	225	0	-180	-90	440	-
" (LRP 62A)	230	0	-180	-90	450	-
"	235	0	-180	-90	440	-
"	240	0	-180	-90	440	-
"	245	0	-180	-90	440	-
Middlesex	250	-50	-180	40	450	-
"	255	-30	-180	30	460	-
"	260	-30	-180	40	480	-
"	265	-20	-190	50	480	-
Sea Colony	270	-20	-190	70	500	430
"	275	-20	200	70	600	450
"	280	-30	-200	150	960	500
"	285	-20	-200	80	1280	560
"	290	-20	-200	30	1300	630
Bethany	295	-20	-140	30	1360	750
"	300	-20	-150	40	1380	760
"	305	-40	-150	30	1380	780
"	310	-40	-130	40	1400	800
"	315	-30	-90	20	1450	850
"	320	-20	-110	20	1500	840
"	325	-20	-120	30	1480	860
"	330	-20	-110	20		
" (LRP 60A)	335	-30	-150	80		
"	340	-40	-160	40		
Unincorp. sussex	345	-40	-190	60		
" (LRP 60)	350	-50	-210	60		
"	355	-80	-240	60	700	
"	360	-80	-240	50	700	
"	365	-80	-220	80	740	
" (LRP 59)	370	-90	-210	80	760	
"	375	-90	-220	100	780	
"	380	-100	-240	90	760	
"	385	-90	-240	80	770	
"	390	-70	-220	70	760	
"	395	-50	-170	20	810	
"	400	-60	-190	-	820	
"	405	-70	-200	40	840	
"	410	-60	-170	60	870	
"	415	-50	-170	50	860	
"	420	-60	-180	30	840	
" (LRP 58)	425	-50	-190	30	820	
"	430	-50	-190	20	800	
"	435	-60	-180	40	790	
"	440	-60	-180	40	790	
"	445	-70	-180	50	800	
"	450	-70	-180	50	800	

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Location	Measurement Station (100 ft increments from MD border)	Reference Feature to Dry Sand (ft)	Reference Feature to Swash (ft)	Reference Feature to Building Set Back (ft)	Distance to Rt 1 Center Line (ft)	Distance to Alternate Center Line (ft)
"	455	-80	-200	40	760	
"	460	-80	-200	50	740	
"	465	-70	-200	70	740	
" (LRP 57)	470	-60	-180	40	740	
"	475	-70	-180	30	760	
"	480	-70	-180	70	760	
"	485	-90	-200	60	760	
"	490	-70	-190	20	800	
"	495	-100	-220	10	780	
"	500	-160	-240	-	700	
"	505	-220	-350	350	620	
park	510	-220	-380	-	600	
"	515	-180	-360	-	580	
"	520			-		
" (LRP 56)	525			-		
"	530			-		
"	535			-		
"	540			-		
"	545			-		
"	550			-		
"	555			-		
"	560			-		
" (LRP 55)	560			-		
Indian River Inlet						
DSSP	835	-40	-200	-	630	
"	840	-30	-200	-	600	
Indian Beach	845	-30	-210		600	
"	850	-20	-200	60	650	
"	855	-20	-180	60	720	
"	860	-20	-180	20	760	
N Indian Beach	865	-20	-160	-80	800	
Dewey Beach	870	-20	-170	40	780	
"	875	-10	-160	20	720	
"	880	-10	-150	-10	700	
" (LRP 47)	885	-10	-140	-50	670	
"	890	-10	-180	0	620	
"	895	-20	-160	-10	600	
"	900	-20	-160	0	610	
"	905	-20	-180	-10	720	600
"	910	-30	-180	0	1120	580
"	915	-20	-180	20	-	600
"	920	-20	-200	20	-	600
"	925	-40	-260	0	-	600
Silver Lake	930	-30	-270	60	-	-
Rehoboth	935	-40	-270	50	-	-
"	940	-30	-270	80	-	-

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Location	Measurement Station (100 ft increments from MD border)	Reference Feature to Dry Sand (ft)	Reference Feature to Swash (ft)	Reference Feature to Building Set Back (ft)	Distance to Rt 1 Center Line (ft)	Distance to Alternate Center Line (ft)
"	945	-20	-270	70	-	-
"	950	-30	-270	60	-	-
"	955	-30	-240	80	-	-
"	960	-30	-210	30	-	-
"	965	-100	-200	20	-	-
"	970	-100	-190	20	-	-
"	975	-80	-160	30	-	-
"	980	-70	-160	40	-	-
"	985	-70	-150	10		-
"	990	-70	-150	10		-
"	995	-30	-120	60		-
"	1000	-90	-190	-		-
"	1005	-100	-190	-		-
"	1010	-100	-190	-		-
Henlopen Acres	1015	-100	-180	-		360
"	1020	-100	-190	-		340
"	1025	-110	-190	-		300
"	1030	-60	-160	50		260
North Shores	1035	-80	-180	30		210
"	1040	-80	-170	0		200
"	1045	-80	-170	40		200
"	1050	-100	-180	40		200