CAPE COD
COMMISSION

Water Quality and Cape Cod's Economic Future: Nitrogen Pollution's Economic Impact on Homes and Communities

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An analysis of the effect of impaired water quality due to nitrogen pollution on Cape Cod's housing market

Executive summary

Cape Cod depends on the quality of its water resources to drive its tourism-led seasonal economy. Nitrogen from septic systems leaching into groundwater and ultimately reaching surrounding coastal waters is an existing and future threat to the quality of water resources. Excessive nitrogen is the documented cause of severe eutrophication in a majority of Cape Cod's estuaries. As housing has expanded, the potential for nitrogen pollution has as well.

Waterfront homes on the Cape derive a significant portion of their value from their ocean views and proximity to water-based recreational activities. Water with high levels of nitrogen becomes cloudy and unattractive. Waterfront homes that are surrounded by low-quality water lose value, as their views are less attractive and water-based recreation seems less appealing. Lower home values reduce the tax base and shift tax burdens among property owners. There is a concern across the Cape that ubiquitous nitrogen pollution may lead to a shift in tax burden toward those less able to pay.

A new study from the Cape Cod Commission based in the Three Bays area of the Town of Barnstable developed an economic model to examine how water quality affects the price of a single-family home. The study found high levels of nitrogen decreased a home's value, where a 1% decline in water quality led to an average loss in home value of 0.61%, after controlling for other factors. This finding will have a notable effect on coastal areas, with potential ripple effect across the entire region's economy. During the study period 2005-2013, water quality in Three Bays degraded by 15.8%. If applied Cape-wide, the study suggests towns could see their tax bases decline by hundreds of millions of dollars if nitrogen levels continue to rise; while homeowners would lose equity on their home investment.

At the local and regional levels, continued impairment of water quality is likely to have ripple effects beyond lower property sale prices and the consequent fiscal impact on the community. From a Cape-wide survey of residents, if the water quality became worse, 31% of the respondents mentioned they would change or stop recreational behavior, such as fishing and swimming, while 8% of the respondents mentioned moving away from the Cape.

Focus groups of long-term residents in the study sites reinforced findings that water quality has been degrading over a generation and is dissuading recreational activities. Participants multiple focus groups confirmed that while preserving the quality of water in this unique location is a primary concern for them, further degradation could cause some of them to move away from the impaired embayment, if not the Cape itself.

An important implication of the findings is that as property taxes collected from coastal residents declines as a consequence of degrading water quality, the burden on inland residents may increase due to towns raising property tax rates to make up for reduced revenues from coastal properties.

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Environmental Economist,
Cape Cod Commission

WATER QUALITY AND CAPE COD'S ECONOMIC FUTURE: NITROGEN POLLUTION'S ECONOMIC IMPACT ON HOMES AND COMMUNITIES

An analysis of the effect of impaired water quality due to nitrogen pollution on Cape Cod's housing market

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Introduction

Cape Cod's tourism-based economy depends on clear, attractive beaches and coastal waters. For home buyers on the Cape, especially those purchasing vacation homes, ocean views and access to water-based recreation can be a key factor in their purchase decisions. A home's sale price is a factor the property tax base of the town, the largest revenue source for a community to pay for schools, public safety, infrastructure and other essential public services.

Most houses on the Cape use on-site septic systems. Nitrogen leaches out of these systems, seeping into groundwater and ultimately reaching the surrounding coastal waters. Fertilizer for lawns represents another source of nitrogen pollution. Excessive nitrogen in water leads to eutrophication, where an overgrowth of nitrogen-fed algae makes water appear murky and harms the ecosystem. Eutrophication is a problem in the majority of Cape Cod’s saltwater estuaries. Low water quality and eutrophication can reduce the appeal of water-based recreation, and dull the appearance of ocean views.

This report reviews the issue of low water quality due to excess nitrogen, describes a new study that combines geographic data, water quality measurements, input from local residents and economic modeling to assess the impact of low water quality on single-family housing prices, and explains what the study's outcome could mean for the future of the Cape. A detailed explanation of background material and methodology is included in the Appendix.

CAPE PROPERTIES AND WATER QUALITY

Housing prices are important not only for individuals who are buying or selling property, but for the community at large. A house's price is a combination of many factors, including both the house itself (size, quality, age), and nearby amenities (waterfront, beaches, neighborhood, schools). For those buying second or vacation homes on Cape Cod, features such as waterfront views and proximity to water for recreational purposes are one of the most important amenities. If the water quality in nearby bays or inlets declines, or appears murky, water views become less attractive and water-based recreation is less appealing. The loss of these features can lead to lower sales value.

Lower home sale values have a community-wide impact. A home's sale price among other factors determine how much its owners will pay in property taxes, which represent an important source of revenue for the town. Poor water quality due to high levels of nitrogen affects not just one or two houses, but an entire inlet, bay or coastal area. A large number of homes in an affected area may derive a great deal of value from their waterfront locations or proximity to waterfront recreational opportunities. If the assessed value for all of those homes declines, a town's property tax base will shrink over time, and worse, property tax burdens will shift.

A majority of the Cape's coastal waters suffer from some level of nutrient pollution. Too much nitrogen in an aquatic system will cause an excess growth of algae, clouding the water and reducing clarity. As the algae dies, its decomposition reduces the surrounding water's oxygen concentration, which can kill fish and other marine life.

Cape Cod's two largest nitrogen sources are septic systems and lawn fertilizer. Septic systems leach nitrogen into the ground, which eventually contaminates the surrounding groundwater. Lawns frequently have excess fertilizer applied. This excess washes away, flowing into nearby groundwater and streams. Both eventually drain into a local embayment. Growth in the housing market over time (See Figure 1) increased the number of septic systems and amount of fertilizer, leading to declining water levels across the Cape.

For an enhanced understanding of how crucial clean water is for the Cape, the Cape Cod Commission surveyed 650 year-round residents about their water-based recreational activities. Their responses to the questions about how they currently use Cape Cod's waters, and how poor water quality might change these, are shown in Figure 2. From a list of options, a plurality of participants (36%) said they most enjoyed water vistas, followed by swimming (24%), boating (21%) and fishing (14%). When asked how they might change their behavior in response to worse water quality in the future, 27% of the survey participants said they would not change their behavior, and 22% said they were uncertain or did not know. The majority of respondents (51%) said they would change how they used the Cape's waters. Of this 51%, 31% responded that they would change their recreational behavior or stop doing that activity, 12% would stop using the water for recreation all together, and 8% would consider leaving the Cape for a location with better-quality water (Figure 3).

This survey demonstrates the importance of clean water for the Cape's economy. Lower-quality water due to excess nitrogen would impact or reduce the appeal of each of these water-dependent recreational activities. As eutrophication sets in, water becomes cloudy and algae filled, harming both the visual and recreational appeal. Eutrophication also harms fishing by lowering aquatic oxygen concentration, which suffocates fish and reduces animal life in the area. Because the survey did not include seasonal residents or visitors, their recreational water use and responses to lower quality were not captured.

The willingness of 20% of year-round residents to stop using the water or move elsewhere would be magnified if visitors were included; visitors can easily choose to visit other locations. Given the Cape's tourism-based economy, a loss of visitors could be catastrophic to the region.

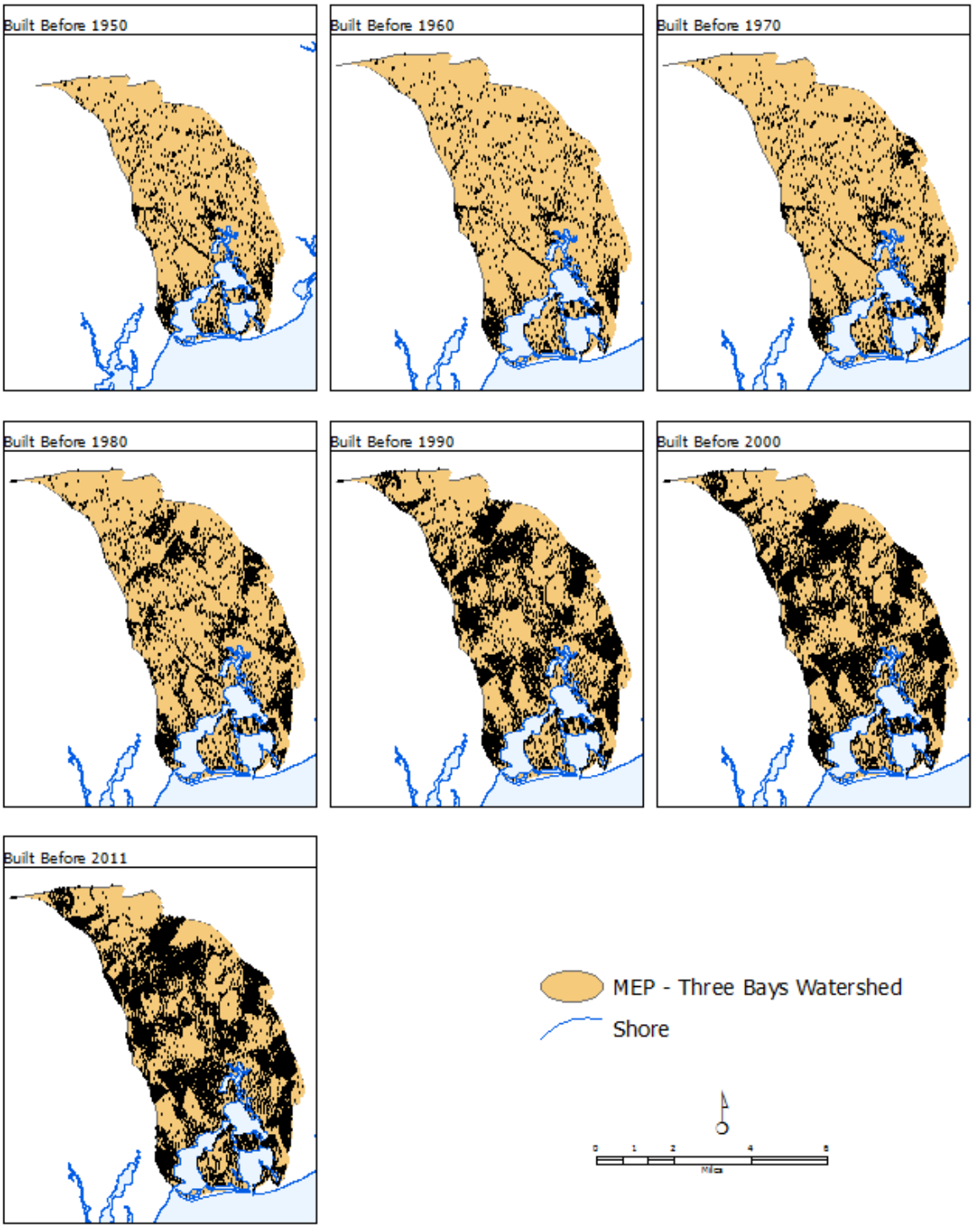


FIGURE 1: PROPERTY DEVELOPMENT IN THE THREE BAYS WATERSHED

As of 2013, there are 40,349 properties Cape-wide that are within one kilometer/a little over a half-mile of the coast, or about a 10-minute walking distance. Even a marginal impact on property values due to nitrogen-impaired water quality could have a significant impact on the regional economy. To better understand what nitrogen-impacted water quality means for the Cape and its residents, the Commission designed a study that examined if, and to what extent, increased nitrogen concentration has affected home prices.

The site chosen for the study is the Three Bays watershed, located on the south coast of the town of Barnstable. Three Bays supports a variety of recreational uses including boating, swimming, shellfishing and fin fishing. Like the rest of Cape Cod, the Three Bays watershed saw a dramatic increase in residential property development between 1950 and today (Figure 4). About 60% of the growth has occurred in the last 30 years. A consequence of the residential growth is the increase in the number of fertilized lawns and septic systems and increased nitrogen outflow into the embayment. The Three Bays watershed discharges its nutrient load into the Three Bays embayment, affecting both the natural habitat and recreational activities of its residents. The Massachusetts Department of Environmental Protection has rated the embayment as "seriously degraded to moderately degraded," and classified it as an impaired water body. The Massachusetts Estuaries Project (MEP) attributes the embayment's severe eutrophic conditions to an overload of nitrogen from the contributing watershed.

WATER ACTIVITIES CAPE COD RESIDENTS ENJOY

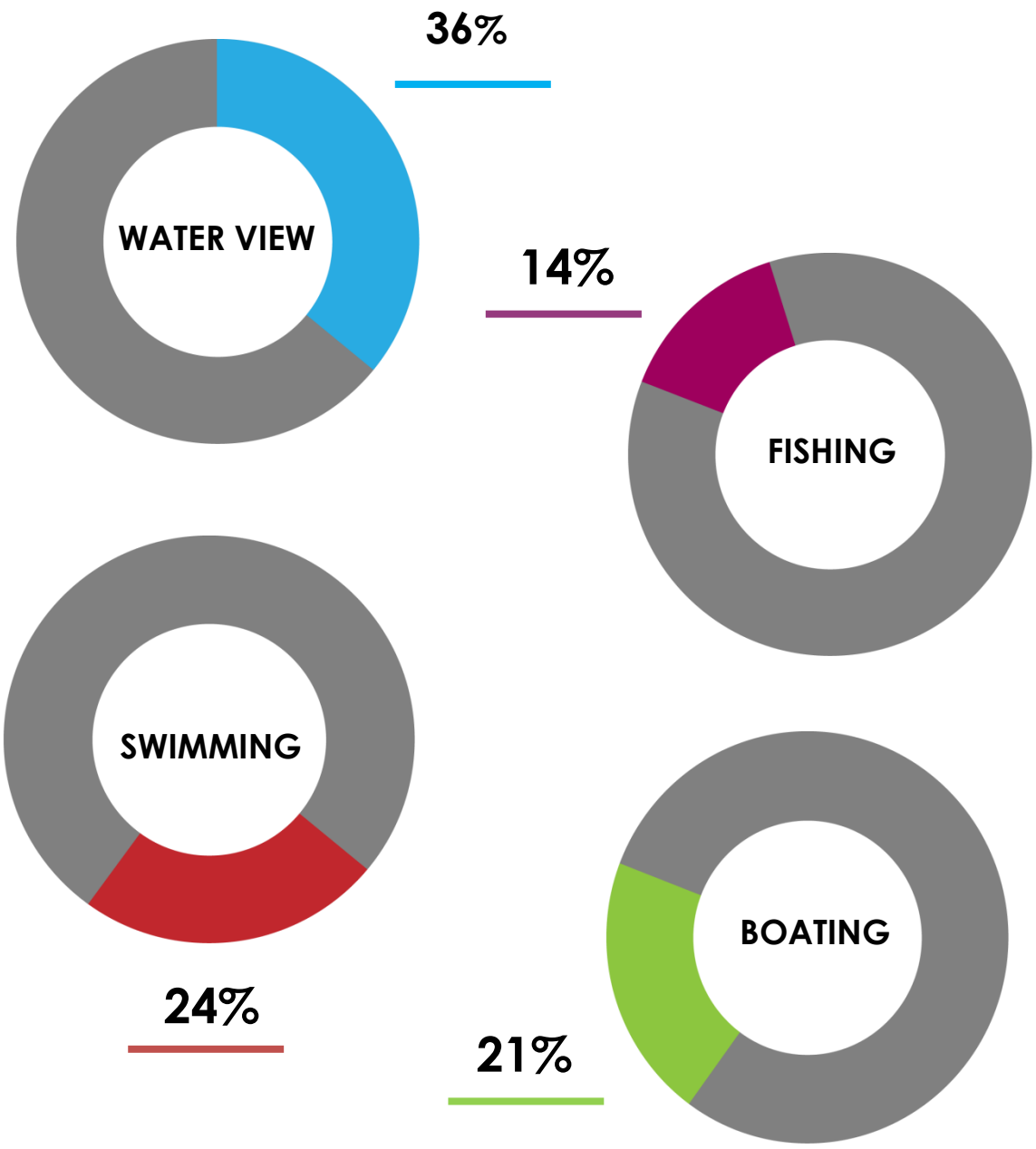


FIGURE 2: WATER ACTIVITIES CAPE COD RESIDENTS ENJOY

IF THE WATER QUALITY BECAME WORSE, WHAT WOULD YOU DO?

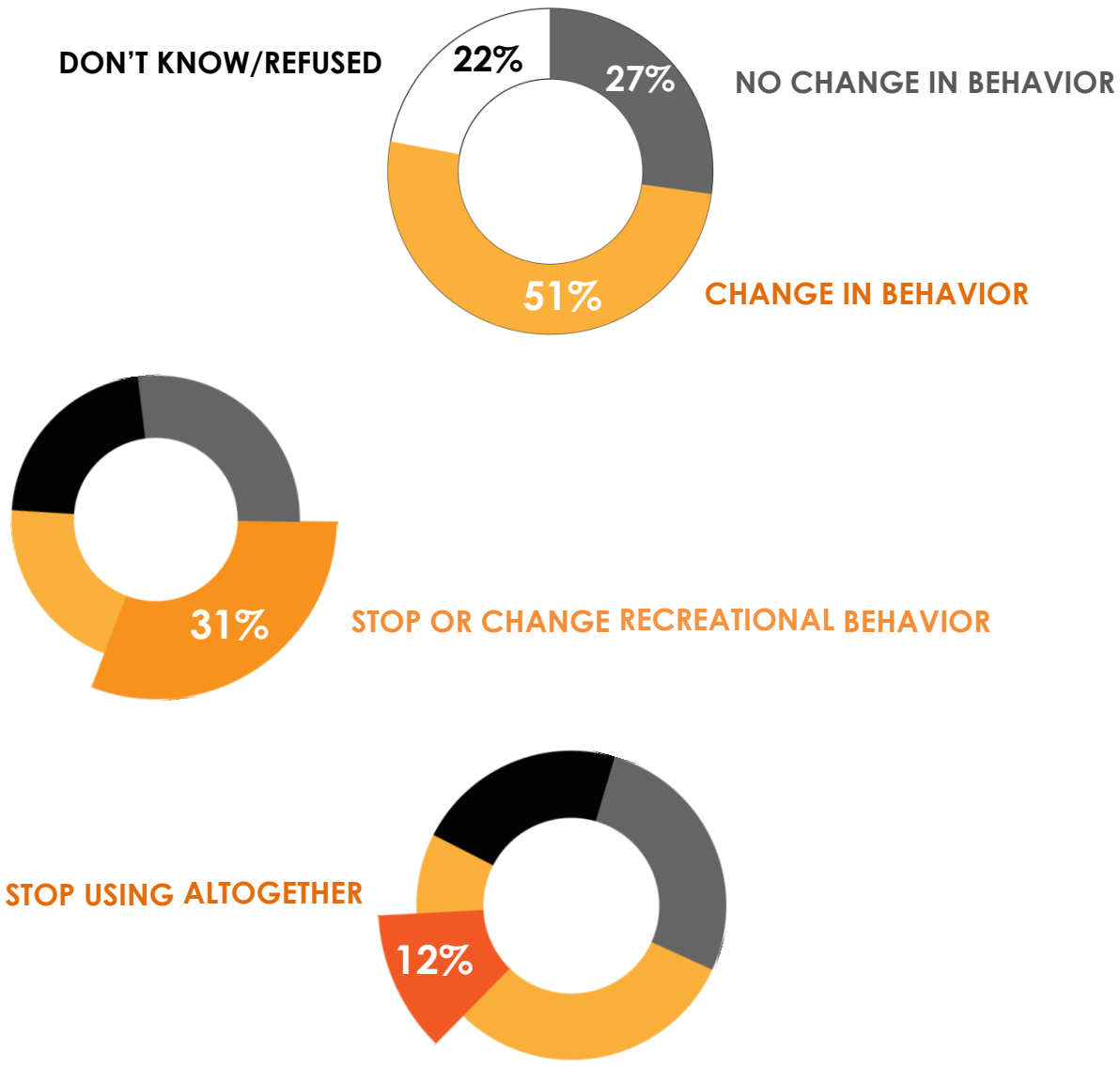
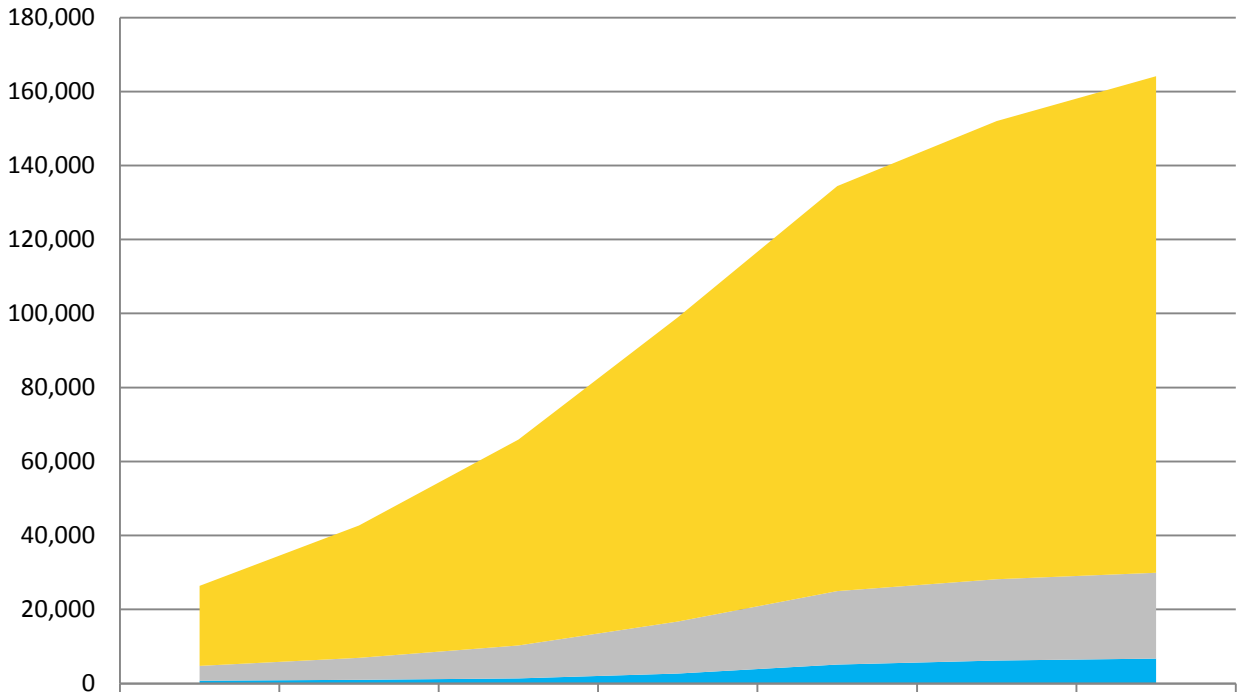


FIGURE 3: IF THE WATER QUALITY BECAME WORSE, WHAT WOULD YOU DO?

There are 18 water quality monitoring stations in the embayment. Water quality monitoring data from Barnstable Department of Public Works is used to calculate the nitrogen concentration for each of the 18 stations, for each year between 2002 and 2013. Figure 5 presents the average nitrogen concentration in the embayment compared to the threshold set by the Massachusetts Estuaries Project for Three Bays. The embayment has been far above the 0.38 threshold for a "healthy" water body for over a decade. Between 2002 and 2013, nitrogen concentration increased by 27% (0.5510 to 0.7559 MgL).

In the past decade, homes in the Three Bays region have sold for nearly twice as much as those in the rest of Barnstable County, and more than double the median prices in Massachusetts as a whole, as shown in Figure 6. Many homes near the waterfront cost nearly three times more than median prices on the rest of the Cape. Although Three Bays property prices declined between 2007 and 2009, the total assessed property value in the study site alone is worth around three billion dollars (Figure 6). Any loss in home value in this area could translate into a significant impact in terms of dollar magnitude.

FIGURE 4: TREND IN RESIDENTIAL PROPERTY DEVELOPMENT OVER SIX DECADES



	Before 1950	1950- 1959	1960 - 1969	1970 - 1979	1980 - 1989	1990 - 2000	2000 - present
Capewide Sum (All 15 Towns)	21,630	35,772	55,643	82,219	109,457	123,835	134,209
Town of Barnstable	3,993	5,935	8,896	14,054	19,859	21,976	23,199
Three Bays Watershed	768	998	1,382	2,693	5,121	6,207	6,731

Note: The numbers under each time period above is the cumulative total of development up to that point.

THE STUDY: WATER QUALITY AND HOME PRICES

In order to understand the potential effect of water quality degradation on property values, the Commission developed a study that used a combination of geostatistical analysis, focus groups, and GIS-based hydrological modelling. Data was drawn from property sales and assessment data, water quality sensors in the Three Bays embayment collected by Barnstable County's Department of Public Works, and Cape Cod Commission's GIS division. The inconsistency in the availability of data on all three fronts restricted the analysis to period between 2005 and 2013. There are 6,731 households in the Three Bays watershed, or about 5.2% of all households on the Cape. Of the 6,731 households, one third (2,435) are one kilometer/half mile from water, or within a 10-minute walk, as displayed in Figure 7. A detailed explanation of the study's methodology and results are included in the Appendix.

To map nitrogen levels across the Three Bays embayment, this study gathered data from 18 government-owned water quality measurement stations around the embayment and used geostatistical methods to generate a map displaying nitrogen concentration across the embayment over the study period. This surface is visible Figure 8.

FIGURE 5: TREND IN NITROGEN LEVELS OVER TIME IN THREE BAYS WATER (MGL)

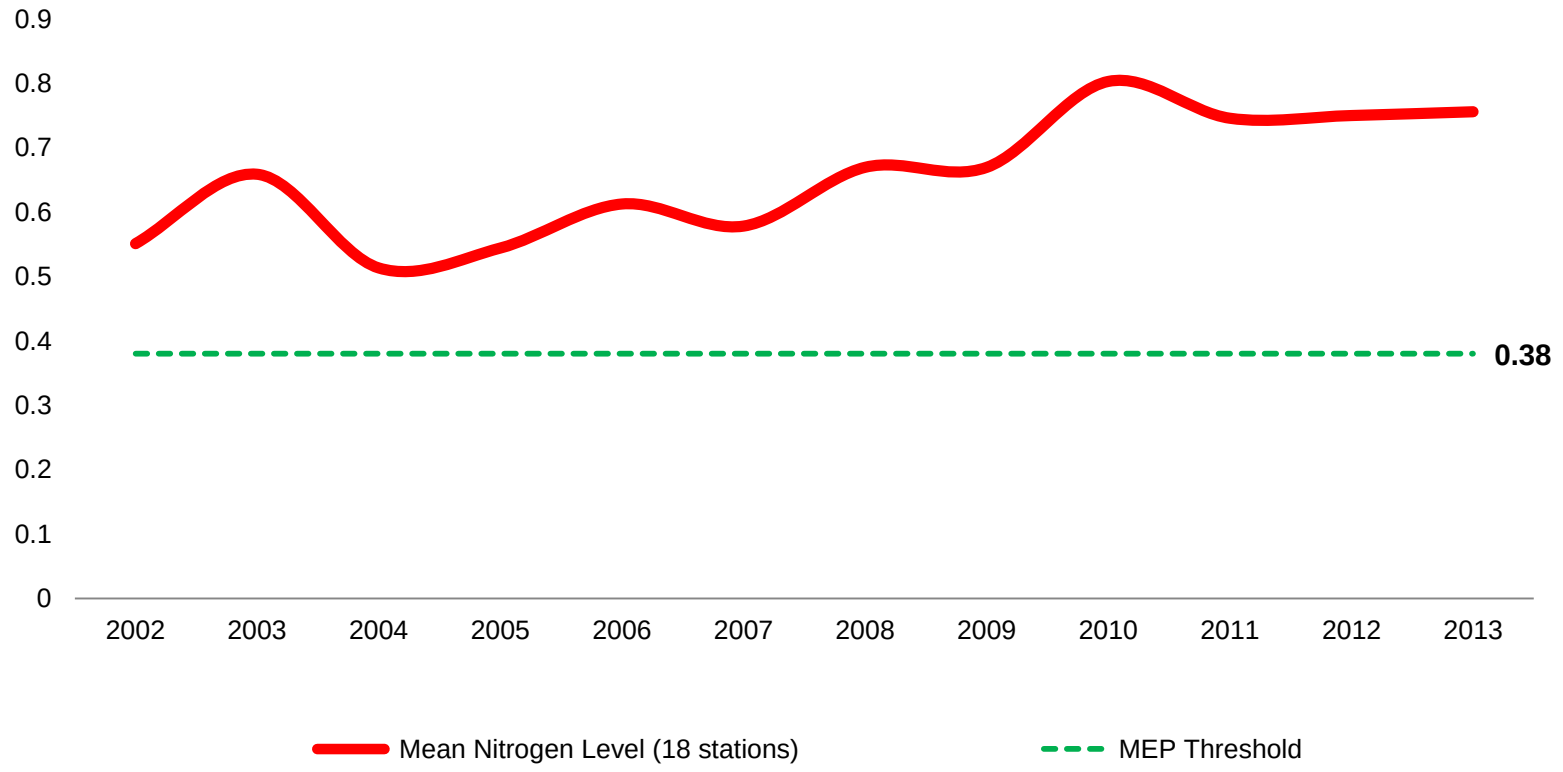


FIGURE 6: TREND IN THE MEDIAN SINGLE-FAMILY HOME SALE PRICES (THOUSANDS, $)

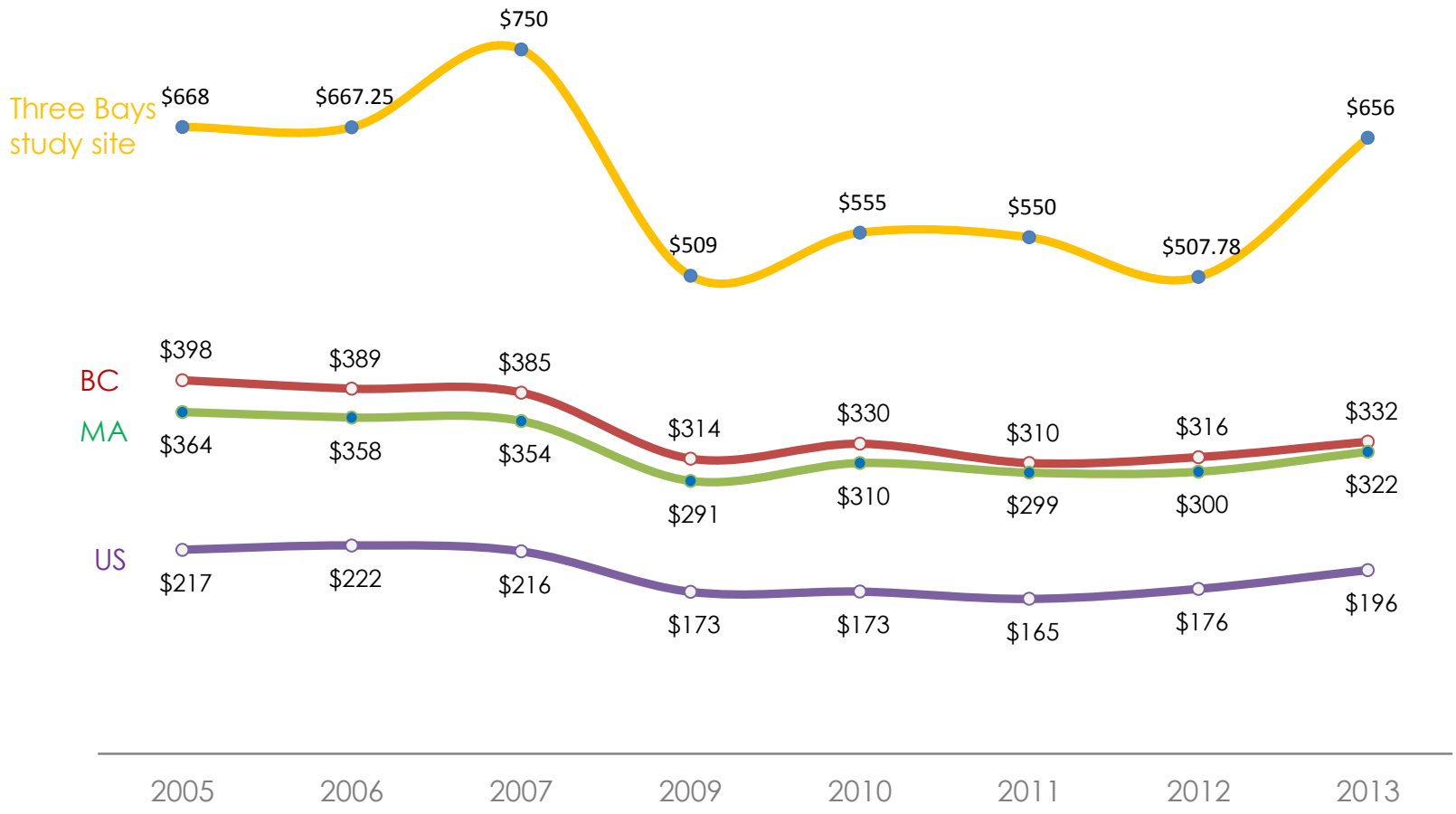
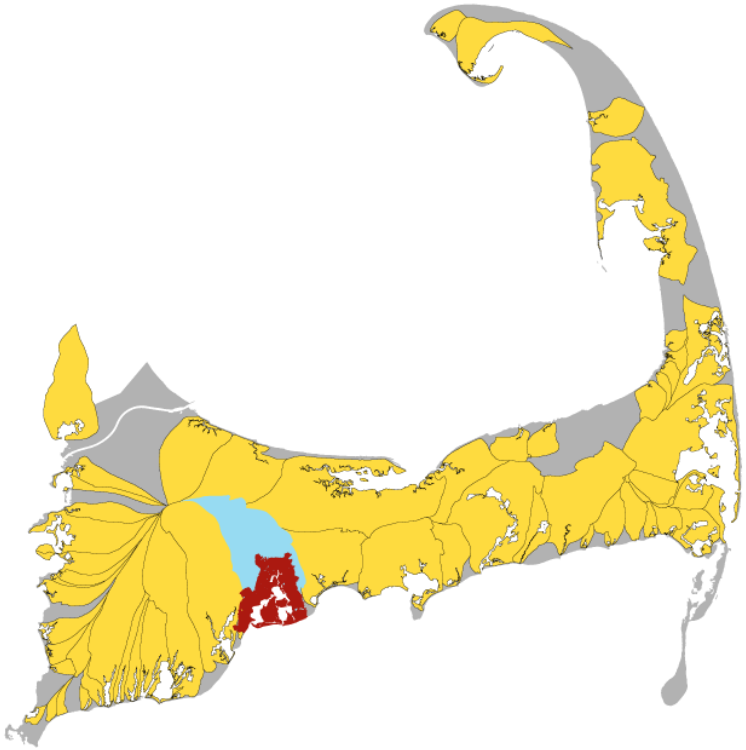


FIGURE 7: STUDY SITE



2,435 Households within 10 Minute walk of water in Three Bays

6,285 Households in Three Bays

120,117 Households on Cape Cod

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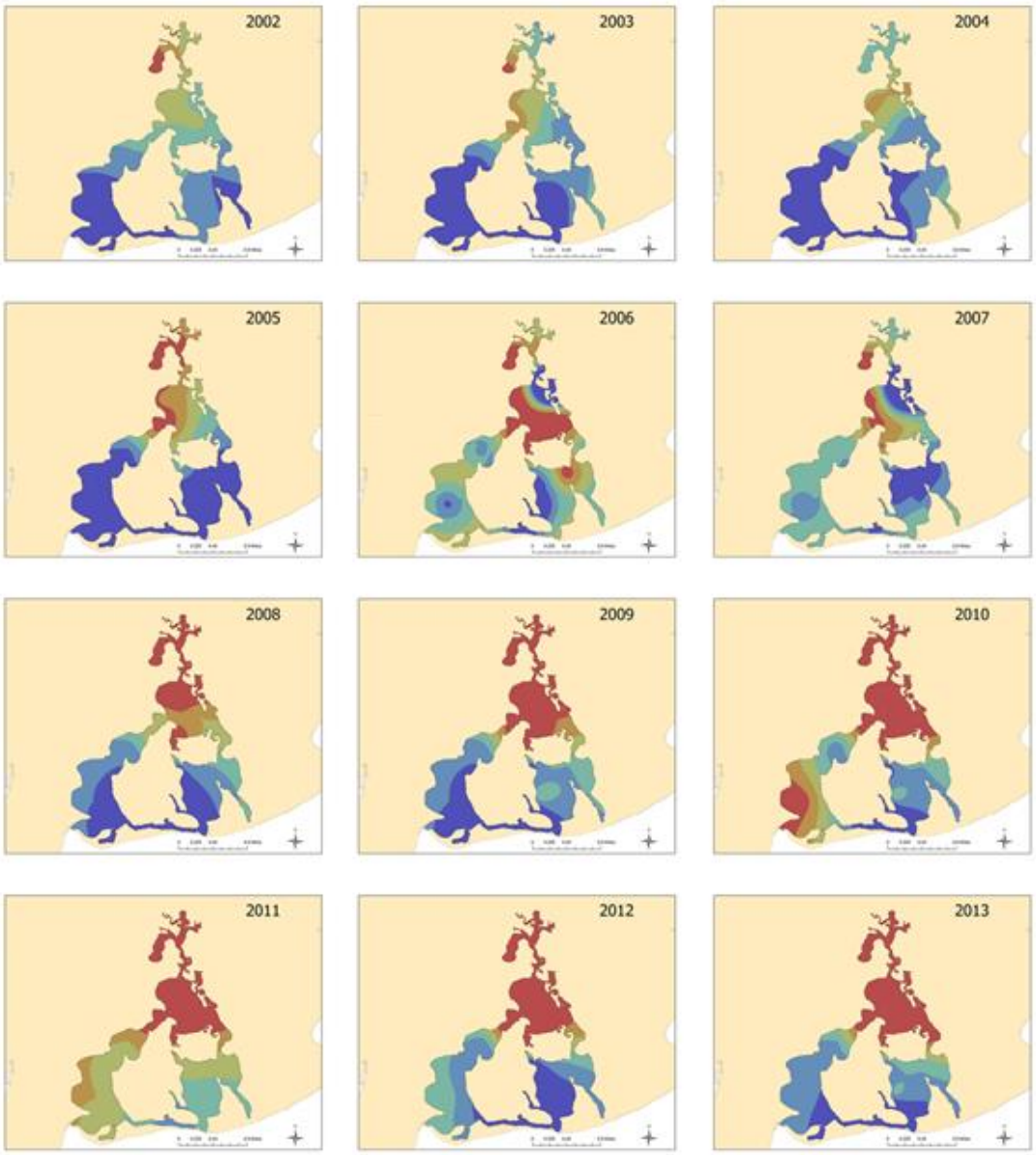
The analysis is based on an economic model that separated out the different qualities of a home, such as size, age, and surrounding amenities, and determined how much each characteristic added to a house's sale price. The model accounts for market-level influences on home prices. Water quality, as measured by nitrogen concentration, was included as one of the amenities. Using assessment and home sale data, this technique allowed the study to financially measure how much value a home lost due to declining water quality.

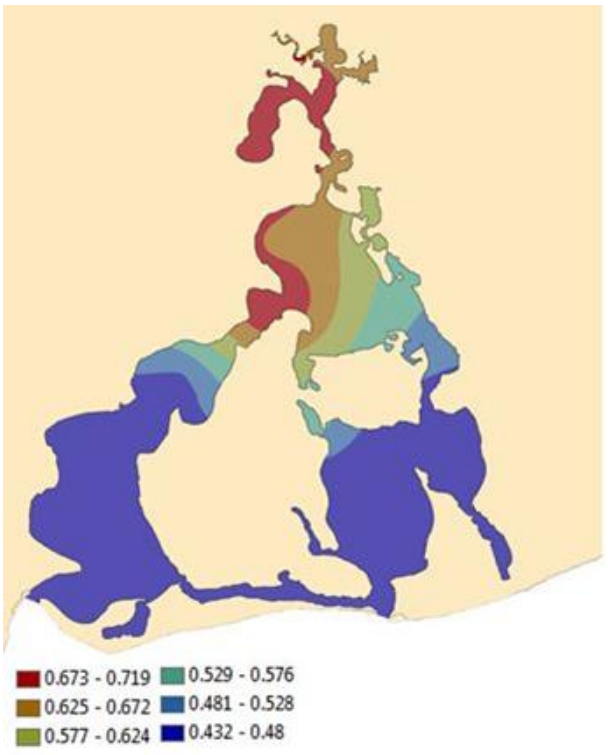
Focus groups were gathered to understand both how long-term study site residents perceived water quality, and verify the link between their perceptions and the nitrogen concentration levels used in the hedonic model portion of the study. In collaboration with a local non-profit, Three Bays Preservation, Inc., the series of four focus groups drew residents from across the study site who regularly use the embayment for water-based recreation. Participants shared their opinions about the area's current status, local housing development, and changes in water quality. The map created by focus group participants that rated percieved water quality was similar to water quality readings from the sensors in the embayment, suggesting residents' percieved water quality corresponds with measured nitrogen levels and validating the use of measured nitrogen levels for this study's hedonic model. Both of these maps are visible in Figure 9.

FIGURE 8: TREND IN NITROGEN LEVELS IN THREE BAYS WATER

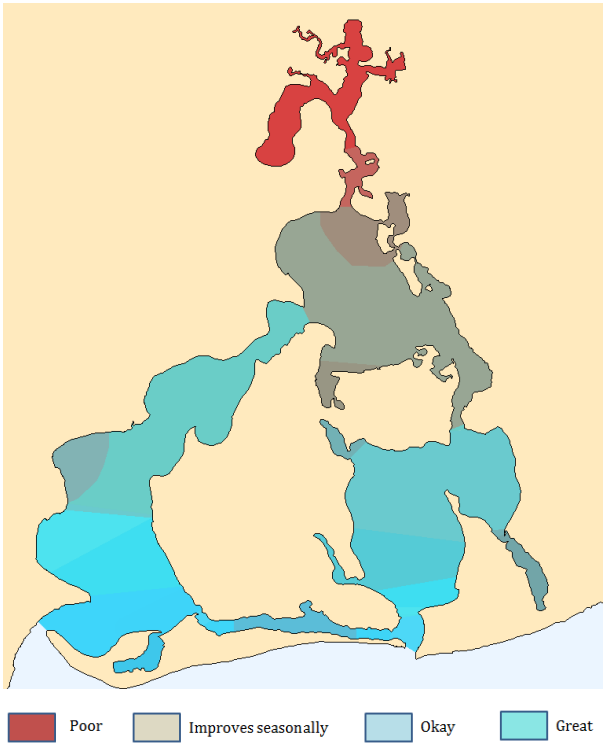


MASSACHUSETTS ESTUARIES PROJECT'S THRESHOLD FOR HEALTHY WATER = 0.38 MGL

SIMILARITY BETWEEN NITROGEN CONCENTRATIONS & WATER QUALITY AS PERCEIVED BY THREE BAYS RESIDENTS



Nitrogen concentration gradient created based 18 station data from Three Bays.



Meta-Map created from focus group participant responses.

FIGURE 9: SIMILARITY BETWEEN NITROGEN CONCENTRATIONS & WATER QUALITY AS PERCEIVED BY THREE BAYS RESIDENTS

STUDY FINDINGS

After controlling for property attributes and market level and macroeconomic trends, the model found that low water quality appears to influence property prices. Home prices in the study site fell an average of 0.61% for every 1% decline in water quality (or 1% increase in nitrogen concentration). This loss in value would translate into a noticeable fiscal impact for the community, as the lower assessed value means a shift in the tax burden on those less able to afford it. More details about the findings are available in the appendix.

For a broader understanding of how the housing value loss from nitrogen pollution would affect the Cape at large, the data from this study is incorporated into the Cape Cod 3VS Model under development by Industrial Economics, Inc. of Cambridge, MA and U.S. EPA. The model uses multiple factors to create an estimate of how the entire economy of Cape Cod might react to water quality changes. Preliminary calculations project a value loss of hundreds of million between 2010 and 2030 (undiscounted for inflation). The above estimate of the Cape-wide effect is subject to change as the model is further developed, but gives an idea of the magnitude of the problem faced by the Cape.

IMPLICATIONS FOR THE CAPE

During the time period of the study (2005-2013) water quality declined (or nitrogen concentration increased) by 15.84%. For the above findings of a 0.61% decline in value per 1% drop in water quality, the jump in nitrogen concentration translates into a noticeable fiscal impact on the community, both in terms of decreased sale price and consequent impact on the assessed value.

For example, if efforts had been made to curb the discharge of nitrogen into the Three Bays water resulted in a modest 3% decrease in total nitrogen levels in 2005, the average single-family home sale price in the study area would have been $16,774 to $32,957 higher in 2013. That translates into potential sale value loss (and consequent assessed value loss) in the range of $41 to $80 million in the study site alone. This estimated loss in assessed value means $295,715 to $581,019 in shifted property tax burden for 2013 (the shift in burden depends on relative assessed value changes between near waterfront and inland properties). The current study of waterfront properties in Three Bays serves to illustrate the point that a decrease in water-quality can have a significant impact on property values that affects not just the property owner, but all the taxpayers within the town.

Assuming that the percentage change in sale value in response to nitrogen in Three Bays is the same for other impacted embayments on the Cape, it is likely that coastal properties will lose proportionally more value than inland homes. If a town is losing tax base due to lower waterfront home values, it must make up for the loss by raising property tax rates

overall. This increase in property taxes would shift relatively more of the tax burden onto non-coastal homeowners than today. Overall, while coastal property owners face a loss in the sale value of their homes and a loss of amenity benefits from high-quality water, non-coastal property owners will also see a financial loss from increased property taxes and potential ripple effects through the property market, making the issue a Cape-wide instead of just coastal.

Figure 10, presents a rough estimate of potential growth in annual property tax rates for non-coastal single-family properties. It is important to note that the estimates of potential increases in property taxes for non-coastal property owners are rough and intended to provide general direction for further discussion and research, and should not be considered a precise calculation.

Conclusion

Cape Cod's high property values are dependent on clean and attractive water. A recent poll of residents reiterated the importance of water-based recreation, and revealed up to one-fifth of the population might consider stopping water-based recreation all together or leaving the Cape if local waters were to become too polluted due to high levels of nitrogen. Because high-value vacation homes derive a significant portion of their value from water views and water-based recreation, there is a concern that low water quality could lead to lower home prices for all properties in a nitrogen-polluted area. Falling home prices mean a lower property tax base for towns, affecting the community at large.

The Commission's study found a statistically significant relationship between reduced coastal home values and high nitrogen levels. Applied across the Cape, the findings suggest a decline in property taxes that could lower the tax base by hundreds of millions for towns. This scenario supports the importance of reducing nitrogen concentration levels in Cape Cod's waters, showing the long-term economic harm that could occur if nothing is done.

A HYPOTHETICAL SCENARIO OF PROPERTY TAX IMPACT ON NON-COASTAL PROPERTIES

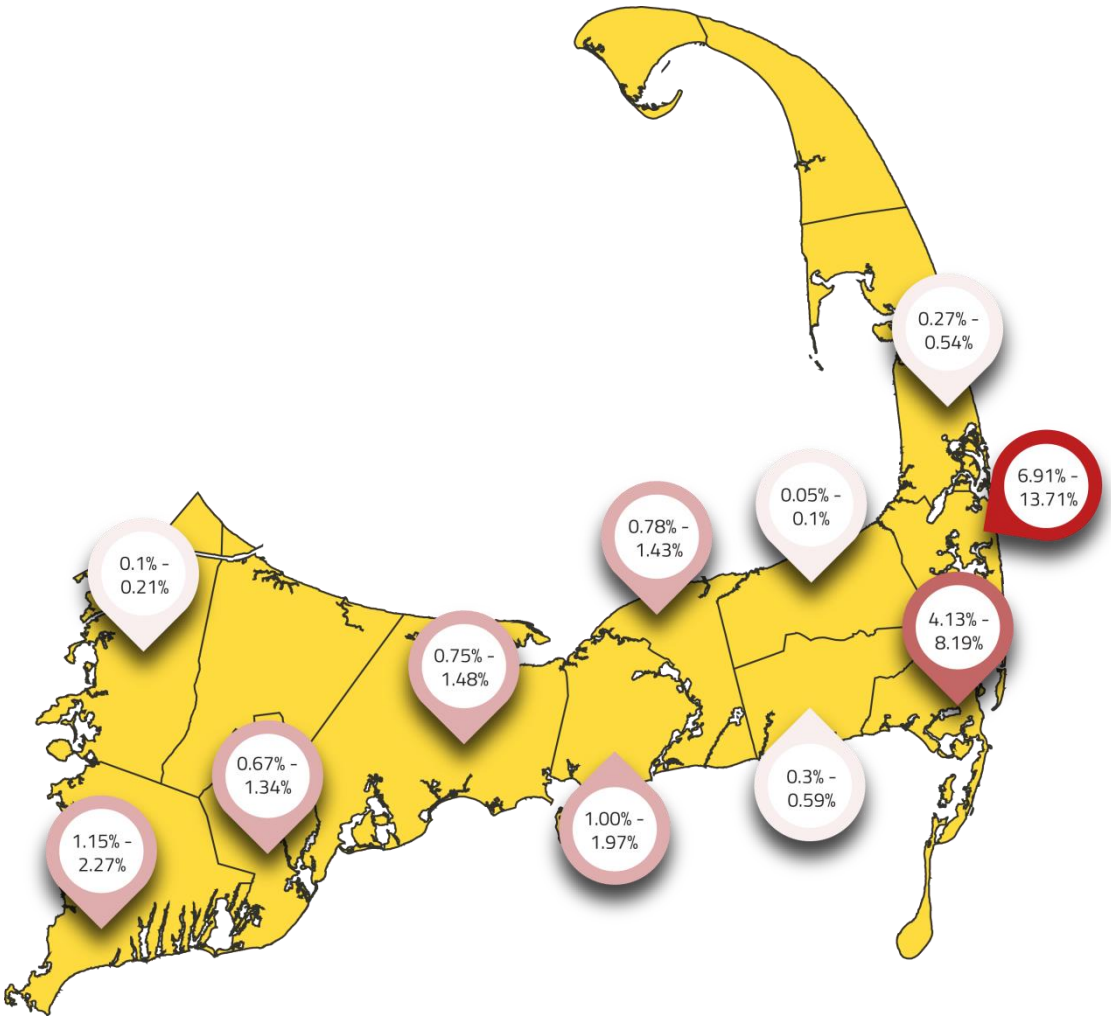


FIGURE 10: HYPOTHETICAL SCENARIO OF PROPERTY TAX IMPACT ON NON-COASTAL PROPERTIES

The map shows the potential additional property tax every year on non-coastal residents.

Note: The exact calculations depends on how the ripple effect of loss in value affect properties inland and how that effect changes the relative loss in value of property value between inland and near waterfront. The illustration is meant to inform a general discussion on this topic and hopefully is a starting point for further research.

Appendix

This appendix contains further descriptions of the study's methodology and results, including technical details and further findings. As with any model, this study's calculation of nitrogen concentration and use of hedonic analysis represents a statistical approximation of reality. In this study, all discussed findings from the hedonic analysis were statistically significant, with a 99% confidence level. Despite this high confidence level, this study is not authoritative and there are factors that affect property values within and between towns that could not be controlled for in the model. As with all models, additional data might improve a model's outcome or alter its results.

HEDONIC ANALYSIS OF HOME PRICES

In hedonic analysis, houses are understood not as homes, but as a collection of environmental benefits, location amenities, and property characteristics. In the real world, homes are sold as a single unit, and the sale price does not "itemize" the value of these characteristics. This makes it difficult to parse out which factors may influence sale prices. In this case, the goal was to use a spatially explicit multivariate regression model to determine whether the environmental amenity of good water quality influenced home prices within the study area, and if so, by how much. To accomplish this, the study built an economic model that approximated the price of individual home amenities using property sales prices, assessment data, location, and other quantifiable attributes. With this data, the constructed hedonic models were used to estimate the price of individual home characteristics while controlling for the effects of other variables such as house size, beach accessibility, and waterfront views.

The conceptual model behind hedonic analysis is shown below:

$$\hat{y}_i = f(D, H, L, N)$$

$$\boldsymbol{value\ of\ a\ good} = \{(value\ of\ attribute\ 1) * (quantity\ of\ attribute\ 1)\} +$$

$$\{(value\ of\ attribute\ 2) * (quantity\ of\ attribute\ 2)\} + \cdots$$

$$+ \{(value\ of\ attribute\ N) *$$

$$(quantity\ of\ attribute\ N)\}$$

Table 1: Hedonic model estimations

	Model (1)	Model (2)	Model (3)	Final Model
Water quality (Nitrogen levels)	-	-0.668***	-0.673***	-0.607***
		(-7.69)	(-7.22)	(-5.95)
Waterfront	0.858***	0.839***	0.829***	0.900***
	(9.54)	(9.83)	(9.59)	(9.75)
Distance from water	-0.205***	-0.231***	-0.229***	-0.199***
	(-4.27)	(-5.05)	(-4.96)	(-3.99)
Distance to nearest public beach	-	-	0.00108	0.00588
			(0.04)	(0.20)
Number of rooms in the home	-	-	-	0.0319***
				(3.45)
Age of the home	-	-	-	0.0000821
				(0.13)
Macroeconomic Influences and Market trend (Time fixed effects)	*Binary variables for 8 years (2005 - 2013)*			
Initial quality of construction of the property	*Binary variables for 19 levels of property quality*			
Constant	14.25***	14.05***	14.02***	13.63***
	(41.41)	(42.87)	(36.60)	(33.19)
R-squared	68.00%	71.30%	71.30%	72.30%
Z statistics in parentheses * p<0.05 ** p<0.01 *** p<0.001				

TABLE 1: HEDONIC MODEL ESTIMATIONS

The summary of the hedonic model estimation is presented here. This table shows maximum likelihood estimations of the four variations of the hedonic property price model specification. The purpose of four variations is to test the sensitivity of the model to specification changes. The first model tests some general characteristics of the neighborhood and location: waterfront location, distance to the water, general market trends, and quality of construction. The subsequent two models include amenities such as water quality and distance to the nearest public beach. The final model adds more detailed property attributes (i.e. number of rooms in the home and age of the home) to fine-tune the control in the model.

HYDROLOGIC NITROGEN CONCENTRATION MAPS

In order to understand the spatial pattern of nitrogen concentration in Three Bays waters, the study created a surface that displayed nitrogen concentration levels over the embayment for the 2002-2013 time period. The nitrogen concentration data was retrieved from 18 government-owned water quality measurement stations around the embayment. As seen in Figure 8, the output of the model shows not only changes in nitrogen concentration over time, but also how the concentration varies across different parts of the embayment. This output also displays the varied health of different embayment areas, and the potential impact on recreational water use across different part of the embayment. In Figure 8, the gradual decline in water quality over time is visible, with higher nitrogen levels in red and lower levels in blue.

The nitrogen concentration surfaces were created using Kriging, an advanced geostatistical procedure that generates a probability-based surface to best fit a scattered set of data points. The procedure, performed using Spatial Analyst in ArcGIS, also includes advanced statistical methods to account for expected non-uniformity due to natural variation. Like any model, the outcome represents estimated conditions; there is always room for improvement with additional data. The image in Figure 8 is meant to improve understanding of the trends in nitrogen concentration; it is not a substitute for hydrogeologic modeling.

THE THREE BAYS FOCUS GROUPS

The study gathered four focus groups to understand both how long-term study site residents perceived water quality, and verify the link between their perceptions and the measured nitrogen concentration levels used in the hedonic model portion of the study.

For the hedonic model to be useful there must be at least a reasonable overlap between perceived water quality and measured nitrogen levels to ensure the validity of measured levels as an indicator.

In collaboration with a local non-profit, Three Bays Preservation, Inc., the study invited both permanent and seasonal Three Bays residents to share their thoughts on changes in the embayment and its water quality. The series of four focus groups drew residents from across the study site who regularly use the embayment for water-based recreation such as swimming, boating, and fishing. All the participants were homeowners, and had lived in the study site for an average of 10 years.

Participants shared their opinions in discussions about the area's current status, local housing development, changes in water quality, and how they use the embayment for recreation. Residents were asked to mark where they swam or went boating and observations on water quality, past and current, on a map. The combined map from the four sessions is shown in Figure 11 (a higher resolution copy is available in study's website). Below is summary of what the four maps say.

All groups reported that parts of the embayment are unsuitable for swimming or fishing during the summer due to low water quality and eutrophication. Erosion of the coast and issues with sendimentation was another common issue. Most participants cited increased housing development across the Cape, particularly in the upper Three Bays watershed, as the primary cause of water quality degradation. Some of the participants offered that there is an increased "culture of lawn" as compared to 30 years ago. The increase in lawns and resulting increase in fertilizer use can be a contributing factor to eutrophication as fertilizer run-off adds to the nutrient pollution in the waters.

The map created by focus group participants that rated percieved water quality was similar to the water quality readings from the sensors in the embayment, both visible in Figure 11. Each map demonstrates the same pattern of most-to-least nitrogen pollution on a north-south axis, suggesting residents' percieved water quality corresponds with measured nitrogen levels and validating the use of measured nitrogen levels for this study's hedonic model.

WATER QUALITY AND USE BY THREE BAYS RESIDENTS

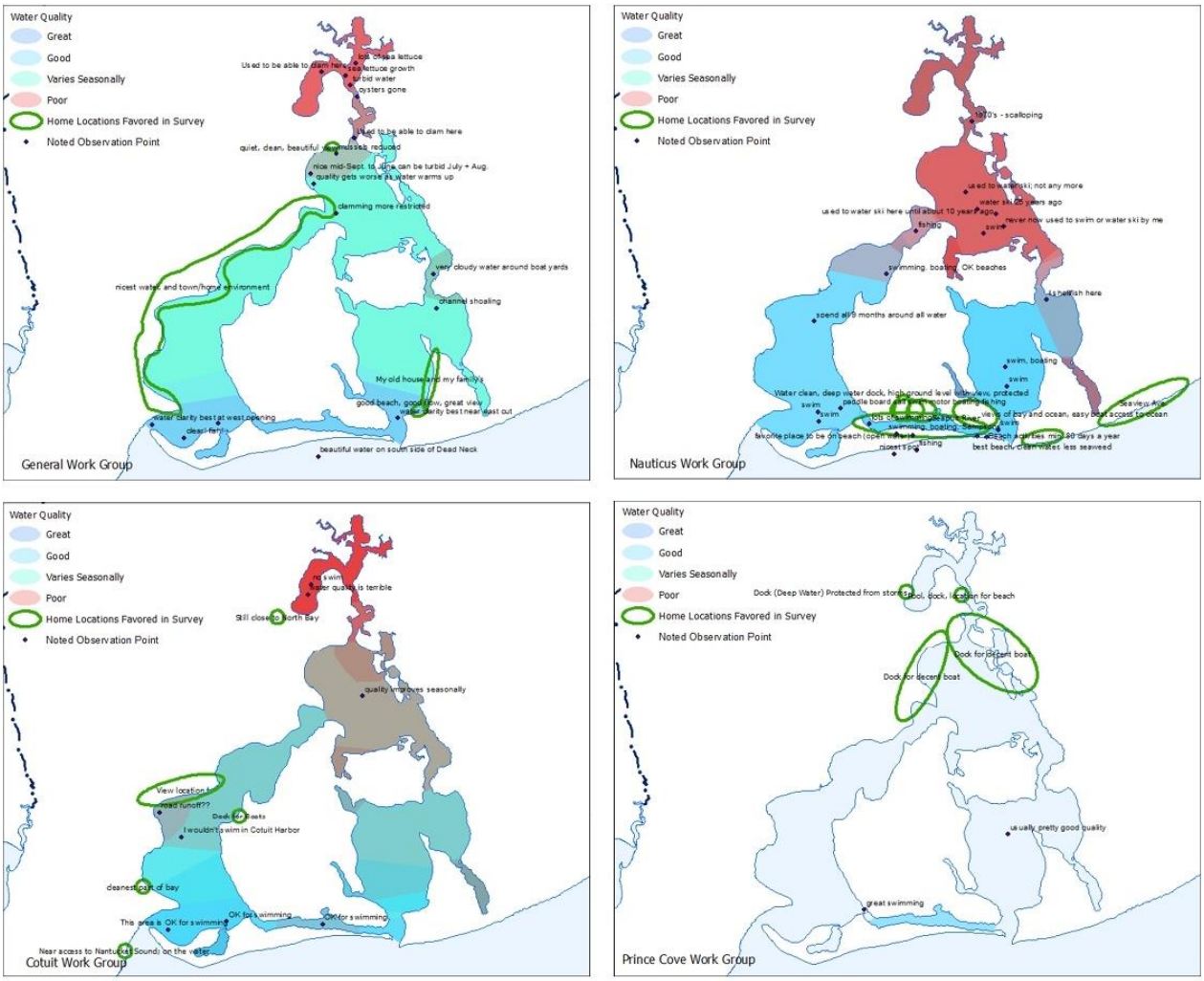


FIGURE 11: WATER QUALITY AND USE BY THREE BAYS RESIDENTS

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