# Willingness to Pay for Alternative Programs to Improve Water Quality in the Chesapeake Bay

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## ABSTRACT

Over the last century the Chesapeake Bay has been plagued by pollution, disease and overharvesting of its resources. As a result, the Bay has been the focus of substantial research and the beneficiary of numerous environmental programs. Previous work has suggested that people are willing to pay for improved water quality in the Chesapeake Bay. For policymakers, the key challenge is to determine how to allocate scarce funds across alternative regulatory and subsidy programs. This thesis investigates three new research questions that relate to the policymaker's problem. First, does WTP for a given water quality improvement depend on the process used to obtain that improvement? Second, does introducing a publicly funded program to improve water quality crowd out private donations to charitable organizations? Third, could oysters in the Chesapeake Bay be successfully marketed as a "green" good?

The results from an attribute based choice experiment survey indicate that individuals value process and that they have a higher value for water quality improvement processes that include positive externalities such as increasing oyster populations and planting acres of tall grasses. The results also imply that the new water quality program will crowd out a small portion of private donations to charitable organizations. For example, a $1 tax increase for a new water quality program would crowd out approximately $0.02 of private donations to Chesapeake Bay organizations. Finally, results from a contingent valuation exercise suggest that oyster consumers are willing to pay a significant premium for ecolabeled oysters. Specifically, consumers are willing to pay a 58% premium for half-shell oysters.

# Dedication

*To my grandparents*
*For instilling the value of education in me*

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# Chapter 1: Introduction

### 1.1. Background

The Chesapeake Bay watershed covers 64,000 square miles and is home to 17 million residents. Over the last century the Bay has been plagued by pollution, disease, and overharvesting of its resources. These factors have contributed to declining populations of crabs, clams, oysters, and other native species. For example, the native oyster (*Crassostrea virginica*) has declined by nearly 50% relative to the 1958 harvest of 25 million pounds (National Marine Fisheries Service). Congress has long sought to address the Chesapeake Bay's environmental problems through regulation. The regulatory process began with the creation of the Chesapeake Bay Program in 1976 to examine the factors that were altering the Bay's ecosystem. It continued with the passage of the Clean Water Act and subsequent amendments designed to protect surface water quality and reduce discharges into waterways. Recently, Congress expanded its regulation of the Chesapeake Bay by using the 2008 Farm Bill to allocate $438 million in new funding for improving water quality and enhancing related resources.

For policymakers seeking to improve water quality in the Chesapeake Bay, the key challenge is determining how to allocate scarce funds across alternative regulatory and subsidy programs. In the past, policymakers have focused on regulating emissions from sewage treatment plants and other "point sources" of pollutants, while simultaneously paying farmers to use less fertilizer and to implement practices which reduce runoff of chemicals and fertilizer. In the future, another option would be to subsidize the commercial production of oysters. Oysters are not only a source of income for watermen. They also provide a number of ecosystem services through their filtering capacity. [1] For example, water clarity is improved through the filtering of

[1] Ecosystem services are socially valuable in ways that are not immediately calculated (Daily 1997). The filtration service provided by oysters provides an economic motive for state and federal policymakers to increase commercial oyster production.

phytoplankton and nitrogen and phosphorus which becomes embodied in the filtered material is removed through biomass sequestration (Newell 2004; Newell et al. 2005). These processes in turn may aid the growth of submerged aquatic vegetation (SAV) and increase habitat for other marine species.

The most direct approach to allocating scarce resources across alternative regulatory and subsidy programs would be to fund the combination of programs that leads to the largest improvement in water quality at the lowest cost. Yet this approach does not take into account the values people assign to the processes through which water quality improvements are made. The rapid growth in markets for "green" goods illustrates that people care how products are produced. For example, people are willing to pay a premium for shade-grown coffee because it provides biodiversity conservation and sustainable growing practices. Similarly, people are willing to pay more for "green" electricity because of the renewable form of generating capacity and reduced emissions (Kotchen [2006]). A similar logic may apply to funding public programs to improve water quality in the Chesapeake Bay.

### 1.2. Research Objectives

The primary objective of my thesis is to investigate how the willingness to pay (WTP) for a fixed water quality improvement in the Chesapeake Bay varies with the *process* for obtaining that improvement. The main focus will be comparing the willingness to pay for increasing the population of oysters to the willingness to pay for additional regulation of point sources and the willingness to pay for additional farm subsidies. To investigate this issue, a survey of Virginia residents was conducted. The survey consists of attribute based conjoint questions which force respondents to choose between alternative water quality improvement programs. Lancaster's (1966) attribute based theory of consumer demand is used to define the utility from each

program in terms of its attributes. Random utility maximization provides the empirical framework to estimate the model using the survey data on consumer choices between competing alternatives. By including price as an attribute, marginal utility estimates can be converted into willingness to pay for changes in attributes.

A secondary objective of this thesis is to investigate whether a new publicly funded program to improve water quality will crowd out donations to charitable organizations like the Chesapeake Bay Foundation. Andreoni's (1989) warm glow model suggests that a tax on a public good like water quality may crowd out private donations to the public good. The possibility of crowding out is important to consider when evaluating a public policy to improve water quality because if crowding out is complete, the tax may fail to improve water quality.

The final objective of this thesis is to determine whether oysters in the Chesapeake Bay can be successfully marketed as a "green" good. Consumers are often willing to pay more for goods or services considered environmentally friendly or "green" (Kotchen [2005]). Recent media articles have highlighted the green good phenomena, even making reference to oyster aquaculture in the Chesapeake Bay (Moorhead [2009]). Contingent valuation questions on the survey provide the means to estimate the consumer's willingness to pay for the water quality services provided by Chesapeake Bay oysters.

### 1.3. Blueprint for subsequent chapters

Chapter 2 describes the Chesapeake Bay watershed, reviews past studies of the willingness to pay for improved water quality, and provides background on: why "process" matters, "green" goods, and the "crowding out" hypothesis. The discussion begins with background on water quality in the Bay. The Bay's conditions have deteriorated substantially and a number of public and private efforts have emerged to try to restore it. An overview of these efforts is followed by a

review of nonmarket valuation theory and previous empirical studies of the willingness to pay for improved water quality in the Chesapeake Bay. Finally, three new research questions are defined based on the thesis objectives. These questions provide the basis for the theoretical and empirical models developed in Chapter 3.

Chapter 3 presents theoretical and econometric models that describe consumer preferences for water quality program attributes, assess the impact of a new program on private donations, and consider the willingness to pay for a "green" good that would improve water quality in the Chesapeake Bay. This chapter begins by using Andreoni (1989) as the basis for developing a model where a public good, water quality, is produced from a private good, donations. This baseline model is then extended to describe willingness to pay for a new program, crowding out of private donations, and the introduction of a green good. Econometric models are proposed to test each of these three extensions. Finally, the chapter concludes by summarizing the choice experiment approach to nonmarket valuation.

The survey procedures are described in Chapter 4. The discussion coves the design process, the implementation process and the issues that arose in construction of the survey. The survey is broken down section by section to show examples of specific questions and explain their purpose. One of the most important steps in developing a choice experiment survey is the development of the choice sets. The water quality program attributes and their levels must be defined and used to develop conjoint questions. The development of the survey also involved generating several alternative treatments in which different respondents received different versions of a particular question. After describing this process, the chapter concludes with a description of the sample population and the pretesting and mailing procedures.

Chapter 5 begins with a statistical summary of the survey results, followed by econometric results from the three models developed in Chapter 3. The results from the choice experiment questions are used to estimate households' willingness to pay for the attributes of programs that would improve water quality in the Chesapeake Bay. Then, survey data on donations are used to test Andreoni's crowding out theory in the context of a new water quality improvement tax. Finally, data from the contingent valuation questions on the survey are used to estimate whether people would be willing to pay a premium for ecolabeled oysters grown in the Chesapeake Bay. Policy implications from each set of results are discussed. In conclusion, chapter 6 summarizes the key results from this thesis and provides recommendations for future research.

# Chapter 2: Water Quality in the Chesapeake Bay: An Economic Perspective

## 2.1. Introduction

This chapter discusses the recent history of the Chesapeake Bay, empirical studies of the willingness to pay for improved water quality in the watershed, and emerging issues in the management of the Bay. Section 2.2 begins by describing the watershed and the characteristics that make the Bay unique. Environmental conditions in the Bay have deteriorated over the last century and considerable resources have been devoted to fix it. Section 2.3 reviews key areas of nonmarket valuation theory and how it relates to measuring the willingness to pay for improved water quality in the Bay. It also describes previous nonmarket valuation studies conducted in the Chesapeake Bay region. Then, section 2.4 discusses how the existing literature relates to the research questions that are the focus of this thesis. The justification for why "process" matters, the introduction of "green" goods, and the "crowding out" hypothesis are all covered in this section. These issues form the basis for the empirical models developed in Chapter 3.

## 2.2. Water quality in the Chesapeake Bay: background and current status

The Chesapeake Bay watershed is 64,000 square miles and home to almost 17 million residents. The watershed's boundaries, which stretch through six states and the District of Columbia, are outlined in figure 2.1. The Chesapeake Bay is the largest estuary in North America and home to an array of marine species.[2] Over the past 100 years, the Bay's condition has declined substantially due to a combination of population growth, harvest pressure on wild stocks, and diminished water quality. Nutrients, sediment and chemical contaminants all contribute to the deteriorated water quality and low levels of aquatic species in the Bay.

### 2.2.1. Water Quality

[2] As a result of its size, 15,000 streams covering 100,000 miles feed into the Bay. Though most of these streams are small in size, there are ten major river systems which make up 90% of the Bay's freshwater and 50% of the freshwater comes from the Susquehanna River.

An important health indicator of the Chesapeake Bay's ecosystem is the level of water quality necessary to sustain all the plants and animals that reside in the watershed. This includes rockfish, crabs, oysters, underwater Bay grasses, and other aquatic organisms. There are multiple criteria used to evaluate water quality. One criterion is the balance between nutrients and normal fluctuations in salinity and temperature. Another criterion is dissolved oxygen. Based on current levels of nutrients and dissolved oxygen, the water quality in the Chesapeake Bay is rated as "*very poor"* by the Chesapeake Bay Program.[3] Excessive levels of nutrients have also caused the Bay to be placed on the EPA's list of "dirty waters" (Chesapeake Bay Foundation [2009]).

Nitrogen is a nutrient necessary for plant growth but, in excess, nitrogen can over-stimulate growth of aquatic plants and algae. This leads to "algae blooms" that block out sunlight for other marine species (Bricker et al [2007]). This process is illustrated in figure 2.2. When the algae blooms occur on the surface of the water, it prevents the sun's rays from reaching the underwater bay grasses. These grasses which provide food and habitat for many marine species and are an important food source for blue crabs and waterfowl, cannot grow without sunlight. Algae also have the ability to grow directly on the grass leaves, further reducing the amount of sunlight they receive. After an algae bloom, leftover algae die and sink to the bottom of the Bay. They are then decomposed by bacteria using a process that leaves little or no dissolved oxygen (DO) for crabs, oysters and other bottom-dwelling species.[4] DO moves through the water and is absorbed by gills which pass it into the animal's blood. As the oxygen levels decrease, it becomes harder for the animals to get the adequate amount of oxygen to

[3] This rating means that only 21% of the water quality goals outlined in the Chesapeake Bay Agreement are being met as of 2008. Pollution, algae blooms, and increased chemical contaminants all contributed to this low rating (Chesapeake Bay Foundation [2009]).

[4] Dissolved oxygen refers to the amount of oxygen that is present in the water. Scientists agree that DO concentrations of 5.0 mg/L or higher allow aquatic species to thrive (US EPA [2003]).

survive. These algae blooms have been used as another metric for Bay health because of the high correlation between the amount of nutrients in the water and the size of the algae blooms.

Phosphorous is a second nutrient that contributes to the Bay's poor water quality. Excess phosphorus can cause eutrophication in rivers and watersheds causing it to be labeled as the most difficult water pollutant by both the Council on Environment Quality and the Federal Water Quality Association (Knud-Hansen [1994]). In the mid-1960s most laundry detergents contained phosphates and were the main source of effluent phosphorous (Knud-Hansen [1994]). By 1971, several states had limited the content of phosphorus detergents and successfully minimized phosphate effluence. Urban sources are no longer the number one contributor of phosphate; agriculture is now the leading source of phosphorous pollution. In particular, manure run-off from fields and pits creates excess phosphorous in the Bay.

Because nitrogen and phosphorus are not classified as pollutants under the Clean Water Act, the Bay states have relied on state programs to achieve Bay program goals.

### 2.2.2. Chesapeake Bay Agreement

In an effort to improve water quality in the Bay, the neighboring states signed a series of agreements between 1983 and 2000. In 1983 the first *Chesapeake Bay Agreement* was signed by the governors of Virginia, Maryland, and Pennsylvania; the Mayor of the District of Columbia; and the Environmental Protection Agency. The signatories committed their resources to improving environmental quality and living resources in the Chesapeake Bay (Krupnick [1987]). In 1987, and subsequently in 1992, they reinforced their commitment by signing a new agreement that aimed to reduce nutrient loads by 40% (using 1985 as a baseline) by the year 2000. Then, in 2000, the *Chesapeake Bay Agreement* was updated in order to reinforce the signatories' commitment to improving water quality and to recognize that the Bay was still

significantly degraded. Table 2.1 compares the policy targets for nutrients with actual nutrient levels from each of the adjusted *Agreements*. The *Chesapeake 2000* (C2K) agreement set the following objective: "By 2010, correct nutrient-and sediment-related problems in the Chesapeake Bay and its tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act."

Evidence on the effectiveness of the Chesapeake Bay Agreement is mixed. Over the years, the Chesapeake Bay Program has relied on computer models to track cleanup progress. However, these computer models showed pollution reductions that might occur in the future, not what was really happening. In 2006, the US Government Accountability Office found that the Chesapeake Bay Program's model portrayed the conditions in the Bay in an unduly positive light (Dyson [2009]). As for the C2K's effort to achieve and maintain a 40% reduction in nutrients relative to 1985, the Chesapeake Bay Program acknowledges that total phosphorus has fallen by 30% and nitrogen, 22%, far from the 40% reduction goal for both. [5] Figure 2.3 and figure 2.4 display the trends in nitrogen and phosphorous from both point and nonpoint sources over time.[6] Figure 2.5 displays the annual flow of water between 1990 and 2008. Generally, as the water flow increases, more nutrients load into the Bay. Water flow volume appears to drive annual pollution levels because the agricultural runoff from winter and spring rains delivers more pollution into the Bay (Chesapeake Bay Program [2008]). This makes it difficult to judge the efficiency of the Chesapeake Bay Agreement.[7]

[5] The progress of the C2K goals can be tracked online at: http://dnrweb.dnr.state.md.us-/bay/res_protect/c2k/progress.asp

[6] "Point source" pollution comes from a single, identifiable source such as industrial or sewage treatment plants. "Nonpoint source" pollution comes from many different sources like fertilizer runoff from agricultural lands, sediment from streambanks, and nutrients from livestock (US EPA 2008).

[7] On a more positive note, the C2K agreement has cut pollution from sewage treatment plants, restored 12,500 acres of wetlands and rockfish levels have increased by 15 times (Dyson, 2009).

From the trend line in figure 2.6, it is apparent that there has been some success in decreasing the *total* amount of nitrogen loads, but *nonpoint source pollution* has become an increasing problem. Figure 2.7 provides a snapshot of the manure excreted from farms in Virginia between 1982 and 1997. The trend is moving upwards even as the number of Virginia farms has decreased (Pease [2007]). There are certain agricultural sectors such as the poultry industry which have blossomed over the past forty years as the consumption of poultry has increased. Before the 1999 Poultry Waste Management Act (House Bill 1207), famers were spreading fields with untreated and unregulated amounts of poultry litter which found its way into the Chesapeake Bay watershed. With the help of both government cost-share programs and farmer education programs, approximately 70% of the Shenandoah Valley poultry farms have voluntarily constructed poultry litter storage buildings and implemented nutrient management plans (VA Poultry Federation [2007]). Unfortunately it is difficult to assess whether these programs have reduced nutrient loading because 1997 is the last year that the USDA estimated nutrient loading from animal feeding operations in the Chesapeake Bay.

Preliminary estimates indicate that 291 million pounds of nitrogen loaded into the Chesapeake Bay during 2008. This is 13 million pounds less than in 2007, but still far above the amount necessary to remove the Chesapeake Bay from the EPA's "dirty waters" list. This is also far more than the *Chesapeake 2000* goal of "an annual nitrogen cap of 175 million pounds." For phosphorous, preliminary estimates indicate that 13.8 million pounds entered the Bay in 2008. This is 7.5 million pounds less than the 21.3 million pound average load from 1990-2008 (Chesapeake Bay Program [2008]).

### 2.2.3. Strategies for Cleaning the Bay

The Chesapeake Bay Program (CBP) partnership has focused on two pollution source sectors to achieve 80% of the nutrient reductions necessary to restore the Bay: wastewater treatment plants and commercial agriculture. From figure 2.8 and figure 2.9 it is apparent that these two sources load the most nitrogen and phosphorous into the Bay.

Point source polluters, such as wastewater treatment plants, have become pioneers in reducing nutrient runoff. Once a technological improvement is made to a wastewater treatment plant, the reductions are measurable. According to the Chesapeake Bay program, wastewater treatment plants have achieved 69% of the 2010 pollution reduction goals. There are 483 significant municipal and industrial wastewater treatment facilities that represent more than 95% of the total flow and contribute to 20% of the nitrogen and 22% of the phosphorus loads entering the Chesapeake Bay. Locations of the major wastewater treatment plants are displayed on the map in figure 2.10. Because of increases in technology, wastewater treatment plants have contributed a significant portion of pollution reduction in the Bay watershed. Even though wastewater treatment plants are not the least cost alternative, with a removal rate for one pound of nitrogen costing $11.06, they have the most certain outcome in terms of a measurable success (VA DEQ [2008]). The measureable success is due to the point source technology. Once a filtration system is installed, it can produce measureable rates for pollution control. For wastewater treatment plants, the EPA and its partners (under the cooperative Chesapeake Bay Program) agreed to cap annual nutrient loads for each major tributary basin and jurisdiction at levels set in the 2000 Agreement.[8] To help implement this cap, the EPA and the Chesapeake Bay partner jurisdictions developed new National Pollutant Discharge Elimination System (US EPA [2008]) permits for significant point source discharges of nutrients to the Chesapeake Bay

[8] Current water quality standards have been modified by refining aquatic life uses and water quality criteria applicable to the Chesapeake Bay as recommended by recent EPA guidance. The EPA's partners consist of the states of New York, Pennsylvania, Maryland, Delaware, Virginia, and West Virginia, and the District of Columbia.

watershed (US EPA [2008]). They agreed to issue NPDES permits for all new point sources and began to reissue NPDES permits to existing significant point sources.[9]

The second main focus of nutrient reductions is the agricultural sector. The agricultural sectors of the six Chesapeake Bay partner states contribute 42% of the nitrogen and 47% of the phosphorus loads to the Bay. Twenty two percent of the land in the Bay's watershed is used for some type of agriculture production. As outlined in figure 2.11, the watershed consists of a diversified range of land uses including agricultural lands, forests, urbanized cities and suburban developments. Farming and current farm practices emit substantial amounts of waste into the Bay. As seen previously in figures 2.8 and 2.9, agriculture is the number one polluter of nutrients in the Bay. One of the *2000 Chesapeake Agreement* goals is to use farm conservation efforts to reduce the amount of nutrient and sediment runoff from agricultural lands. Since 1985 the Bay partners have seen a 46.57 million pound reduction, half their goal, in pollution from agricultural lands (Chesapeake Bay Program [2008]). Some of this reduction can be attributed to implementation of farm best management practices (BMP). Best management practices are conservation mechanisms that try to prevent or reduce the amount of pollution generated by agriculture by decreasing the amount of nutrients and sediments leaching into the Chesapeake Bay. Table 2.2 reports cost estimates for five best management practices used to decrease nutrient and sediment loads.[10]

All BMP practices are designed to increase conservation on farms as well as reduce soil and fertilizer runoff throughout the watershed. The USDA Natural Resources Conservation

[9] In 2007 litigation over the NPDES permitting began in Pennsylvania. Adopted in 2007 by the Pennsylvania Department of Environmental Protection, the NPDES permits have begun Pennsylvania's commitment to implement nutrient and sediment reductions in the Chesapeake Bay watershed for municipal wastewater treatment plants (Argent Communications Group [2008]).

[10] Cost estimates for agricultural BMPs can vary widely, adding an uncertainty about actual costs (Stephenson, et al 2009).

Service has established a standard set of practices to help farmers install BMPs. In Virginia, the Department of Conservation and Recreation has established a set of programs that share the costs of implementing BMPs or provide tax credits for doing so (DNM [2001]). Incentives to install farm BMPs come from programs which offer financial as well as technical assistance for construction and implementation of selected practices. The cost to remove one pound of nitrogen from an agriculture BMP improvement can vary from as little as $0.34 for a traditional nutrient management plan to $12.00 for streambank fencing (DNM [2001]).

The partner states have agreed to implement conservation practices on 6.5 million acres of agricultural land (Chesapeake Bay Commission [2004]). They have begun by implementing the most cost-effective conservation methods that produce the greatest nutrient reductions. Some of this funding comes from the 2008 Farm Bill and includes a total of $188 million to be distributed over the next four years to the Chesapeake Bay Watershed Initiative (Chesapeake Bay Program [2009]).[11] This more than doubled the current amount of federal technical and financial assistance for farmers compared to the 2002 Farm Bill (Chesapeake Bay Foundation [2008]).

A third way to improve water quality that has not yet been pursued by the CBP is to invest in expanding the oyster population in the Bay. The Chesapeake Bay's native oyster (*C. virginica)* is able to improve water quality through its filtering capacity, which according to the Natural Resource Conservation Service, can be between 25 to 50 gallons of water per oyster per day. It is widely recognized that the filtering capacity of oysters provides a number of water quality services (Dame [1996]; Cerco and Moore [2001]; Newell [2004]; Newell et al. [2005]). Filter feeding oysters can remove nutrients by the biomass sequestered in their shell and meat,

[11] For more information on the Chesapeake Bay Watershed Initiative refer to: http://www.chesapeakebay.net/press_2009farmbill.aspx

and by accelerating a denitrification process (Stephenson et al [2009]). Through the filtering of phytoplankton (and seston in general), water clarity can be improved. In addition, the nitrogen and phosphorus embodied in the filtered material can be removed from ambient waters through biomass sequestration (N and P contained in oyster shell and meat) as well as through chemical transformation of oyster feces and pseudofeces (nitrification/denitrification of oyster biodeposits) (Newell [2004]; Newell et al. [2005]). These processes in turn may aid the growth of submerged aquatic vegetation (SAV) and increase habitat for other marine species.

Though oyster aquaculture may not substantially improve water quality quickly, some have suggested that a subsidy program similar to the established agriculture BMP programs could be used to provide growers with incentives to increase oyster populations and begin the filtration process on a larger scale. The cost per pound of nitrogen removed through oyster aquaculture was calculated as $248.68. The calculation was based on a supply-demand model for oyster aquaculture in Virginia (Bosch et al [2008]).

On the surface, agriculture appears to be the most desirable nutrient removal method because it has the potential to be the least cost alternative. This goes without investigating the probability of meeting nutrient reduction goals. Uncertainty is a topic in environmental evaluation that has been discussed since the early 1970s. The existence of uncertainty may lead to a reduction in net benefits of an activity with environmental costs (Arrow and Fisher [1974]). Improvements in water quality from nonpoint sources must include a measure of uncertainty because a storm can cause increased leaching from fields and oysters can be killed by disease. The certainty or percentage chance of meeting a nutrient reduction goal is lower for nonpoint source polluters because the reductions are tough to predict and difficult to measure whereas point source emissions are predictable and measurable.

The Virginia Department of Environmental Quality uses a 2:1 trading ratio for nonpoint source and point source pollution reductions.[12] The trading ratio is the number of units of non-point source abatement that must be provided for a one-unit reduction in point sources. There are disputes over whether the nutrient trading ratio should be greater or less than one. Hanson and McConnell (2008) conclude that a trading ratio higher than one is problematic because this ratio is based solely on abatement, not emissions. They believe that the public is more concerned about the damages caused by emissions, rather than abatement and that policy should focus on emissions. The debate about uncertainty and determining an appropriate trading ratio between point and nonpoint source of pollutions is ongoing.

### 2.2.4. Private Efforts to Restore the Chesapeake Bay

In addition to state and federal funding, privately funded organizations also seek to improve water quality in the Bay. The Chesapeake Bay Foundation (CBF) is the largest privately funded, non-profit organization dedicated solely to protecting and restoring the Chesapeake Bay. It was formed in 1967 and works in two key areas; environmental protection and restoration and environmental education. The "environmental protection" arm of the CBF fights for legislation to protect the Bay from pollution and other harmful activities while the "environmental education" arm encourages people to become stewards of the Chesapeake Bay. The financial summary of the CBF in 2007 shows 60% of their funding comes from grants and gifts (Figure 2.12). In 2007, this amounted to over $12 million, down from $14 million in 2006 (Gelman, Rosenberg & Freeman [2007]). In terms of membership contributions, the CBF received $4.7

[12] A 2:1 trading ratio means that reducing two pounds of nitrogen from a nonpoint source is equal to reducing one pound of nitrogen from a point source.

million in 2007 which was two hundred thousand dollars more than 2006. More than 80% of the total funds for the CBF go towards environmental protection and education.[13]

Each year the CBF prepares a *State of the Bay* report that uses 12 different indicators to rank the different aspects of water quality and health in the Bay. These indicators are measured using the best available information representing three major categories; pollution, habitat, and fisheries; with four subsets of each. A rating of A (Excellent) through F (Critical) is used to evaluate the Bay. Figures 2.13.a, 2.13.b and 2.13.c display selected grades from the 2008 report. The grades are calculated by combining monitoring data along with in-the-field observations. Nitrogen, water clarity, dissolved oxygen, and oysters all receive failing grades. Yet it is oysters, as seen in figure 2.13.c, that received the lowest score out of all the sub-categories. The current state of the Bay is measured against the conditions described by Captain John Smith's account from his exploration of the watershed in the 1600s. Thus, a score of A (70 or better) would mean that Bay's condition is similar to what was described in the early 1600s whereas a score of F (below 20) means that water quality is deteriorating, populations are at their lowest or near lowest levels and pollution continues to be at a high level.

In 2008, the cumulative *State of the Bay* index was 28, which is the same level as 2007 and far below the 2010 goal to increase the Bay's Health Index from 27 to 40 by 2010.[14] The overall net improvement to Bay health between 1998 and 2008 has been slight (State of the Bay

[13] There are other publicly funded Chesapeake Bay organizations, along with the CBF, worth mentioning because of their promotion for healthy watershed and reliance on public donations. The *Alliance for the Chesapeake Bay* produces the *Bay Journal* which combines the latest information on the Chesapeake Bay. This organization of mainly funded through federal and state grants but does receive some public contributions. The *Chesapeake Bay Trust* was created by the Maryland General Assembly to further public awareness and participation in the restoration of the Bay. This nonprofit organization receives most of its funding though the sale of "Treasure the Chesapeake" license plates as well as private and corporate contributions. The *1000 Friends of Maryland* is a nonprofit whose support comes from the Foundation and membership donations to "preserve what is best about Maryland and encourage sensible growth." The *Maryland League of Conservation Voters* is a small group of citizens who endorse candidates with "green" causes. This group receives all of its funding through major donors and small gifts.

[14] The CBF's mission is to "Save the Bay" as defined by a Health Index of 70 by the year 2050 (Chesapeake Bay Foundation, 2009).

[2008]). The 2007 State of the Bay concludes that the "Chesapeake Bay is dangerously out of balance… Clearly, what public officials have done to date is insufficient, and has fallen short of their commitments to restore water quality in the Bay" (State of the Bay [2007]). This same conclusion is made in the 2008 State of the Bay report. Moreover, evidence from previous economic studies suggests that Chesapeake Bay residents are willing to pay for programs that would improve water quality in the Bay.

### 2.3. Measuring the WTP for improved water quality in the Chesapeake Bay

In order to value an ecosystem service, economists must measure its total contribution to human well-being (Freeman [1993]; Brown et. al. [2006]). Therefore, in order to calculate the total economic value of the Chesapeake Bay, economists must measure both "use values" and "nonuse values." Use values include *direct use* and *indirect use*. *Direct use* involves some type of physical interaction, such as fishing in the Chesapeake Bay. *Indirect use* involves human consumption of ecosystem services that contribute to the quality of life such as marine biodiversity and wetlands habitat. The nonuse values consist of *existence* and *bequest* values. *Existence values* are the benefit people receive from just knowing a resource exists, like a national monument or an endangered species. The benefits from preserving a natural resource for future generations are known as *bequest values*. The total economic value is the sum of all of the use and nonuse values. The total economic value of an ecosystem service can be measured by the maximum amount a person would be willing to pay (WTP) for some service or the minimum amount they would be willing to accept (WTA) in payment if the service were taken away.

The methodology of valuing non-market goods and services consists of two branches: revealed and stated preference methods. Revealed preference methods (such as the travel cost

method and hedonic method) infer a value of non-market goods by studying actual (revealed) behavior on an implicit market. Stated preference techniques (such as contingent valuation and choice modeling) assess the value of non-market goods by using individuals' stated behavior in a hypothetical setting because no market data exists (Alpizar et. al. 2001; Holmes 2003).[15] Both revealed and stated preference methods focus on the individual's choices and preferences, based on the fundamental assumption that individuals act so as to maximize their utility (Brown and Peterson [2003]).

### 2.3.1. Review of nonmarket valuation theory

The theoretical framework behind nonmarket valuation consists of three basic steps. The first step derives an expression for willingness to pay as a function of the environmental variable, either from the expenditure function or the indirect utility function. The second step is to develop a specific model of individual utility maximizing behavior that relates the individuals' choices to the relevant prices and constraints. The third step is to collect the data needed to estimate the model and calculate WTP (Freeman [2003]).

The indirect utility function may be used to assess the benefits of improved environmental quality through *compensating* or *equivalent* welfare measures. *Compensating welfare* measures the amount of income that an individual would give up after a policy has been implemented that would exactly return them to their utility status quo. Using the indirect utility function to describe this new scenario, $P$ represents the prices of all the market goods, $Q$ is the level of the nonmarket goods, $y$ is income, 0 denotes the status quo, 1 denotes the new equilibrium after the policy is in place, and $C$ defines the compensating welfare measure.

$$v\left(P^0, Q^0, y^0\right) = v\left(P^1, Q^1, y^1 - C\right) \tag{2.1}$$

[15] The production function method and replacement cost method are two nonmarket valuation methods used infrequently to value ecosystem services (Brown et. al. [2006]).

The compensating welfare measure can be negative or positive depending on the nature of the quality change and any subsequent changes to prices and income.

The second basic welfare measure is the amount of additional income that the individual would need with the initial conditions to obtain the same utility as after the change. This is an *equivalent welfare* measure and is represented as $E$ in the following equation.

$$v\left(P^0, Q^0, y^0 + E\right) = v\left(P^1, Q^1, y^1\right) \tag{2.2}$$

The two measures differ by the implied assignment of property rights. The compensating welfare measure uses the initial utility level as the basis for comparison while the equivalent measure relies on the subsequent level of utility as the basis for comparison. Compensating welfare and equivalent welfare can be interpreted as measures of willingness to pay (WTP) and willingness to accept (WTA) for a given quality change. WTP and WTA are measuring total economic value, including both use and nonuse values, and can be measured using a variety of methods. Both stated and revealed preference methods have been used to estimate WTP for improved water quality in the Chesapeake Bay.

### 2.3.2. Review of previous empirical studies of the Chesapeake Bay

Table 2.3 provides a summary of previous valuation studies of the Chesapeake Bay. The studies can be organized by valuation method: hedonic, contingent valuation (CV), and benefit transfer. The hedonic method is an indirect valuation method in which the researcher does not observe the value consumers have for the characteristics directly, but infers it from observable market transactions (Taylor [2003]). The method is often applied to housing markets to estimate the value of amenities that vary across space. CV is a survey-based stated preference method. Benefit transfer uses information from existing studies to conduct policy analysis in settings other than the original study site. The remainder of this sub-section discusses how hedonic

methods, CV, and benefit transfer have been used to estimate WTP for improved water quality in the Chesapeake Bay.

In 1987 Bockstael, McConnell, and Strand used CV to estimate a moderate improvement in water quality in the Chesapeake Bay. The motivation for their study was twofold. One reason was to understand how people use the Bay and the ways in which they derive enjoyment from it. The other motivator was to find out how much people are willing to pay for access to recreational activities in the Bay, and how this WTP changes as water quality improves. Specifically, the authors attempt to answer "what is the monetary worth of pursuing the programs outlined in the Chesapeake Bay Restoration and Protection Plan?" (Bockstael, et al. [1987]). The authors consider a hypothetical change from the current water quality condition, to an improved condition, which the respondent considers "acceptable swimming." They conducted a telephone survey of households in the Washington-Baltimore area. Each respondent is asked whether they consider the Chesapeake to be acceptable or unacceptable for swimming and other activities. Those who answered "unacceptable" were then asked if they would support a new federal tax to improve water quality.[16] The bid amount varied randomly from $5 to $50 per year over the sample. Results from their study indicate that users are willing to pay three times as much in extra taxes as nonusers. In order to gain insight into specific uses of the Bay, the authors choose three recreational activities; beach use, boating and striped bass fishing to estimate the benefits of improved water quality. Bockstael et al's 1987 final estimate for aggregate annual WTP for improved water quality ranged from $20 to $204 million in 2008 dollars.[17]

[16] This included the costs of construction of wastewater treatment plants, funding government programs to monitor agricultural effluents, subsidize best management practices and restrictions on housing developments.

[17] The authors express some uncertainty about their estimates. First, the relationship between environmental policy and pollution is uncertain. Environmental policy affects effluents directly through regulations and indirectly though changes in incentives. Second, for the use values, there is considerable room for error between the parameter estimates and the relationship between total phosphorus and total nitrogen in 1977 and in 1983. Third, there were

Two more CV studies involving the Chesapeake Bay were conducted by Lipton (2004) and Hicks, Haab, and Lipton (2004). The Hicks et al study is aimed at identifying the economic benefits associated with oysters in the Chesapeake Bay. They use two groups; recreational fishermen and those who have non-use values for oyster resources. Each respondent was asked whether they would vote for a program if the estimated cost was $X to their household and Y acres of oyster sanctuary were constructed over Z time period. There were 18 versions of the question. The results for a 10 year project had a mean WTP of $179.61 per year per household. Due to the short nature of the phone survey, a follow-up mail survey was distributed to those willing to participate. Because the respondents were self-selected, the authors suggest that their results are not representative of the population as a whole and expect the $179.61 to represent an upper bound on average WTP.

The other study by Lipton (2004) uses CV to value a hypothetical water quality improvement for boaters in the Chesapeake Bay. The design is an open-ended CV question as part of larger mail survey on Maryland boaters. The CV question asked respondents "what is the maximum amount you would be WTP per year in state or local taxes for a one step improvement in water quality?"[18] The boaters' WTP ranged from $55-$93 and is surprisingly lower than comparative boating CV studies (Lipton [2004]). This study only measured one specific use value, boating, thus leaving out any value from other users or nonusers of the Bay's resources.

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severe difficulties in inferring the relationships between ambient water quality and willingness to pay. There was the problem of sampling and non-sampling error associated with the measurement of the number of trips per participant and the number of participants in each activity for boating. In addition, the boating and fishing users only included Maryland residents thus excluding a major portion of the users of the Bay. Another source of error comes from the authors' aggregation of benefits. Many fishermen have boats and in this case, their benefits would be double counted.

[18] Open-ended CV questions have fallen out of favor for multiple reasons. For example, if a respondent is very passionate about seeing a new policy improve water quality in the Bay, they may state an open-ended value that exceeds their WTP.

Another Chesapeake Bay study by Leggett and Bockstael (2000) used hedonics to determine whether water quality had an effect on residential land prices in Anne Arundel County, Maryland. Water quality was measured by fecal coliform bacteria levels, which can have serious human health effects. For the estimation of the hedonic model the water quality variable was derived from samples collected weekly at 104 monitoring states along the Anne Arundel County coastline. After estimating their model, the authors found that fecal coliform levels have a significant effect on property values. They concluded an upper bound estimate of the benefits for improving water quality at all 494 waterfront properties is $12.1 million (Bockstael and Leggett [2000]).[19] This study only focused on the water front property values in Maryland and did not include people who value the Bay but do not own waterfront property. A large part of Bay's shoreline is in Virginia and users who own property in this state were not considered in this study.

Finally, Morgan and Owens (2001) estimated the benefits of water quality legislation in the Chesapeake Bay from 1972, the year the Clean Water Act (CWA) was signed, to 1996. The benefits were assessed using a 'with-without' perspective.[20] In order to conduct a benefit transfer, the authors first updated the benefit estimates from Bockstael et al (1987) by extrapolating the water quality conditions to reflect the 1996 population and include Virginia's portion of the Bay. The authors also predict overall improvements in total nitrogen and phosphorous loads as a result of the CWA as 60%. Bay-wide aggregate benefits were then scaled to capture the additional benefits from the estimated 60% improvement in water quality. The benefit estimates range from $49.95 to $251 per person. These benefits represent use values for

[19] The authors make note that even though hedonics can provide a convincing argument, the applications are plagued with ambiguities. Choice of the functional form is arbitrary, the definition of the market is problematic and there is always the possibility that omitted variable bias may lead to a biased estimate of the environmental quality parameter.

[20] That means comparing 1996 water quality with what it would have been without the CWA and related legislation.

persons living in the District of Columbia and portions of Virginia and Maryland. The authors believe that they have either over or under estimated the benefits for some of the use values like fishing. One of the limitations for benefit transfer is the implicit assumption that the statistical relationship between econometric dependent and independent variables at the study site are the same at the policy site. Empirical tests have shown that this may be false (Rosenberger and Loomis [2003]).

### 2.4. New Research Questions

There are three important questions that have not been addressed in the existing literature on willingness to pay for improved water quality in the Chesapeake Bay. First, does willingness to pay for a given water quality improvement depend on the process used to obtain that improvement? Second, does introducing a publicly funded program to improve water quality crowd out private donations to charitable organizations like the CBF? Third, because of their water filtration properties, could oysters in the Chesapeake Bay be successfully marketed as a "green" good? Each of these questions is discussed in turn.

#### 2.4.1. Does process matter?

The relevance of process to specific goods has been discussed before within the context of international trade organizations. "Process attributes" are defined as any attribute of the production process that are not related to the good's performance but that nevertheless would be relevant to some potential purchasers given perfect information (Frank [2006]). "Dolphin-safe" tuna, "fair-trade" coffee and "green" electricity are examples of process attributes that have been considered in previous work (Ek and Söderholm [2008], Loureiro and Lotade [2005], Teisl et al. [2002], and Ethier et al. [2000]). The consumer cannot see the difference directly from the

tuna or the coffee but they may care about the different production processes. This logic may also apply to the characteristics of a public program.

The previous literature on estimating WTP for water quality in the Chesapeake Bay has not considered the potential effect of process attributes on WTP for a new program. The hedonic method does not include a process attribute and CV is tied to a specific process. Thus, the existing literature assumes that the process to improve water quality is fixed. However, a consumer may be willing to pay more for a tax which improves water quality if it also provides environmental benefits. For example, consumers may be willing to pay more for a program that not only improves water quality but also increases the native oyster population in the Bay. Alternatively, they may be willing to pay more for a program that improves water quality by providing money to farmers; who in turn use best management practices that increase wildlife habitat in addition to improving water quality.

### 2.4.2. Will a water quality tax crowd out private donations?

In 1984 Russell Roberts made a bold statement by implying that the large expansion in government services since the Great Depression has resulted in an equal decline of private charity to the poor, leading to the result that the governmental services had no net effect on alleviating poverty. He went on to claim that this was true for all public-private partnerships in providing public goods. Robert's claims were built on a theoretical model by Warr (1982) that showed that any "small" lump sum tax on donors that is contributed to the public good will completely crowd out private donations. In the late 1980s several theoretical papers questioned whether complete crowding out would exist and there was debate in the literature over whether government taxes on public goods are completely neutral (Bernheim [1986], Bernheim and Bagwell [1988]), and Andreoni [1990]). In the early 1990s Andreoni proposed a theory of

"warm-glow" giving and tested the public-goods crowding out hypothesis by using a laboratory experiment with "no-tax" and "tax" trial groups (Andreoni [1990,1993]). His results provide evidence that incomplete crowding out occurs when a group is taxed. He interprets this result as providing evidence the people assume some private benefit from contributing to a public good, known as "warm-glow" (Andreoni [1993]).[21]

The crowding out phenomenon is important for this study because a new tax to improve water quality may decrease donations to charitable organizations like the Chesapeake Bay Foundation. The existing literature does not address the possibility of taxes crowding out charitable donations for the Chesapeake Bay. The introduction of a new tax may decrease donations to the Chesapeake Bay Foundation if the consumer sees this tax a substitute for the environmental quality that would be provided by an organization like the CBF. If crowding out is complete, the tax may fail to improve water quality.

### 2.4.3. Is there a demand for "green" goods that reduce nutrient loading?

Consumers are often willing to pay more for goods or services considered environmentally friendly or "green" (Kotchen [2005]). A "green" good can be defined as an impure public good jointly produced through production in the private market and through the supply of an environmental public good (Kotchen [2006]). Shade-grown coffee and eco-friendly water are two examples. These products bundle private market services with environmental benefits. Shade grown coffee is grown under a canopy of trees that provides tropical biodiversity while eco-friendly water has a share of the profits contributed to counties without adequate drinking

[21] In 2006 Andreoni develops a "warm-glow" giving model to analyze why people give and demonstrate that in large economies, warm-glow will become the dominate motivator for giving.

water. Market pricing suggests that consumers are willing to pay more for these goods than for ordinary coffee or water.[22]

There may be a strong demand for green goods that bundle environmental quality in the Chesapeake Bay with private market goods. This possibility has not been considered in the existing literature. Recent media articles have highlighted the green good phenomena, even making reference to oyster aquaculture in the Chesapeake Bay. CNN recently published an article highlighting the sustainability of oyster aquaculture and how it is conducted in an eco-friendly manner (Moorhead [2009]). The filtration services, which improve water quality, are a positive environmental benefit from oysters thus making oysters liable to be considered a "green" good. With appropriate labeling and education of consumers, aquaculturists may be able to receive a higher price per oyster due to their "green" good characteristics. If these benefits could be collected monetarily though branding or a new ecolabeled oyster, growers would have incentives to increase production.

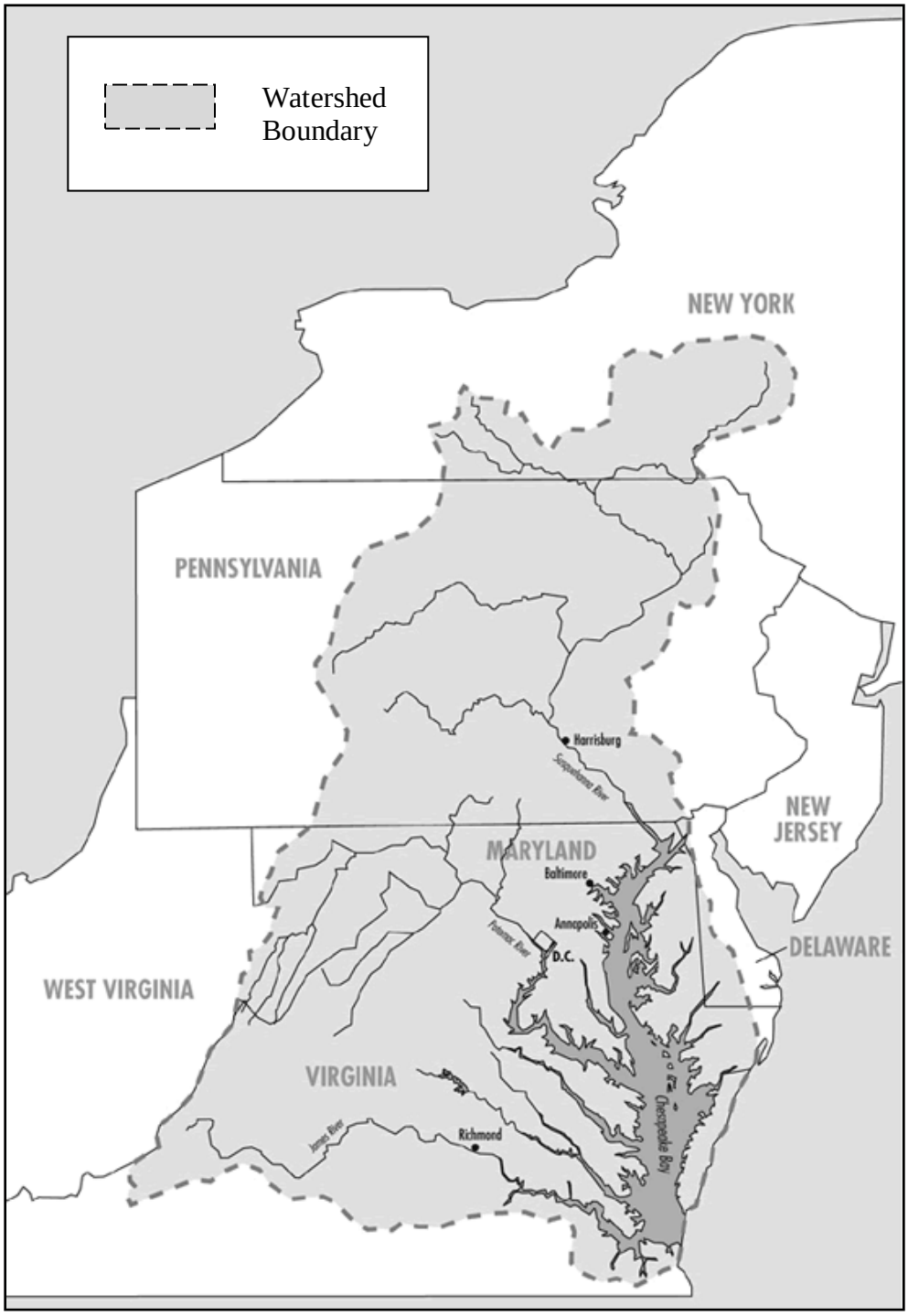
### 2.5. Conclusion

The Chesapeake Bay is unique attribute of the Atlantic Coast providing environmental and recreational benefits to millions. Due to a combination of natural and man-made pressures the Bay's resources have become severely depleted. Previous work used a variety of stated and revealed preference methods to measure the Bay's values. This chapter has proposed three new research questions. First, does WTP for a given water quality improvement depend on the process used to obtain that improvement? Second, does introducing a publicly funded program to

[22] Kotchen sets up a model to demonstrate the choice settings for a green market. The model captures three choices: conventional (pure private) good, a direct donation to an environmental (pure public) good and a green (impure public) good (2006). His results indicate that green technology can affect the price level of private provisions depending on whether the public good is a compliment or substitute for private consumption. He also concludes that green technologies can be either welfare-improving or impairing, despite the fact that they expand the consumer choice set.

improve water quality crowd out private donations to charitable organizations like the CBF? Third, because of their water filtration properties, could oysters in the Chesapeake Bay be successfully marketed as a "green" good? These questions provide the basis for the theoretical and empirical models described in Chapter 3.

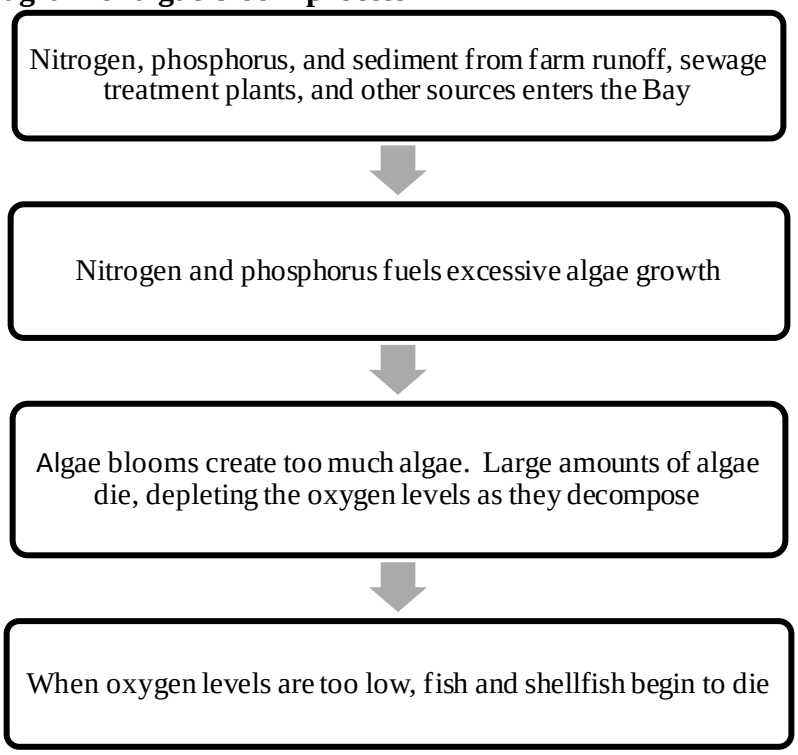
**Figure 2.1. The Chesapeake Bay Watershed**




Source: *Chesapeake Bay Program, 2008*

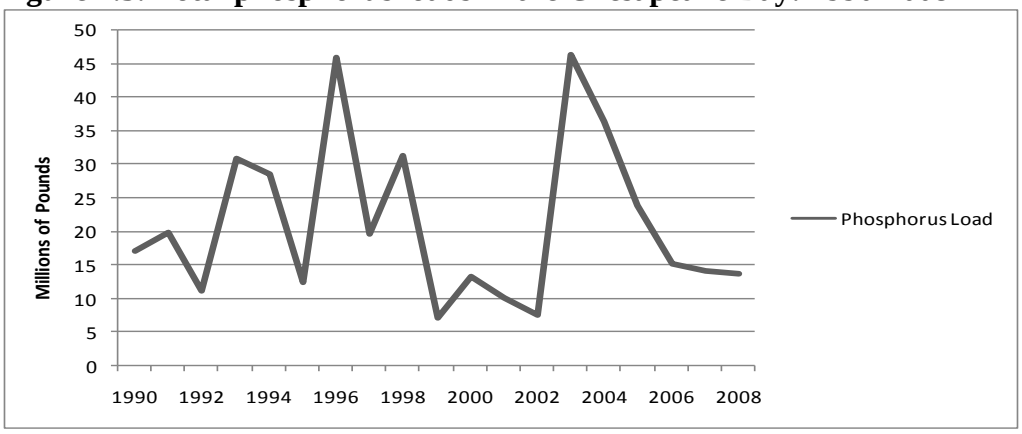
**<u>Explanatory note:</u> The Chesapeake Bay watershed is light grey, the Chesapeake Bay is dark grey and the dotted line indicates the watershed boundary.**

**Figure 2.2. A diagram of algae bloom process**



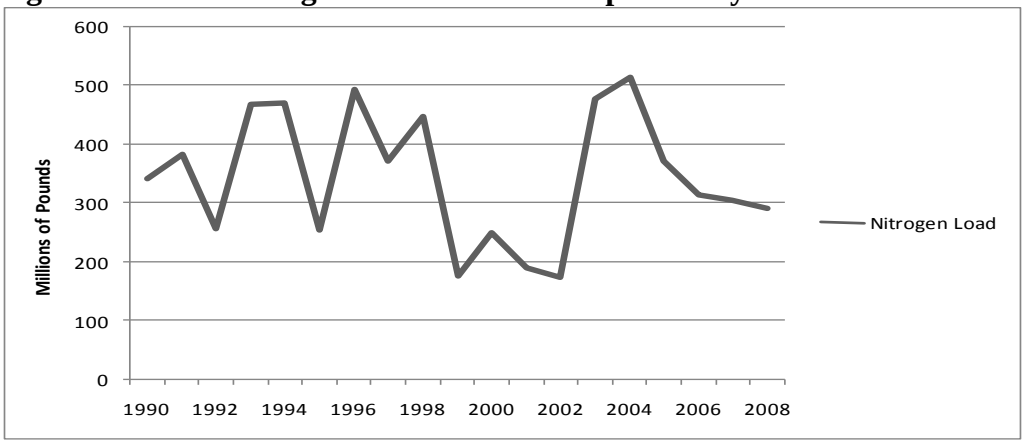

Source*: Bricker et al., 2007*

**Figure 2.3. Total phosphorus loads in the Chesapeake Bay: 1990-2008**



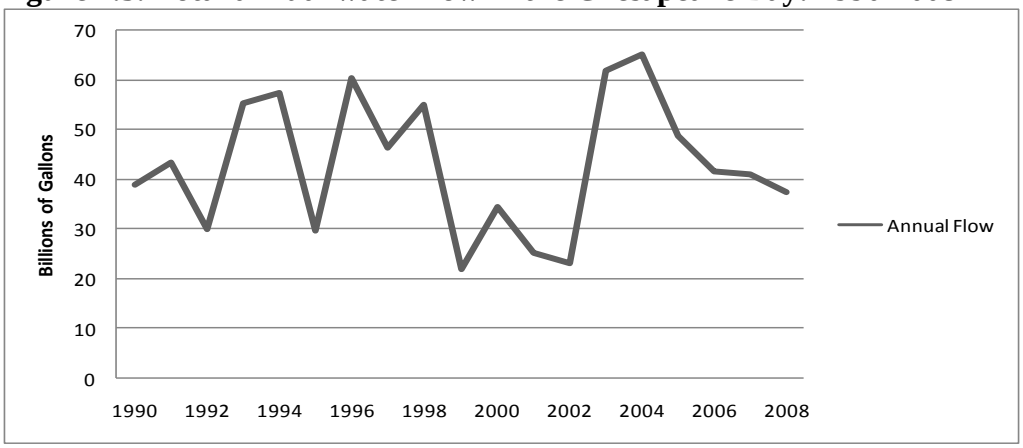

Source: *Data acquired from Foreman, 2009*

**Figure 2.4. Total nitrogen loads in the Chesapeake Bay: 1990-2008**



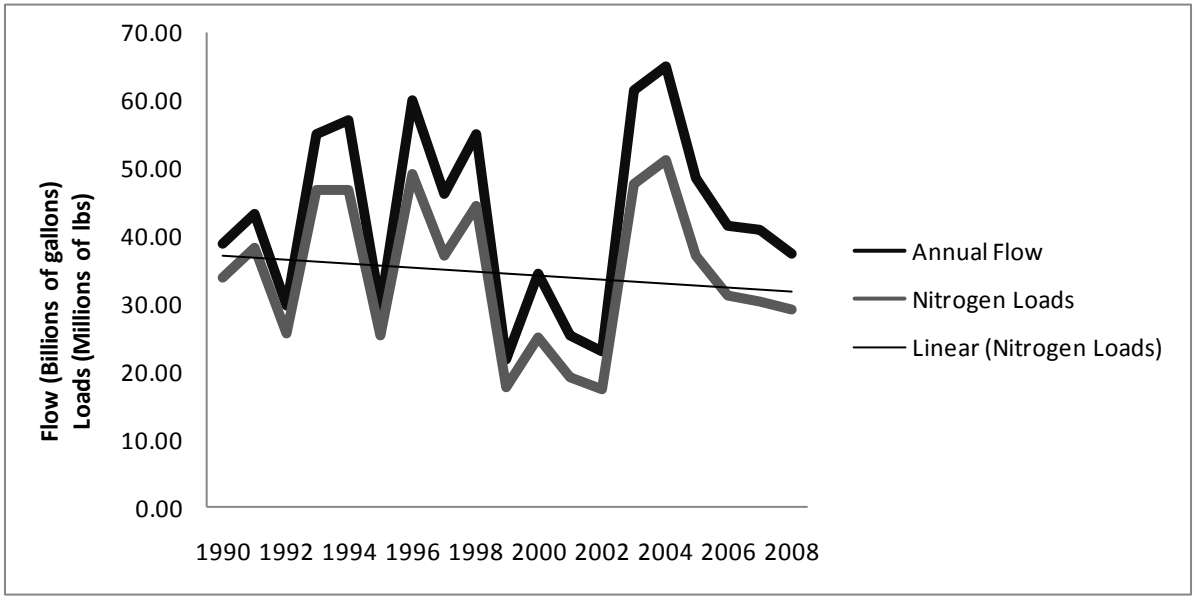

Source: *Data acquired from Foreman, 2009*

**Figure 2.5. Total annual water flow in the Chesapeake Bay: 1990-2008**




Source: *Data acquired from Foreman, 2009*

**Figure 2.6 Annual flow and nitrogen loads in the Chesapeake Bay with a trend line 1990-2008**

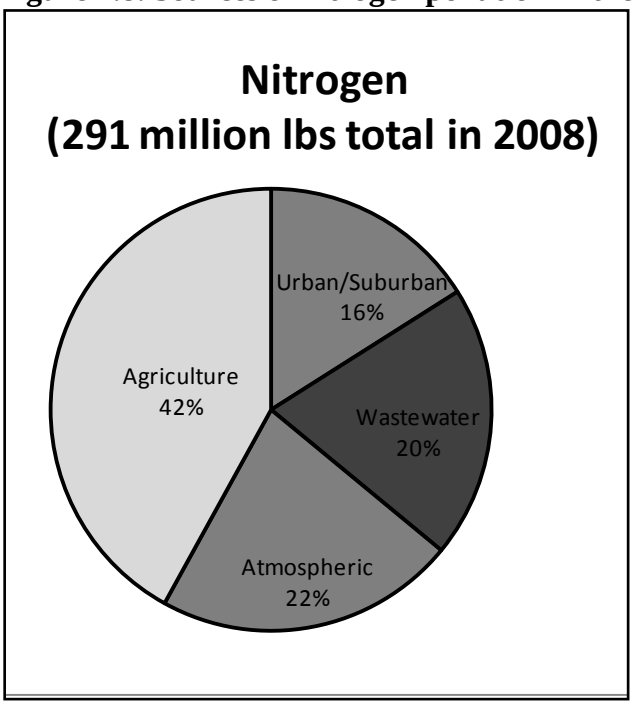



Source: *Data acquired from Foreman, 2009*

**Figure 2.7. Nitrogen and phosphorous manure excreted on Virginia farms 1982-1997**

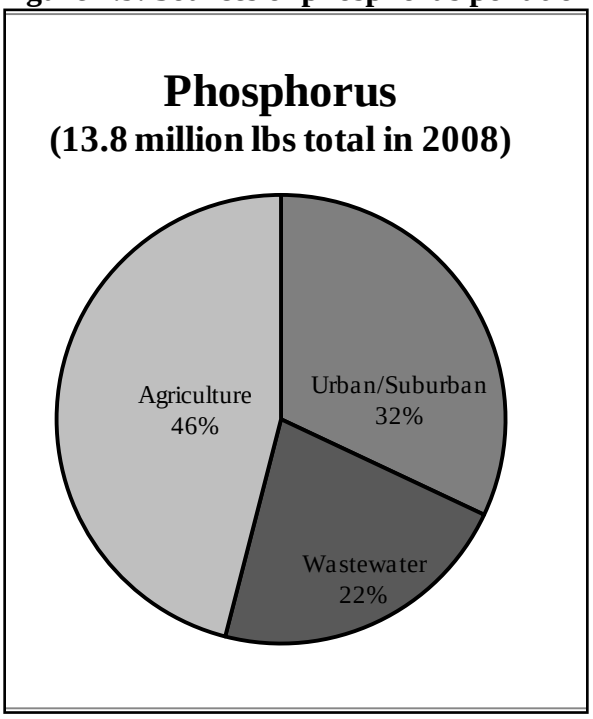

Source: *Confined Animal and Manure Nutrient Data System, United States Department of Agriculture Economic Research Service, 1997*

**Figure 2.8. Sources of nitrogen pollution in the Chesapeake Bay**



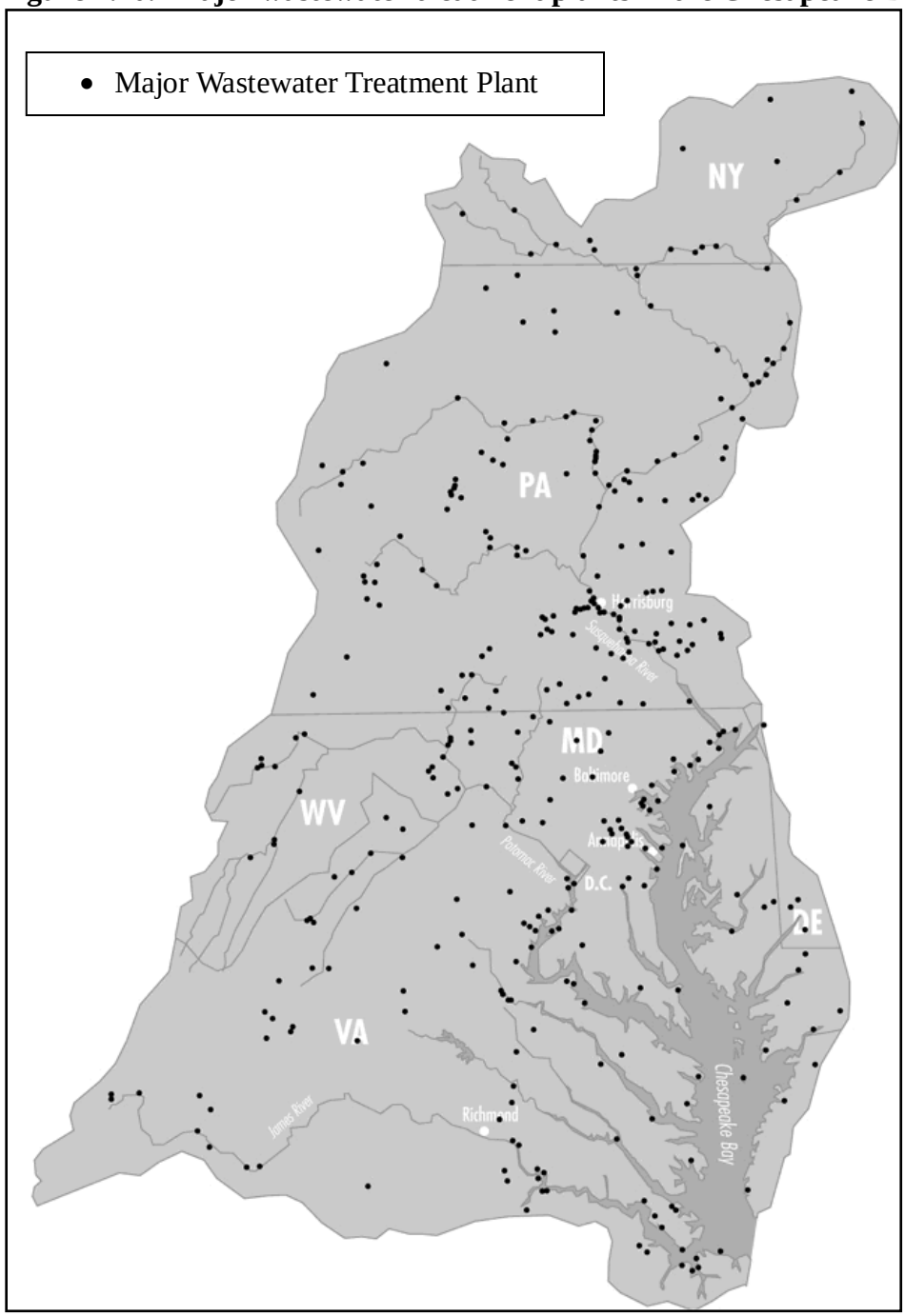

Source: *Data acquired from the Chesapeake Bay Program, 2008*

**Figure 2.9. Sources of phosphorus pollution in the Chesapeake Bay**



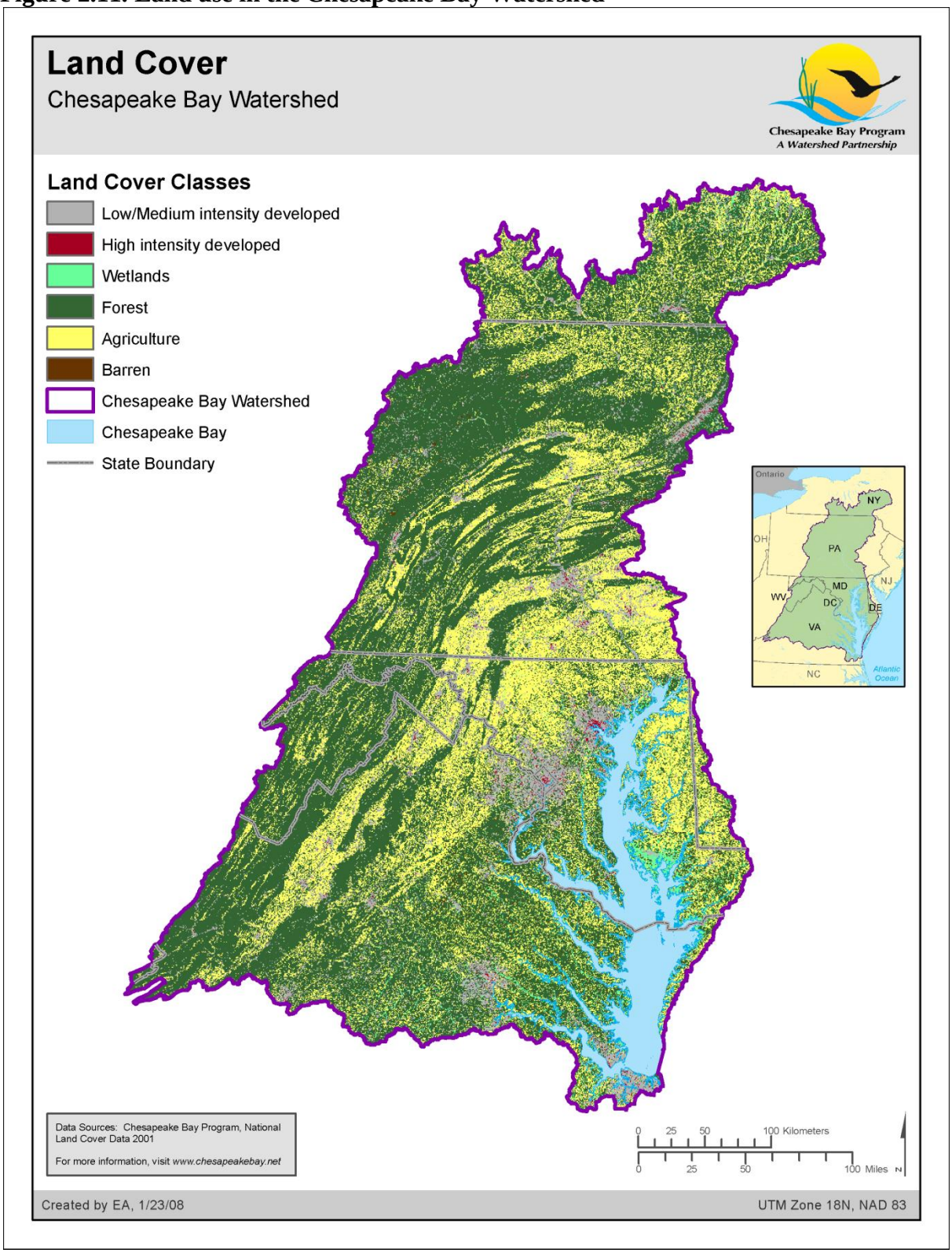

Source: *Data acquired from the Chesapeake Bay Program, 2008*

**Figure 2.10. Major wastewater treatment plants in the Chesapeake Bay Watershed**



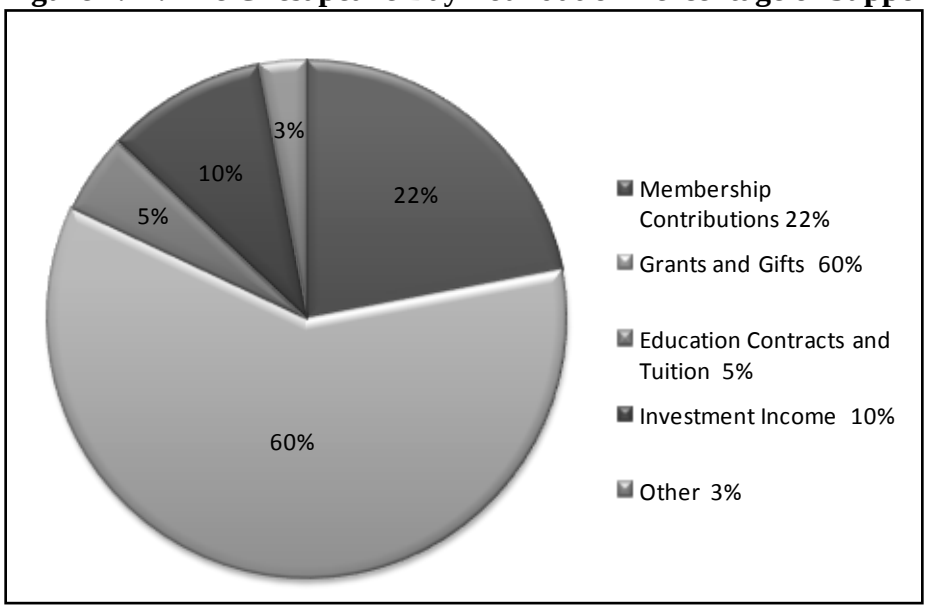

Source: *Chesapeake Bay Program, 2008*

**Figure 2.11. Land use in the Chesapeake Bay Watershed**



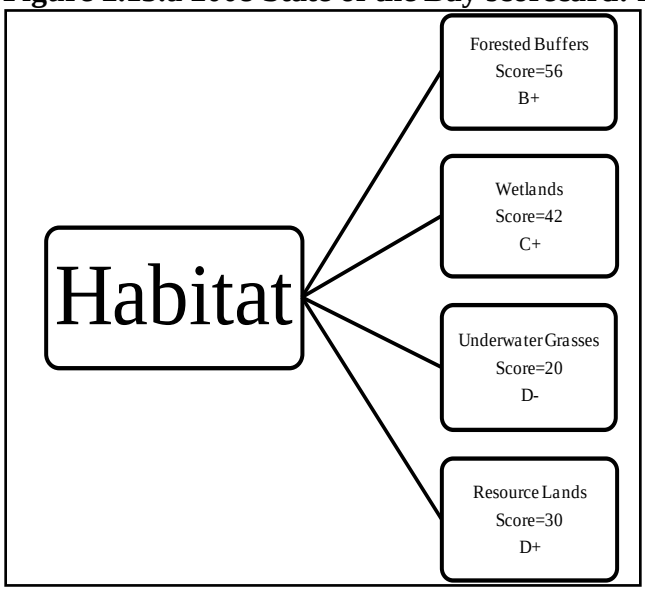

Source: *Chesapeake Bay Program, 2008.*

**Figure 2.12. The Chesapeake Bay Foundation Percentage of Support and Revenue in 2007**




Source: *Data acquired from the Chesapeake Bay Foundation, 2007*

**Figure 2.13.a 2008 State of the Bay scorecard: Habitat categories**




Explanatory note: Each year the CBF prepares a *State of the Bay* report that uses 12 different indicators to rank the different aspects of water quality and health in the Bay. These indicators are measured using the best available information representing three major categories; pollution, habitat, and fisheries; with four subsets of each. A rating of A (Excellent) through F (Critical) is used to evaluate the Bay. Figures 2.13.a, 2.13.b and 2.13.c display selected grades from the 2008 report. The grades are calculated by combining monitoring data along with in-the-field observations. Nitrogen, water clarity, dissolved oxygen, and oysters all receive failing grades.

**Figure 2.13.b 2008 State of the Bay scorecard: Pollution categories**

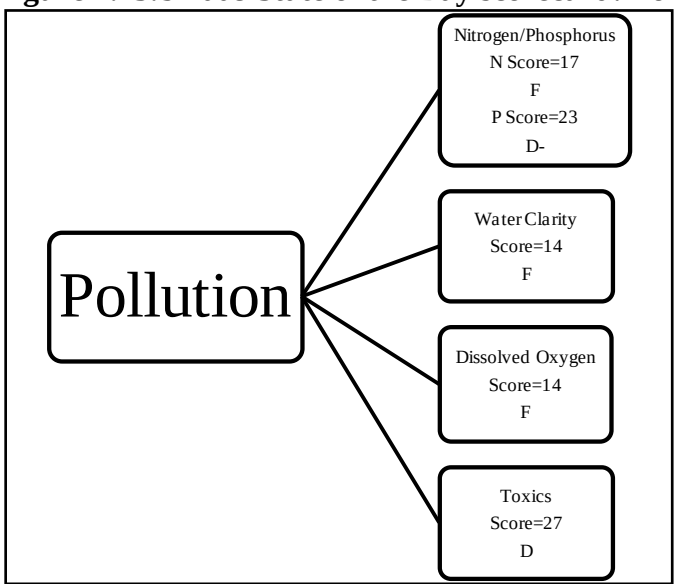
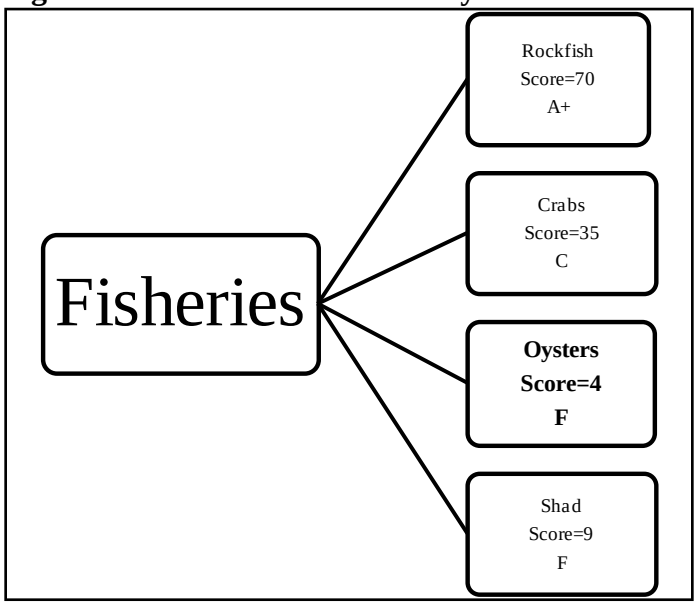



**Figure 2.13.c 2008 State of the Bay scorecard: Fisheries categories**




Source: *State of the Bay 2008, Chesapeake Bay Foundation*

**Table 2.1. The Chesapeake Bay Agreement: years established, policy targets and actual levels**

| Policy | N Level | P Level | Traget Year | N Target | P Target |
|---|---|---|---|---|---|
| 1983 Plan | 338 Million | 27.1 Million | 2000 | NA | NA |
| 1987 Plan | NA | NA | 2000 | 260 Million | 17 Million |
| 1992 Plan | 256 Million | 11 Million | 2000 | 260 Million | 17 Million |
| 2000 Plan | 250 Million | 13.2 Million | 2010 | 175 Million | 12.8 Million |

Source: *These levels were calculated for a variety of sources including: The Chesapeake Bay Program (2008), the Chesapeake Bay Foundation (2007) Chesapeake Bay Journal (2002), and Foreman (2009)*

**Table 2.2. The costs of farm conservation practices**

| Conservation Practice | Cost per Acre |
|---|---|
| Grass Steamside Buffers | $300 |
| Cover Crops | $35 |
| Grass Filter Strops | $300 |
| Forest Riparian Buffers | $178 |
| Wetland Restoration | $285 |

Source: *Delaware Department of Natural Resources and Environmental Control 2007*

## Table 2.3. Summary of previous Chesapeake Bay studies

| Authors | Date | Journal Article | Methods | Benefits Valued | Population | WTP Results | Comments |
|---|---|---|---|---|---|---|---|
| Bockstael, NE, KE McConnell and IE Strand | 1989 | Marine Resource Economics | CV | Recreational and commercial activities such as beach use, boating and fishing in the Chesapeake Bay | Residents of Baltimore and Washington, D.C. Standard Metropolitan Statistical Areas | Range from $10 to $100 per person for a one step improvement in water quality | Derived from CV to measure improved water quality benefits and indirect market methods to measure water quality benefits |
| Krupnick, A. | 1988 | Maryland Law Review | Cost-benefit analysis | Recreation, commercial fishing, option value, and existence value | Maryland, Virginia and DC | $17.61 per beach trip and $51.25 per boat trip | Sketchy evidence of benefits to improved water quality, limited estimates |
| Leggett, C and N.E. Bockstael | 2000 | Journal of Environmental Economics and Management | Hedonic | Reductions in fecal coliform bacteria to 100 counts per 100mL | 494 properties | $5,114 to $9,824 per household | Only Maryland portion of the Bay |
| Morgan and Owens | 2001 | Ecological Economics | Benefit transfer | Use Values; Recreation, commercial fishing, health, non-use, property, regional economic impacts | Persons living in the District of Columbia, Maryland and Virginia | $49.95 to $251 per person | Less accurate than original research |
| Lipton, D. | 2004 | Marine Resource Economics | CV | Improved water quality by Bay boaters | 1,163 registered boaters by MDNR | $54 to $93 per boater | Need direct studies on water quality boating |
| Hicks, RL, TC Haab, and D Lipton | 2004 | Report for the Chesapeake Bay Foundation | CV | Economic benefits of oyster restoration | Random Digit Dial coastal counties from New Jersey to North Carolina | $179 per person | Self-selection in the mail survey provided high WTP estimates |

# Chapter 3: Measuring the willingness to pay for water quality programs: Theory and Econometrics

### 3.1. Introduction

This chapter presents theoretical and econometric models that describe consumer preferences for water quality program attributes, assess the impact of a new program on private donations, and consider the willingness to pay for a "green" good that would improve water quality in the Chesapeake Bay. Section 3.2 introduces a basic model of individual willingness to pay for a new water quality program that is consistent with the existing literature. The basic model follows Andreoni (1989). Each of the subsequent sections extends the baseline theory and proposes an econometric model to test the extension. Section 3.3 uses Lancaster's (1966) attribute based model of demand to describe consumer preferences for program characteristics. A random utility model is proposed to recover preferences. Section 3.4 applies Andreoni's (1989) warm glow model to illustrate how a tax on a public good like water quality may crowd out private donations to the public good. A first-differenced model is proposed to test how changes in donations depend on tax rates, program characteristics, and individual demographics. Section 3.5 uses Lancaster's attribute based model to describe the demand for oysters that improve water quality in the Bay. A single-bounded dichotomous choice contingent valuation model is proposed to estimate the potential price premium for these oysters. Finally, section 3.6 describes the choice experiment approach for nonmarket valuation and summarizes the issues associated with designing a choice experiment to estimate the models described in the previous sections. This section also provides background for the actual design presented in Chapter 4.

### 3.2. Baseline model

For now, assume that the economy has only one private good and one public good. The public good, water quality, is produced from the private good, donations, in a simple linear relationship therefore making it measurable in dollars. According to Andreoni (1989) people make private

donations for a public good for two reasons. First, they demand more of the public good, which is classified as "altruism." Second, people receive a "warm glow" from donating. A warm glow effect is the utility one gets from giving charitable donations and is also called "egoism." Intuitively, "egoism" means that an individual gets satisfaction from giving that is separate from the satisfaction they get from consumption of the public good itself (Andreoni [1989]).

Suppose all donations are given directly to the public good and there are *i* individuals in the economy. Equation 3.1 depicts the consumer's utility maximization problem. The consumer chooses the level of donations and the amount of the composite private good subject to a budget constraint. In equation (3.1) $q$ represents water quality, which depends on donations. Let $g_i$ represent an individual's donations to the public good and let $G = \sum_{i=1}^{"} g_i$ be the donations of everyone. Finally, $z_i$ is the composite numeraire and utility may depend on both demographics ($d_i$) and preferences ($\beta_i$).

(3.1) $$\max_{g,z} U_i = f\left[q(G), g_i, z_i \mid d_i, \beta_i\right] \text{ subject to } m = z_i + g_i$$

Note that $g_i$ enters utility twice; once as a part of the public good and again as a warm glow effect.

From the consumer's optimization problem in (3.1), one can separate out the effects of altruism and egoism on an individual's utility for improved water quality by taking the first order condition:

(3.2) $$\frac{\partial U_i}{\partial g_i} = \frac{\partial f[\cdot]}{\partial q} \times \frac{\partial q(G)}{\partial g_i} + \frac{\partial f[\cdot]}{\partial g_i}.$$

Equation (3.2) depicts the two separate ways in which donations affect utility. The first term of (3.2) can be broken down into the marginal utility of water quality multiplied by the marginal

effect of an individual's donations on water quality. However, with warm-glow, the others' donations are imperfect substitutes for one's own (Andreoni [2006]). Hence, a person who experiences warm-glow may not reduce their own donations in response to increased donating by others because they care about the source of their donations. This warm-glow or egoism effect is captured by the second term on the right hand side of equation 3.2.

Water quality improvements can come from public policy mechanisms rather than direct donations. A public program to improve water quality through taxes is an alternative mechanism. A prime example of a public policy mechanism is the Maryland "flush tax." The flush tax is a $2.50 monthly fee on sewer bills and an equivalent $30 annual fee on septic system owners. The revenue from this tax goes directly towards improving water quality in the Chesapeake Bay as well as improving the overall condition of the Bay. This type of public good tax benefits the Bay both directly and indirectly. Direct users of the Chesapeake Bay benefit from improvements made by the tax revenues while nonusers indirectly receive an existence value from the Bay being healthy.

For simplicity, suppose the tax revenue from a new public program is a perfect substitute for donations. This implies that water quality now depends on the sum of tax revenues and donations:

(3.3) $$\max_{g,z} U_i\left[q(G+T), g_i, z_i \mid d_i, \beta_i\right] \quad \text{s.t.:} \quad m_i - \tau_i = z_i + g_i .$$

Each household pays a tax of $\tau_i$ and all tax revenue goes directly towards supporting the public good. In equation (3.3) let $T = \sum_{i=1}^{"} t_i$ be the total tax revenue. By using the indirect utility function, we can measure WTP for improved water quality. To get the indirect utility function, rewrite the budget constraint as $z_i = m_i - \tau_i - g$ and substitute it into the utility function:

(3.4) $$V_i\left[q(G+T), g_i, m_i - g_i - \tau_i \mid d_i, \beta_i\right].$$

WTP is synonymous with compensating variation and represents the amount of money needed to compensate a person for some change. Equation (3.5) represents a welfare change from the water quality improvement provided by tax revenue:

(3.5) $$V_i\left[q_0(G), g_i, m_i - g_i \mid d_i, \beta_i\right] = V_i\left[q_1(G+T), g_i, m_i - g_i - \tau_i^* \mid d_i, \beta_i\right]$$

where $q_0$ represents the initial water quality level without any improvements. On the other side of the equation, $q_1$ represents an improvement in water quality from $q_0$ to $q_1$. The equality of utility is determined by the level of tax, $\tau_i^*$, which represents an individual's WTP for the water quality program. This is the logic implicitly used in the existing literature summarized in section 2.3.2.

The problem with (3.5) is that the welfare changes do not consider whether process matters, it ignores crowding out, and it does not consider the possibility of green markets. First, the improvement process is ignored because program characteristics are assumed not to affect utility. Second, crowding out is not tested because the level of donations is held constant. Third, the opportunity for a green market cannot be evaluated without a process attribute that uses joint public and private contributions. These issues will be considered separately in the following three sections.

### 3.3. Estimating Consumer Preferences for Water Quality Program Attributes

The objective of this section is to develop a model that recognizes program characteristics may matter to consumers. This idea draws on Lancaster's (1966) theory of demand where attributes of a good are demanded rather the good itself. Random utility maximization provides the empirical framework to test the model from data on consumer choices between competing

alternatives. By including prices as an attribute, marginal utility estimates can be converted into willingness to pay for changes in attributes. This is formally shown using a conditional logit model.

### 3.3.1. Theory

Lancaster's (1966) attribute based theory of consumer demand suggests demand is being driven by the attributes of a commodity. The attributes of the program that improves water quality were not defined in (3.5). Characteristics of the program may enter utility separately:

$$V_i\left[q_1(G+T), s\ , g_i, m_i - g_i - \tau \mid d_i, \beta_i\right] \tag{3.6}$$

in equation (3.6) $s$ represents the different processes or program characteristics that directly affect utility. For example, planting tall grasses along streambanks is one program characteristic that could be used to improve water quality in the Chesapeake Bay.

It is important to note that the level of water quality in (3.6) is represented as a function of the summation of taxes and donations. A more general way to write (3.6) is to recognize that different processes to improve water quality may represent technologies that differ from how donations are used. In this case, $s$ enters the production function:

$$V_i\left[q_1(G,T,s), s, g_i, m_i - g_i - \tau \mid d_i, \beta_i\right]. \tag{3.7}$$

The alternative program characteristics $s$ now enter equation (3.7) indirectly through the water quality term in addition to the direct effect on utility. As a result, WTP can now be defined for a change in program characteristics holding water quality constant.

$$\begin{aligned} & V_i\left[q_1(G,T,s_1), s_1, g_i, m_i - g_i - \tau \mid d_i, \beta_i\right] \\ = & V_i\left[q_1(G,T,s_2), s_2, g_i, m_i - g_i - \tau - WTP_i \mid d_i, \beta_i\right] \end{aligned} \tag{3.8}$$

Water quality ( $q_1$) is held constant while the vector of program parameters *s* changes from $s_1$ to $s_2$. The program attributes used to improve water quality change but the overall improvements

in water quality, the level of donations and the tax revenues remain constant. Now that water quality is held constant an econometric model will be developed to estimate consumer preferences ( $\beta_i$ ) and evaluate WTP for changes in program attributes.

### 3.3.2. Econometrics

The foundation for modeling discrete choice behavior came from psychology, where a paper by L.L. Thurstone (1927) introduced the choice probability for a conjoint question. This work was introduced into economics by Jacob Marschak (1960) who explored the theoretical implications for choice probabilities and provided a derivation from utility maximization. Marschak called this maximization of utilities a Random Utility Maximization (RUM) model.[23] Another influential study of choice behavior by R. Duncan Luce (1959) introduced the Independence from Irrelevant Alternatives (IIA) axiom that simplified the collection of choice data by allowing multinomial choice probabilities to be inferred from binomial choice experiments. For a more thorough review of the literature on discrete choice modeling, the reader is referred to Train (2002). Due to the nature of the discrete dependent variables, maximum likelihood estimation and the logit model are the tools used for econometric analysis.

Utility is constructed as a measure of well-being and has no natural level or scale. In order to fit a discrete choice model to data on individual choices, the choice set needs to exhibit three characteristics. First, the alternatives must be mutually exclusive. That is, choosing one alternative precludes choosing any of the others. Second, the choice must be exhaustive meaning that all possible alternatives are included. Third, the number of alternatives must be finite.

[23] Random utility maximization (RUM) has been the most predominant form of evaluation for choice models (Scarpa and Rose 2008). The basic choice model is known as the multinomial logit (MNL) model (McFadden 1974). The word 'logit' is a contraction of the **log**arithm**i**c **t**ransformation of an odds ration such that the utility value of one alternative must be set to some constant, typically zero, because only *J-1* of the utilities are identified.

From our behavioral model an individual *i* considers the characteristics of choice *j*. Following Holmes and Adamowicz (2003) utility can be written as the sum of systematic ($U_{ij}$) and random $\varepsilon_{ij}$ components:

(3.9) $$V_{ij}\left(q_j, s_j, \tau_j \mid d_i, \beta_i, m_i, g_i\right) = U_{ij}\left(q_j, s_j, \tau_j \mid d_i, \beta_i, m_i, g_i\right) + \varepsilon_{ij}$$

Because the researcher does not know $\varepsilon_{ij}$, it is treated as random. The logit model is obtained by two key assumptions; 1) that utility is additively separable where the deterministic component of *i*'s utility is calculated from observed variables and $\varepsilon_{ij}$ is a random component of *i*'s utility and 2) each $\varepsilon_{ij}$ is an independently, identically distributed *(iid*) extreme value error. The *iid* assumption implies that the errors are independent of each other. In this case, independence means that the unobserved potion of utility for one alternative is unrelated to the unobserved portion of utility from another alternative (Train [2002]).

(3.10) $\varepsilon_{i,j}$ ~ Type I Extreme Value

Though this new assumption on the error term appears restrictive, it is important to note that $\varepsilon_{i,j}$ is defined as the difference between the utility that the decision maker actually obtains, $V_{ij}$, and the representation of utility that is developed using the observable variables, $U_{ij}$. One hopes to have defined $U_{ij}$ well enough that the remaining unobserved portion of utility is considered "white noise" (Train [2002]). Following McFadden (1974), Train (2002) derives the logit choice probabilities that decision maker *i* will choose alternative *j*.

(3.11) $$P_{ij} = \frac{\exp\left[U_{ij}(\beta)\right]}{\sum_m \exp\left[U_{im}(\beta)\right]}$$

The result is the closed form expression given in equation (3.11), which is the logic choice probability.[24] Equation (3.11) also reveals that the traditional maximum-likelihood procedures can be applied because the logit probabilities take on a closed form. Again following the derivations from Train (2002), the probability of person *i* choosing the alternative that he was actually observed to choose is expressed as

$$\prod_j \left[P_{ij}(\beta)\right]^{c_{ij}}, \tag{3.12}$$

where $c_{ij} = 1$ if person *i* chose *j* and zero otherwise. Note that since $c_{ij} = 0$ for all non-chosen alternatives and $c_{ij} = 1$ if the alternative is actually chosen, equation (3.12) is simply the probability of the chosen alternative. Assuming that each decision maker's choice is independent of all others choices, the probability of each person in the sample choosing the alternative that he was actually observed to choose is

$$L(\beta) = \prod_{i=1}^{I} \prod_j c_{ij} \ln\left[P_{ij}(\beta)\right] \tag{3.13}$$

where $\beta$ is a vector containing the preference parameters. The log-likelihood function is then

$$LL(\beta) = \sum_{i=1}^{I} \sum_j c_{ij} \ln\left[P_{ij}(\beta)\right] \tag{3.14}$$

and the estimator is the value of $\beta$ that maximizes this function (3.14). In the derivations from McFadden (1974) it is shown that $LL(\beta)$ is globally concave for linear-in-parameters utility. There are many standard software packages like STATA that can estimate the log-likelihood function to recover beta.

The logit model implies a certain pattern of substitution across alternatives because an improvement in one alternative will cause the probability of choosing that alternative to rise.

[24] For derivations, see Train (2002) or McFadden (1974).

Since the probabilities sum to one, an increase in the probability of one alternative means a decrease in the probability of other alternatives (Train [2002]). The issue of substitution can be seen as a restriction on the ratios of probabilities. The property of Independent from Irrelevant Alternatives (IIA) assumes that for any two alternatives *j* and *m*, the ratio of the logit probabilities does not depend on any alternatives other than *j* and *m*.

(3.15) $$\frac{P_{ij}}{P_{im}} = \frac{\exp(U_{ij})}{\exp(U_{im})}$$

From equation (3.15) it becomes clear that the odds of choosing *j* over *m* are the same no matter what other alternatives are available. Due to this similarity, the odds ratios is now considered independent from all other alternatives (other than *j* and *m*) and it is said to be independent from irrelevant alternatives. The logit model exhibits this *independence from irrelevant alternatives* (Train [2002]). The IIA property can be relaxed using the "nested logit" or "random parameter logit" models.[25]

When the IIA assumption represents reality, it is possible to estimate the model parameters consistently on a subset of alternatives for each sampled decision maker. Another practical use of the IIA property arises when one is only interested in examining choices among a subset of alternatives and not among all alternatives. Similar discrete choice modeling studies have applied the nested logit model which relaxes the IIA property to account for a stronger correlation between "within nest" alternatives (Mansfield [2008]). For example, choosing two program alternatives may have a greater degree of similarity than the opt-out alternative.

If one has access to data on peoples' choices between programs with different attributes, one can measure how much people are willing to pay for changes in program attributes. For example, suppose utility is linear-in-parameters:

[25] For further discussion on random parameter models, see Train (2002) chapters 4 and 6.

(3.16) $$V_{ij} = \alpha_i q_j + \delta_i s_j + \gamma_i \tau_j + \varepsilon_{i,j},$$

$$\text{where } \alpha_i = \alpha_0 + \alpha_1 d_i + \alpha_2 m_i,$$

$$\delta_i = \delta_0 + \delta_1 d_i + \delta_2 m_i, \text{ and}$$

$$\gamma_i = \gamma_0 + \gamma_1 d_i + \gamma_2 m_i + \gamma_3 g_i$$

where $\alpha_i$ represents the preference parameters for water quality and $\delta_i$ represents the preference parameters for program process. In many discrete choice modeling studies, heterogeneity in preferences is incorporated through the systematic component of utility. Equation 3.16 can be used to decompose the effects on preferences of demographic characteristics ( $d_i$ ) and income ( $m_i$ ). The $\gamma_i$ represents the preference parameters for taxes. Using *Roy's Identity* the marginal utility of a characteristic of a good can be divided by the marginal utility of income to find a point on the inverse demand curve which would represent a specific WTP amount.[26] With the estimates for preference parameters, one can measure the marginal willing to pay (MWTP):

(3.17) $$MWTP = -\frac{\partial V_{ij} / \partial s_{j,k}}{\partial V_{ij} / \partial \tau_j} = \frac{\delta_i}{\gamma_i}.$$

The MWTP from (3.17) is simply a ratio of the preference parameters. One can also measure WTP for non-marginal changes using (3.8). These welfare measures describe total economic value including both use and nonuse values discussed in chapter 2.

WTP measures based on (3.8) or (3.17) are partial equilibrium measures. They do not adjust for changes in behavior such as changes in donations. This is important because donation habitats may change following a new tax.

### 3.4. The Impact of a Water Quality Program on Private Donations

[26]Roy's Identity can be used to get a Marshallian demand function for an individual and a good from some indirect utility function.

A new government tax to improve a public good may crowd out private donations for that public good. The possibility of crowding out is important to consider when evaluating a public policy to improve water quality in the Chesapeake Bay. There are many organizations and foundations that rely on charitable donations to fund their efforts to restore the Bay. If a new program (in the form of a tax) were installed, this may affect donations to organizations like the Chesapeake Bay Foundation.

For people who receive a "warm-glow" from giving, government programs will incompletely crowd out private donations. For people who donate solely because they demand more of the public good, crowding out will occur. In order to test whether people are altruistic or egoistic in their giving, a first differenced model of donations can be established. With data on donations before and after the development of a new tax, we can see how the changes in donations depend on the tax rate, program characteristics and individual characteristics.

### 3.4.1. Theory

As previously stated, a problem with increasing taxes for a public good, like water quality, is that it may crowd out private donations to the public good (Andreoni [1993]). To illustrate the crowding out effect, we can modify equation (3.3) following Andreoni (1989):

$$\max_{g,z,Y} U\left(Y, g_i, z_i \mid d_i, \beta_i, s_j\right) \tag{3.18}$$

$$\text{subject to: } m_i - \tau_i = z_i + g_i, \quad \text{and} \quad G_{-i} + g_i + T = Y$$

Process attributes are held constant and taxes and donations are used to produce water quality based on the same technology. In this case, the water quality sub-function disappears under the assumption that water quality can be produced as a linear function of the private good. In other words water quality in (3.18) is determined by total expenditures from tax revenues and

donations. $Y$ is the total amount of tax revenue plus the individual's donations plus everyone else's donations. Let $G_{-i} = \sum_{j \neq i} g_i$ be total private donations of everyone but person $i$.

An individual's total expenditures on the public good is defined by adding their taxes and donations together:

(3.19) $$y_i = \tau_i + g_i \ .$$

The voluntary component of the public good is $g_i$ (donations) and the involuntary component is $\tau_i$ (taxes). To investigate whether a new tax will crowd out donations we can examine the relationship between $g_i$ and $\tau_i$ . If a \$1 increase in taxes is followed by \$1 decrease in donations, then the individual would be considered perfectly altruistic. The new tax would exhibit perfect crowding out of donations to the public good. At the opposite extreme, suppose a \$1 increase in taxes is followed by no change in donations. This individual receives a "warm glow" from giving and their response represents perfect egoism.

Following Andreoni (1989), the utility maximization problem can be simplified by writing it in terms of $Y$, using $Y_{-i} = \sum_{j \neq i} y_i$ to represent the total donations of everyone except person $i$. By substituting $y_i = Y - Y_{-i}$ into equation (3.18) and consecutively substituting the budget constraint into the utility function, the maximization problem becomes

(3.20) $$\max_{Y} \ U\left(Y, Y - Y_{-i} - \tau_i, m_i + Y_{-i} - Y \mid d_i, \beta_i, s_j\right) .$$

Andreoni demonstrates that by differentiating (3.20) with respect to Y and setting it equal to zero, one can solve for the optimal level of $Y$ for person $i$.

(3.21) $$Y = f_i\left(Y_{-i} + \tau_i, m_i + Y_{-i} \mid d_i, \beta_i, s_j\right)$$

Now by subtracting off what everyone else is doing ($Y_{-i}$) we can rewrite (3.21) to represent person *i*'s expenditures as a function of the exogenous components of the optimization problem

(3.22) $$y_i = f_i\left(Y_{-i} + \tau_i, m_i + Y_{-i} \mid d_i, \beta_i, s_j\right) - Y_{-i} \quad .$$

Andreoni explains that the two terms of *f* are the egoism and altruism effects. These can be illustrated by rewriting $e = Y_{-i} + \tau_i$ to represent egoism and $a = m_i + Y_{-i}$ to represent altruism:

(3.23) $$y_i = f_i\left(e, a \mid d_i, \beta_i, s_j\right) - Y_{-i}$$

By substituting the above equations for *e* and *a* into (3.22) to get (3.23) and then totally differentiating the donation function (3.23) of person *i*, we are left with

(3.24) $$dy_i = f_{ie}\left(dY_{-i} + d\tau_i\right) + f_{ia}\left(dm_i + dY_{-i}\right) - dY_{-i} \quad .$$

In equation (3.24) $f_{ie}$ denotes the partial derivative of *f* with respect to changes in individual donations and taxes, while $f_{ia}$ is the partial derivate of *f* with respect to an individual's changes in income and donations. Then by rearranging the terms we see that

(3.25) $$dy_i = \left(f_{ia} + f_{ie} - 1\right)dY_{-1} + f_{ia}dm_i + f_{ie}d\tau_i \,.$$

Assume that income is held constant ($dm_i = 0$) and *i* does not consider reactions from other individuals ($dY_{-1} = 0$). Then the individual's change in total expenditures on water quality just depends on the egoism effect:

(3.26) $$\frac{dy}{d\tau_i} = f_{ie} = f_{ie}\left(d_i, \beta_i, s_j\right)$$

Under the assumption that both donations and private goods are normal, $f_{ie}$ will lie between 0 and 1 (Andreoni [1989]). In the extreme case that $f_{ie}$=0, this individual would exhibit pure altruistic behavior because donations and taxes are perfect substitutes. On the other hand, if

$f_{ie}$=1, then the individual exhibits pure egotistic behavior and an increase in taxes has no effect on donations. In general, a tax on more egoistic people would exhibit less of a crowding out effect. The degree of egoism may vary across people according to demographics and preferences. Equation (3.26) suggests that demographics ( $d_i$ ), preferences ( $\beta_i$ ), and program characteristics $(s_j)$ may all have an effect on $f_{ie}$.

The key point of (3.26) is that the *total* public good expenditures can be increased by taxing people who are more egoistic. [27] A tax on more egoistic individuals would have less of a crowding out effect. A regression model can be used to estimate how the crowding out effect varies across individuals according to their demographic characteristics.

### 3.4.2. Econometrics

The basic idea of equation (3.26) is to see how changes in donations $(\Delta g)$depend on tax rates, program characteristics and individual demographics.

(3.28) $$\Delta g_i = \Delta g_i(\tau_i, s_i, d_i).$$

Given a specific functional form for the right hand side, equation (3.28) could be estimated by ordinary least squares from actual data on changes in donations in response to changes in taxation and program characteristics; or, it can be estimated using stated choice data. For example, suppose *i*'s donations in the presence of program *j* can be written as:

(3.29) $$g_{i,j} = \theta_0 + \theta_1\tau_j + \theta_2\tau_j s_j + \theta_3\tau_j d_i + \theta_4\tau_j m_i + \theta_5 m_i + \theta_6 d_i$$

[27] Note that this key point not only holds true for a partial equilibrium but also for a general equilibrium if individuals do react to each other's actions in a Nash equilibrium (Andreoni [1989]). The revealed preference data necessary for this type of calculation is not achievable through a choice experiment mail survey. Observable data using a laboratory setting would provide the researcher to actual observable tradeoffs between individuals based on one another's reactions. Also, long term trends over time of donations relative to a new public program could also help predict the general equilibrium effect on crowding out. Since the general equilibrium effect is not achievable from a one-time mail survey, this study focuses on the partial equilibrium framework.

where $\theta$ represents the marginal affect of each variable on donations. Equation (3.29) is consistent with the theory from equation (3.26) in the sense that the marginal effect of taxes on donations may depend on program characteristics ( $s_j$ ), demographics ( $d_i$ ) and preferences ( $\beta_i$ ). Therefore, a change in donations $g_i$ may result from changes in taxes $\tau_i$ or the interactions between taxes $\tau_i$ and demographics $d_i$ or taxes $\tau_i$ and income $m_i$.

Prior to the new water quality program, the tax equals zero and as a result we have:

(3.30) $$g_{i,0} = \theta_0 + \theta_5 m_i + \theta_6 d_i .$$

Once the program has been introduced we now have:

(3.31) $$g_{i,1} = \theta_0 + \theta_1\tau_1 + \theta_2\tau_1 s_1 + \theta_3\tau_1 d_i + \theta_4\tau_1 m_i + \theta_5 m_i + \theta_6 d_i .$$

The tax variables in (3.31) are included because a new tax has been introduced. Subtracting (3.30) from (3.31) gives us:

(3.32) $$g_{i,1} - g_{i,0} = \Delta g = \theta_1\tau_1 + \theta_2\tau_1 s_1 + \theta_3\tau_1 d_i + \theta_4\tau_1 m_i .$$

Equation (3.32) can be rewritten to make the interpretation clearer:

(3.33) $$\Delta g_i = \theta_i\tau_1, \quad \text{where} \quad \theta_i = \theta_1 + \theta_2 s_i + \theta_3 d_i + \theta_4 m_i .$$

This new notation of equation (3.33) suggests two separate research questions. The first research question concerns the magnitude of the crowding out parameter, $\theta_i$. Data on donations, taxes, and program characteristics, as well as consumer demographics can be used to estimate the magnitude of $\theta_i$. If $\theta_i = 0$, then the individual is perfectly egoistic. If $\theta_i$ is between 0 and -1, then the individual would be considered altruistic to some extent because a new tax has a negative effect on the amount they donate. The second research question addresses how demographics and individual preferences will affect the magnitude of $\theta_i$. For example, higher

income people may be less likely to change their donation habitats because they have more disposable income available.

### 3.5. Introduction of a Green Market to Improve Water Quality

Instead of using a public program to improve water quality, now consider the effects of introducing a green market. Markets for environmentally friendly goods have expanded into many sectors of the economy. As we know, oysters can be considered a green good. An ecolabel could be used to convert oysters from a private good into an impure public good. This section develops such a model using Lancaster's characteristics approach. This approach is broadly consistent with Kotchen's (2006) model of impure public goods. The econometric model is based on the standard single-bounded contingent valuation model following existing literature.

#### 3.5.1. Theory

Again using Lancaster's (1966) theory that individuals derive utility from characteristics of good rather than the goods themselves, we can model the utility from oyster consumption. First, oysters must be taken out of the composite numeraire ($z$). This requires a slight abuse of notation relative to equation (3.3), so that oysters can now be chosen, even though $z$ remains the same:

$$\max_{g,o,z} U_i = h\left[q_i(G,O), g_i, o_i, z_i \mid d_i, \beta_i\right] \quad \text{subject to} \quad m_i = z_i + g_i + p_i \cdot o_i \tag{3.34}$$

As shown in equation (3.34), we are no longer including a water quality improvement program but have now introduced a new variable, $o$, to represent oyster consumption. Let $O = \sum_{i=1} o_i$ be the total production of aquaculture oysters which equals total consumption. The price of oysters ($p$) is included in the budget constraint because oysters can be bought and sold in the private market.

A "green" good is one which generates both private and public good characteristics (Kotchen [2006]). Oysters can be considered a "green" good due to their private and public good contributions. The public and private effects from marginal increases in oyster consumption can be seen by partially differentiating (3.34):

$$\frac{\partial U}{\partial o_i} = \frac{\partial h[\cdot]}{\partial q_i} \times \frac{\partial q(G,O)}{\partial o_i} + \frac{\partial h[\cdot]}{\partial o_i} \tag{3.35}$$

As a private good, oysters are purchased for consumption in restaurants and supermarkets. Marginal utility from private good consumption is represented by the second term on the right hand side of (3.35). As a public good, oysters have a natural filtration process, as discussed in Chapter 2. Marginal utility from filtration is seen by the first term on the right hand side of (3.35).

We now construct an indirect utility function to measure the WTP for improved water quality.

$$V_i\left[q_i(G,O), p_i, g_i, y_i \mid d_i, \beta_i\right] \tag{3.36}$$

Because oysters can offer an environmentally friendly benefit in terms of water filtration, a willingness-to-pay premium can be attached to their initial price level.

$$V_i\left[q_i{}^0(G), p_i{}^0, g_i, y_i \mid d_i, \beta_i\right] = V_i\left[q_i{}^1(G,O), p_i{}^1, g_i, y_i - WTP \mid d_i, \beta_i\right] \tag{3.37}$$

The measure of compensating variation in (3.37) represents a price premium for ecolabled versus standard oysters. The initial expression for utility only considers prices and water quality does not depend on oysters, making water quality solely dependent on donations. Once *O* enters the expression for water quality, one would consider oysters to be a "green" good in which case

consumers may be willing to pay a higher price.[28] One way to measure the potential price premium for ecolabeled oysters is to use contingent valuation.[29]

### 3.5.2. Econometrics

A single-bounded dichotomous choice contingent valuation model (CVM) could be used to estimate WTP. The single-bound CVM involves asking an individual if they would pay some given amount; in this case a premium for ecolabeled oysters, X, that would improve water quality in the Chesapeake Bay. The probability of attaining a "yes" or a "no" can be represented by following the expressions from Hanemann et al. (1991):

(3.38) $$\pi^n(X) = G(X;\psi),$$

(3.39) $$\pi^y(X) = 1 - G(X;\psi),$$

where $\pi^n$ is the probability of obtaining a "no" and $\pi^y$ is the probability of getting a "yes" response while $G(X;\psi)$ is some statistical distribution function with parameter vector $\psi$.

Consider participants in the single-bounded CV survey and suppose $G(X)$ is the logit CDF. Then, Hanemann et al. (1991) demonstrate that the log-likelihood function for this set of responses is

$$\ln X^s(\psi) = \sum_{i=1}^{N} \left\{ d_i^y \ln \pi^y\left(X_i^s\right) + d_i^n \ln \pi^n\left(X_i^s\right) \right\}$$

(3.42) $$= \sum_{i=1}^{n} \left\{ d_i^y \ln\left[1 - G\left(X_i^s;\psi\right)\right] + d_i^n \ln G\left(X_i^s;\psi\right) \right\},$$

[28] Despite the intent for green markets to improve environmental quality, Kotchen (2006) has demonstrated that introducing a green market or improving green technology may actually discourage private provisions of an environmental public good. As mentioned earlier, water quality is an environmental public good in which everyone benefits when improved. Since donations are a water quality improvement mechanism, using oysters as another mechanism to improve water quality may be seen as a substitute and hinder the amount people choose to donate. This would in fact represent crowding out. A model to test this relationship could be developed similar to the model in 3.4.2.

[29] An alternative hypothesis that arises from this idea is that some consumers may lower their price (or stop eating oysters altogether) after considering the way oysters feed by filtering "impurities" from the water.

where $d_i^y$ is 1 if the *i*th response is "yes" and 0 otherwise, while $d_i^n$ is 1 if the *i*th response is "no" and 0 otherwise.

The single-bounded dichotomous choice model can estimate the average WTP using the maximum likelihood function in (3.42). A program that seeks to enhance the marketability of shellfish through branding or through the development of an industry ecolabel would be one policy alternative to improve water quality and also increase returns for oyster growers. A positive WTP for ecolabeled oysters would indicate that consumers are willing to pay a premium for ecolabeled oysters.

### 3.6. Survey Design

All three models outlined in this chapter can be estimated using either revealed preference data or stated preference data. Revealed preference data on water quality improvements in the Chesapeake Bay are not available. Therefore, a choice experiment is used to develop stated preference data to estimate the models. A choice experiment survey is designed to elicit information on preferences by asking respondents to choose among versions of an environmental good that vary in the levels of their attributes. For this study, the survey asks people to choose among different water quality improvement program attributes generating the discrete choice data needed to estimate the demand for water quality program attributes as described in section 3.3. The survey also incorporated questions on contingent valuation and crowding out. The CV question provided the data needed to estimate WTP for ecolabeled oysters following the model in 3.5. The crowding out questions ask respondents about their current donation habitats and about whether introducing a new public program would change their donation habitats. The resulting data are used to estimate the crowding out model presented in section 3.4.

#### 3.6.1. The Choice Experiment Approach

The choice experiment approach relies on carefully designed choice tasks to reveal the attributes that influence consumer choice. The key to a successful discrete choice experiment is the extent to which you can capture the different attributes of the good, service or policy you wish to describe without confusing or overburdening the respondent. Therefore, designing a choice experiment requires careful attention to the attributes and their corresponding levels. The respondent may choose one of two alternatives, or the status quo, in each choice pair, of which there are many. This provides repeated opportunities for them to express their environmental preferences. A common recommendation when designing choice experiments is to incorporate an "opt-out" option (Louviere, Hensher, and Swait [2000]). Holmes and Adamowicz (2003) believe that a choice scenario should include an opt-out option because in most real world choice situations, individuals have the option to "choose not to choose." Without this option, respondents are choosing alternatives even when they would rather not choose at all.[30]

There are four steps involved in a choice experiment. The process begins by defining the attributes and their possible levels. The second step is to define the choice set. The third step is to place the choice set in the context of a questionnaire. An important part of the questionnaire development is pretesting with focus groups. Finally, the last step involves selecting the sample area and sampling strategy. The second step, defining the choice set, requires some additional discussion of why this is an integral part of the choice experiment process.

### 3.6.2. Choice set

[30] Closely related attribute based methods include conjoint ranking and rating scale questions. Contingent ranking asked the respondents to rank the environmental problem using a series of choices. However, rankings are more cognitively demanding than a single choice, and respondents may become fatigued or confused as they proceed through the sequence. Rating scale questions require a respondent to make judgments about the magnitude of utility associated with profiles presented in the experiment. The use of ratings is appealing because of the simplicity of the econometric analysis and the ease with which respondents can answer rating questions. Nevertheless, problems arise with this approach. First, ratings must be adjusted to use a common metric across individuals (Roe, Boyle, and Teisl [1996]). Second, a base situation (current choice) must be evaluated using the rating to judge whether a respondent would rate a new alternative higher than the base situation. Third, respondents may have equal ratings for alternatives which presents a problem when estimating the econometric models.

Designing the experiment involves generating a choice set in an efficient way. Many methods have been suggested. The simplest approach is a "full factorial" design which combines every level of each attribute with every level of all other attributes. Each combination of attribute levels is a unique choice alternative.[31] While this approach is simple and statistically efficient, it has a serious problem. As the number of attributes grows larger, so do the number of choice alternatives (Holmes and Adamowicz [2003]). For example, suppose there are three water quality improvement processes; agriculture, oyster aquaculture, and wastewater treatment plants. Each of these three "process" attributes takes two levels. Thus, there are $3^2 = 8$ unique water programs that define the full factorial design. Now consider five "process" attributes with four levels. The full factorial for a $4^5$ design yields 1024 possible choice alternatives. Because of the large number of choice alternatives generated from a full factorial design, many researchers have turned to "fractional" factorial designs.[32]

Fractional factorial designs systematically reduce the number of choice alternatives. A number of the recent environmental discrete choice studies have used fractional factorial designs (Teisl, Boyle, and Roe [1996]; Hanley, Wright, and Koop [2002]; Brey, Riera, and Mogas [2007]; Mansfield et al [2008]). There are different approaches to creating fractional factorial designs. One approach is to introduce real world constraints that limit the number of possible choice alternatives (Teisl, Boyle and Roe [1996]). Another approach is to use only the main-

[31] The advantage of a full factorial design is that all "main" and "interaction" effects are independent (orthogonal) and can be identified (Holmes and Adamowicz [2003]). A "main" effect is the difference between the average response to each attribute level and the overall average. Parameter estimates are the main effects of the attribute levels and the overall average is the intercept. An interaction effect occurs if the response to the level of one attribute is affected by the level of another attribute. Interaction effects are represented by the parameter estimates for the interaction of two or more variables in a multiple regression model.

[32] These designs provide enough information to estimate the "main effects" but do not allow estimation of all the interaction effects (Bliemer et al [2009]). Fractional factorial designs can predict the main effects fairly well and account for over 80% of the explained variance in the choice models (Louviere [1988]).

effects and ignore interactive effects (Johnson et al [2007]).[33] Although there is no definitive number of choice profiles people can respond to without being fatigued, most researchers use between 8 and 16 choice questions, each of which asks respondents to choose among two or three alternatives (Carson et al. [1996], Louviere et al. [2000], Holmes and Adamowicz, [2003], Johnson et al [2007]).[34] However, fractional factorial designs may still have more choice alternatives than respondents can be expected to consider and the question still remains of how to efficiently combine alternatives into choice sets.

The goal of choice set construction is to provide the most statistically efficient design while also reducing the burden on respondents (Johnson et al. [2007]). Optimal design techniques use specific criteria to create the "best" designs. D-optimality is one optimal design criterion (Carson et al. [1994]). D-optimality chooses the choice set design that maximizes the determinant of the Fisher information matrix given constraints on the total number of choice sets and the number of alternatives per choice set (Kanninen [2002]).[35] Maximizing the statistical information provided by the information matrix helps support the overall goal of obtaining estimates that have low variances and covariances.[36] The output from a D-optimal design contains combinations of attributes to be included in each choice set, given the constraints specified by the researcher. This approach will offer the "best" design when the goal is to maximize the statistical efficiency of logit estimation (Johnson et al [2007]).

[33] Interaction effects occur when one factor's main effect is not the same for different levels of another factor (Keppel [1973]). Louviere (1988) demonstrates that main-effects make up almost 80% of the explained variance in choice models.

[34] Another, more restrictive approach is the foldover method. The foldover design contrasts the more desirable and less desirable components of the choice set and requires subjects to weigh the relative importance of the positive and negative features.[34] The foldover method is effective for smaller attribute levels but does not work for problems involving three or more attributes (Johnson et al [2007]).

[35] See Kanninen (2002) for technical derivations.

[36] Orthogonality is another important experimental design property. The same criteria that produces a D-optimal design is needed to obtain an orthogonal design.

Blocking is another strategy used to decrease the burden on individual respondents. For instance, we can divide a 16-choice set design into two 8-set blocks and have two different versions of the survey. A blocking factor (which is equal to the number of desired blocks) is used to ensure that the designs are balanced and orthogonal (Johnson et al [2007]). Many choice studies have implemented blocking to reduce the choice sets shown to respondents (Boxall and Macnab [2000]; Hanley et al [2002]; Oh et al [2005]; Brey et al [2007]; Birol and Cox [2007]).

### 3.7. Conclusion

This chapter began by introducing a baseline model of willingness to pay for a water quality program which ignored crowding out, program attributes and green markets. All three of these concepts may matter when considering new policies to improve public goods. The chapter continued by presenting three separate microeconomic models that extended the baseline theory. The first model measures how much people are willing to pay for *process* using data on people's choices between water quality improvement programs with different attributes. The second model is designed to measure the crowding out effect of a new water quality program tax. Finally, the third model measures the potential price premium for ecolabeled oysters. Each separate model was discussed at length and, when appropriate, an econometric model was suggested to test the different theories.

The choice experiment approach can be used to generate data to estimate each model. There are a number of alternative designs available for choice experiments. It is left up to the researcher to determine which one to use. While this chapter provided general background on the design process, it did not provide detail on how the choice experiment will be implemented. The entire survey design process is described in detail in Chapter 4.

# Chapter 4: Survey Procedures

## 4.1. Introduction

This chapter describes the survey design, the implementation process, and the issues that arose in constructing the attribute-based choice experiment survey. The goal was to design a mail-based questionnaire that would provide the data needed to estimate the models developed in Chapter 3. A review of the survey design literature was conducted prior to construction. The survey was also pre-tested to ensure that respondents clearly understand the information being presented.

Section 4.2 begins by summarizing the objectives in designing the survey. Primary and secondary objectives are briefly explained before presenting an overview of the survey design methodology. Section 4.3 walks the reader through each section of the survey and describes key aspects of the design process. Section 4.4 discusses how the survey was divided into multiple treatments to increase efficiency without overburdening the respondent. Section 4.5 describes how the surveys were assembled and why a randomized design was used to create a unique version of the survey for each respondent. Section 4.6 defines the survey area and explains how it was selected. Finally, section 4.7 outlines the mailing procedures and the Dillman (1978) "total design method" of data collection.

## 4.2. Objectives and Methods

The primary objective of the survey is to investigate whether Virginia residents believe that process matters when improving water quality in the Chesapeake Bay. To address this objective, survey respondents were asked to answer a series of questions in which they had to make tradeoffs between program cost, water quality improvement process, and the probability of meeting a water quality target. The survey also included additional questions to address the two secondary objectives for this thesis: 1) to test whether a new water quality program is likely to crowd-out private donations to the Chesapeake Bay Foundation or other organizations that aim

to improve water quality in the Bay and 2) to see if consumers are willing to pay a premium for ecolabeled oysters that improve water quality in the Bay.

Table 4.1 outlines the four steps that were taken to develop the survey. The initial step is to define the structure of the survey. The structure of the survey begins with defining the potential program characteristics and their appropriate levels. To accomplish this, focus groups were conducted in addition to an extensive review of appropriate literature on water quality improvement processes in the Chesapeake Bay. The development of the conjoint questions comparing two alternative programs is another key aspect of the survey structure. Before answering the conjoint questions, warm-up questions are required to educate the sample population about current water quality problems and offer potential solutions. Along with the warm-up and conjoint questions, questions to test crowding out are also developed. Furthermore, additional questions asked respondents about the WTP for ecolabeled oysters. Finally, respondents are asked to provide socio-demographic information such as their income, gender and education level, which may help explain heterogeneity in preferences (Krupnick and Adamowicz [2007]).

The second step, as shown in Table 4.1, involves assembling the survey. Multiple survey treatments are created. This is done using randomization, blocking and real world constraints; all of which are discussed in section 4.4. The randomized approach to treatment design provides unbiased estimates on the preference parameters. Invoking real world constraints and blocking are both tools used to decrease the number of conjoint questions shown to respondents.

After developing a first draft of the survey, pretesting with focus groups was conducted to gather feedback about the survey and to improve the wording on individual questions.[37]

[37] Focus groups are small group discussions conducted for the purpose of getting feedback to aid in the development of the survey materials (Champ [2003]).

Specifically, a focus group was administered on February 17th, 2009 to a group of fifteen undergraduate Agricultural and Applied Economics Club members.

Defining the sample population is the third step in the survey procedures. An important consideration for any policy analysis is "whose values matter" (Champ and Welsh [2007]). In my research, the answer to this question is relatively straightforward: those who have some direct contact with the Chesapeake Bay based on their residence. People who live near the Bay are the most likely to benefit from improved water quality in the Bay and to pay for the improvement.

The final step in the survey design process is to decide whether to administer the survey by mail, in-person interview, telephone, E-mail, or a mixture of modes. The mode of administration for this study was regular mail. One advantage of a mail survey is that respondents can complete the survey at their convenience and at their own pace (Champ and Welsh [2007]). Respondents may also feel more comfortable answering sensitive questions in the privacy of their home rather than having to tell an interviewer. Mail surveys also require fewer resources to implement and tend to be less expensive than interviews in-person or over the telephone. While these advantages make mail surveys a reliable mode of administration, there are also some downsides. The disadvantages include: (1) lack of control over the order in which the respondent answers the questions, (2) inability to check inconsistent response patterns and (3) a potentially biased response pool due to a disproportionate number of users responding.[38] Despite these shortcomings, mail surveys remain a popular mode of administration in nonmarket valuation studies (Champ and Welsh [2007]). The specific mailing procedures are based on Dillman's (1978) total design method (TDM) which is discussed in section 4.7.

[38] For example, a mail survey on mountain biking in the North East may result in a disproportionate number of mountain bikers responding.

### 4.3. Survey Development

The survey is divided into six sections with a total of 46 questions. Section A provides warm-up questions, section B asks about past recreation in the Chesapeake Bay, section C introduces the idea of a new water quality program and asks the choice experiment questions, section D asks about contributions to nonprofit organizations, section E asks about consumption of oysters and ecolabeled seafood and section F ends the survey by asking for the standard demographic information. The following six subsections walk through each section of the survey, show examples of specific questions, and explain their purpose. A copy of the complete survey is provided in Appendix A.

#### 4.3.1. Chesapeake Bay characteristics (Section A)

The survey begins with a map of the Chesapeake Bay watershed. During pretesting, it became clear that a map would help to clarify the area referred to as "the Chesapeake Bay." After presenting the map, section A of the survey asks respondents to rate characteristics of the Chesapeake Bay according to how important they perceive those characteristics to be. The purpose of this Likert scale question is to provide respondents with a warm-up exercise to get them thinking about characteristics of the Chesapeake Bay.[39] This question is shown in figure 4.1. The structure of the question is based on Boyle and Lawson's (1996) survey of lakefront property owners in Maine.[40]

The specific characteristics in figure 4.1 were gathered from a variety of sources including previous nonmarket valuation studies on the Chesapeake Bay and published reports about the watershed. For example, some of the characteristics are highlighted in the 2007 *State of the Bay* report discussed in Chapter 2. In principle, responses from these questions can be

[39] The terms "Attribute" and "characteristic" are used interchangeably.
[40] In general, a Likert scale question can help to identify the respondent's interest and to focus their mind on the good being evaluated (Krupnick and Adamowicz [2007]).

included as covariates in the econometric analysis and may also be used to segregate the respondents into different groups. For example, one group could consist of respondents who think all characteristics are important while a second group may be respondents who think none or only a few of the characteristics are important.

### 4.3.2. Chesapeake Bay Recreation (Section B)

Section B of the survey asks respondents about their visits to the Chesapeake Bay. These questions are used to determine whether a respondent is a direct user of the Bay's resources. This is important because the mean willingness to pay for improved water quality can vary substantially between users and nonusers (Desvousges et. al. [1987]). The questions in section B ask about the frequency of fishing, swimming, boating, hiking, and wildlife viewing in the Bay. Figure 4.2 provides two examples of the format used in this section. The recreation activities in these questions have been the focus of previous use-value studies of the Bay. For example, Vaughan (1980) uses data from the National Sanitation Foundation's water quality index to create a rating scale with acceptable levels of boating, fishing and swimming. Another contingent valuation survey of the Chesapeake Bay asked boaters about their perception of water quality on a scale of one to ten, and their WTP for an improvement of one unit (Lipton [2004]). While this survey does not ask respondents about WTP for improvements in boating and swimming, by including use value questions, we can test whether WTP for improved water quality varies between users and nonusers.

### 4.3.3. Conjoint questions comparing two alternative programs (Section C)

Section C of the survey forms the basis for valuing water quality program attributes. This section asks whether a respondent would support a new water quality program in the Chesapeake

Bay. It begins by asking several warm-up questions to test a respondent's prior knowledge of water quality in the Chesapeake Bay. This is followed by eight conjoint questions.

#### 4.3.3.1. Warm-up questions

Warm-up questions are typically used in stated preference questionnaires because they introduce the public goods being valued provide as well as provide background to respondents who may be unfamiliar with the public good (Adamowicz et al. [1998] and Dillman [2000]. Too much information in the warm-up questions can overburden the respondent while too little information can lead respondents to make their own inaccurate conclusions. Pretesting with both focus groups and consultation with thesis committee members helped establish the appropriate number of warm-up questions for this section.

The first warm-up question is presented in figure 4.3. This question provides the respondent with some background on the current water quality conditions in the Bay as well as highlighting the major sources of pollution. A visual representation of the three major polluters is provided together with background on the primary pollutant, nitrogen. Providing this type of background is important in choice experiment surveys because the respondents may be unfamiliar with current environmental conditions and may need additional information in order to fully understand the attributes of alternative programs described in the conjoint questions.

The next warm-up question goes one step further by telling respondents that the Chesapeake Bay is on the EPA's list of "dirty waters." Figure 4.4 presents this question. It asks whether the respondent knew the Chesapeake Bay had such serious water quality problems. The purpose of this question is twofold. It measures the level of preexisting knowledge about the Bay's water quality condition while simultaneously conveying how serious the water quality problem has become to respondents who may be unaware.

The following three warm-up questions move from describing the current problems in the Bay to identifying potential solutions. Respondents are presented with three hypothetical removal programs (figure 4.5, figure 4.6, and figure 4.7) and are asked whether they would support them. These warm-up questions are preparing the respondent for the choice questions by forcing them to think about tradeoffs between the different processes that can improve water quality. In figure 4.5 the respondent is asked if they would support a new program that involved paying farmers to plant tall grass on farmland to reduce nutrient runoff and provide wildlife habitat. As introduced in Chapter 2 and detailed in section 3.3.1, it is important to reinforce the secondary benefit of wildlife habitat because respondents may be more willing to support a program that involves both nutrient reductions and other positive environmental externalities. The wastewater treatment plant program in figure 4.6 provides another alternative to improving water quality and explains why these plants have not already been upgraded. Figure 4.7 illustrates the corresponding oyster question. The oyster program introduces a water quality improvement process that may be least familiar to respondents and because of this lack of familiarity, a longer explanation of the oyster filtration process is provided.

The penultimate warm-up question (figure 4.8) introduces another key aspect of the problem, uncertainty. As discussed in Chapter 2, uncertainty about meeting a new water quality target occurs because a sewage pipe can burst, extreme weather can increase nutrient runoff from fields, and oysters are susceptible to death from disease and predators. The question in figure 4.8 explains that the Chesapeake Bay Program has set a target level for water quality that would improve aquatic habitat in the Bay. Unfortunately, no program to improve water quality can be 100% guaranteed to meet this target. This question asks respondents whether they would support a water quality program if the chance of meeting the water quality target was 55%,

slightly better than a coin toss, with no cost to their household. The 55% guarantee was chosen as a way to gauge whether a low probability of meeting the water quality target affected whether a respondent would support a new program.[41]

The final warm-up question prepares the respondent for the choice questions by asking them to consider two program attributes simultaneously, uncertainty and cost. This question, shown in figure 4.9, asks the respondent if they would support a water quality program with a given chance of success and a cost for each household. This question also describes how the new water quality program would be funded (by a new fee added to their water bill) and explains that there is uncertainty about whether the new program would actually meet the water quality improvement goal. This type of warm-up question can also help to identify respondents who tend to oppose funding a public good by increasing taxes (Krupnick and Adamowicz [2007]).

#### 4.3.3.2. Defining program attributes and their levels

The choice questions were introduced once the respondents had been informed about the current water quality conditions in the Bay and about the alternative processes to improve water quality. The development of these questions deserves some further discussion because the attributes and their corresponding levels are the most important part of a choice experiment survey (Holmes and Adamowicz [2003]). Respondents were asked to consider programs that invested in a combination of oyster filtration, wastewater treatment and farmland buffers. Five program attributes were chosen, following the warm-up questions: (1) percent of wastewater treatment plants upgraded, (2) acres of tall grasses planted on farmland, (3) number of wild oysters planted, (4) chance of meeting water quality target and (5) total cost per year to each household. Their corresponding levels were chosen to be roughly consistent with the level of nitrogen reductions

[41] Feedback from thesis committee members helped determine the appropriate level for the water quality target and the need to introduce the water quality target as a single attribute.

needed to meet the Chesapeake Bay Program's goal of a 175 million pound cap on annual loads. This process involved a review of the technical literature on nitrogen loadings.

A series of preliminary calculations were used to define plausible upper and lower bounds on each attribute. One hundred and seventy five million pounds was used as the target load throughout all the nitrogen removal calculations. First, upper bounds were set on the plausible amount of nitrogen that could be removed from each of the different processes (farmland buffers, wastewater treatment, and oyster filtration). Then upper and lower bounds were set for the probability of meeting the water quality target. Finally, the cost per pound of nitrogen removed was calculated from each process and used to set upper and lower bounds on the program cost. Table 4.2 shows the resulting attribute ranges.[42] The remainder of this subsection explains how the bounds were generated.

The first column of table 4.2 displays the bounds on increasing the population of native Chesapeake Bay oysters. The use of filter feeding organisms as a water quality improvement mechanism has been tested in other areas and found to decrease the net transport of nitrogen by around 20% (Lindahl et al [2005] and Stephenson et al [2009]).[43] A program that would subsidize oyster production would cost approximately $248/lb of nitrogen removed (Bosch et al [2008]) and it takes 798 oysters to remove one pound of nitrogen (Stephenson [2000]). Because of the high cost and low removal rate, it seems unlikely that oyster aquaculture could remove more than 1% of the nitrogen needed to meet the total water quality target. Therefore, an upper bound on the number of oysters planted was calculated by multiplying 1% of total targeted nitrogen removal by the number of oysters it takes to remove a pound of nitrogen. The resulting

[42] The rows in table 4.2 have no information content.
[43] As highlighted in table 2.2, Hicks et al (2004) provide WTP estimates of the value of oyster reef restoration in the Chesapeake Bay. This study adds to the literature by considering both nitrogen filtration and oyster reef restoration. This will be discussed in further detail in section 4.4.3.

upper bound on oysters planted was set at 2 billion. This would represent a massive increase from the current population of 7 million oysters (Bosch et al [2008]). However, the resulting oyster population would be comparable to historical figures which indicate average harvest rates of 1.9 billion oysters per year between 1920 and 1969 (Lipton et al [2006]).[44]

Wastewater treatment plants are point source polluters of nitrogen. Recall from chapter 2 that there are 483 significant plants in the Chesapeake Bay (Figure 2.11) which discharge more than 95% of total flow and contribute to 20% of nitrogen loads entering the Bay (US EPA [2008]). Currently, most plants emit around 8mg/l of nitrogen (Chesapeake Bay Program [2004]). Technological advances have created a new standard for wastewater treatment plants. New plants being built and those being upgraded are required to uphold a limit of 3mg/l of total nitrogen. Using this technology to upgrade existing plants costs $11.06 to remove one pound of nitrogen (VA DEQ [2008]). In order to meet the 2010 goal of 175 million pounds, around 91 million pounds of nitrogen must be removed. Based on current calculations, each plant discharges around 140 thousand pounds of nitrogen (Maryland Department of the Environment [2008]). Even if all 483 plants were upgraded, the target for removal would not be met. Therefore, the upper bound on plant upgrades was set to 100%.

The Virginia Department of Environmental Quality recently approved a series of agricultural best management practices to reduce excess nitrogen loads (see chapter 2 for more detail). One of these practices involves converting agricultural land along streambanks to native vegetation by planting tall grasses. This water quality improvement process provides a buffer that reduces nitrogen emissions into waterways and also provides a secondary benefit of increased wildlife habitat.[45] This nitrogen removal process would provide money to farmers in

[44] This was originally 4.9 million bushels and conversion factor of 400 oysters in a bushel was used.
[45] Planting the tall grass buffers requires a minimum width of 35 feet (Wenger [1999]).

the form of a subsidy or cost-share program. The removal of one pound of nitrogen by planting tall grasses costs $6.50 (DNREC [2007]). The 'acres of tall grasses planted' was calculated by dividing the cost per acre by the cost per pound to remove nitrogen. It was around $300 per acre for farmers to install the streambank buffer (DNREC [2007]). The removal of 91 million pounds of nitrogen from only planting tall grasses would imply millions of acres of shoreline to be converted into grassland. Virginia only has 70,000 acres of shoreline. To account for buffers that may already be installed, 60,000 acres was set as the maximum possible level of acres planted. The remaining money could go towards alternative BMP practices. These could include cheaper options such as planting cover crops and creating best management plans or building retention ponds.

The fourth column in table 4.2 displays the chance of meeting the water quality target. As discussed in Chapter 2, planting tall grasses has a lower probability of achieving the target nitrogen reductions than other abatement technologies due to uncontrollable circumstances like weather. Therefore, the probability of meeting the target was allowed to vary from 30% to 100%. This variation also incorporated uncontrollable circumstances such as a pipe leaking, large storms rolling through, or disease outbreaks.

The final step in defining the attribute levels was to determine the cost of the removal processes. The total cost per household was calculated by taking the total cost of each removal process and dividing it by the number of households in Virginia, Maryland, the District of Columbia, Pennsylvanian, New York, Delaware and West Virginia. The household data was obtained from the United States Census Bureau for 2007. The states included in the cost calculation serve two purposes. First, they are all included in the Chesapeake Bay watershed and contribute some nitrogen pollution into the Bay. Secondly, the cost was unrealistically high if

only calculated using households in Virginia. Based on the variation in costs between the removal processes, $90 was set as an upper bound while $10 was set as the lower bound. In comparison, WTP estimates for a one step improvement (e.g. *good* to *very good*) in water quality in the Chesapeake Bay range from $62-$96 in 2009 dollars (Lipton [2004]). Another comparable study produced estimates ranging from $32 to $92 per household (in 2009 dollars) for a one step improvement in water quality from *unacceptable* for swimming to a level that is *acceptable* for swimming (Krupnick [1988]).

#### 4.3.3.3. Choice set design

A choice experiment design has to be large enough to allow for estimation of the most complicated model anticipated while also small enough to be practical. Another issue in designing the choice sets is the question of whether to include an "opt out" option. This question is particularly important if the purpose of the experiment is to calculate welfare measures (Alpizar et al [2001]).

To strike a balance between the criteria for estimation and practicality, the design of the choice experiment question began by building a full-factorial design matrix with all possible attribute-level combinations, implementing real world constraints which decreased the number of combinations, and then restricting the choice experiment to 8 choice sets per respondent. SAS software was used to design the choice experiment questions and the full code is provided in Appendix B.

The D-optimal choice set design began by using the %MktEx SAS macro to generate a complete list of all possible combinations. This macro uses an exchange algorithm to generate D-optimal designs (Kessels et al [2006]). It creates a full factorial design using all attributes and

their corresponding levels.[46] The full factorial design was first decreased by adding real world constraints. The real world constraints were used to reinforce the credibility of the water quality improvement programs to respondents. If the correlation between attributes is ignored, the choice sets may not be credible to respondents (Layton and Brown [1998] and Johnson et al [2000]). Adding real world constraints guarantees that only realistic combinations of attributes occur together. The specific constraints are as follows:

- If the cost is equal to $10, then the program can only plant acres of tall grasses.
- If the cost is greater than or equal to $80, the program must increase oyster populations by 2 billion, cannot plant acres of tall grasses and must have at least an 80% chance of meeting the water quality target.
- If the probability of meeting target is greater than or equal to 90%, the program must upgrade at least 25% of the wastewater treatment plants.

Programs that violate these constraints would be unrealistic. Therefore, it was necessary to remove such combinations making note that it would have been statistically efficient to include them.

The next step of the design process used SAS's %ChoiceEff macro to search the list of combinations for an efficient design with a total of 16 choice sets and three alternatives in each choice set ("Program A", "Program B" or "No Program"). This macro iteratively swaps alternatives from the combinations in and out of the design using a modified Fedorov algorithm to optimize the choice model variance matrix (Fedorov, [1972]; Cook and Nachtsheim [1980];

[46] As discussed in Chapter 3, full factorial designs can create a large number of possible combinations. Fractional factorial designs reduce the number of possible combinations.

Kuhfeld and Tobias [2005]; Kessels et al [2006]). This computerized search algorithm minimizes the D-error in order to construct an efficient, but not necessarily orthogonal design.[47]

In most choice studies, respondents evaluate between one and sixteen choice sets with the average being around eight choice sets per survey (Carson et al. [1994]; Louviere et al. [2000]; Hanley et al [2002]). In order to reduce the burden on respondents, SAS's %MktBlock macro was used to 'block' the design by dividing it into two versions of 8 choice sets. As Kluhfeld (2002) points out, this macro tries to maximize statistical efficiency by creating a block factor that is uncorrelated with every attribute of every alternative. The blocking procedure resulted in a survey design which presents each respondent with eight choice sets composed of two alternative water quality improvement programs and the option of not choosing either alternative. Figure 4.10 provides an example of one of the final choice sets used in the survey.

After the eight choice sets, three debriefing questions were asked. During pretesting it was recommended to add debriefing questions as a way to let respondents explain their choices. The three questions asked whether a respondent had chosen "Program A", "Program B", or "No Program" for every choice set. The answers to these debriefing questions may also reveal whether the respondent understood what was being asked.

### 4.3.4. Impact on donations (Section D)

Section D of the survey deals with crowding out. It begins by asking respondents about their contributions and memberships to specific nonprofit organizations. The organizations of interest were those that directly support the Chesapeake Bay and those that directly support agriculture.

[47] The computerized search does try to satisfy three of the four basic principles for choice experiment sets which are (1) orthogonality, (2) level balance, (3) minimal overlay and (4) utility balance. This design does not rely on any prior information about the utility parameters and hence does not satisfy utility balance. Utility balance is generally difficult to satisfy and can make the choices more difficult for the respondents. This difficulty is because respondents can be forced to choose alternatives that can be very close in terms of utility and this may result in random choice (Alpizar et al [2001]).

These questions are provided in figure 4.11. The main purpose of these two questions is to provide the data needed to investigate whether membership in certain organization makes people more willing to choose an alternative that benefits the organization they are associated with. For example, if a respondent is a member of a farm organization, we would expect them to be more likely to support a process that pays farmers to improve water quality compared to a program that upgrades wastewater treatment plants.

The second part of this section is testing for Andreoni's theory of public-goods crowding out.[48] The first question, shown in figure 4.12, asks the respondent how much they donated in membership fees and other donations over the past year to a variety of charitable organizations. Then, a hypothetical new water quality improvement program is introduced. An example is shown in figure 4.13**.** The purpose is to test whether the installment of a new program with an associated fee will change the respondents' donation amount. If the new program would change the amount a respondent chooses to donate, they are asked to report the amount of the change in a follow-up question. An example of the follow-up question is shown in figure 4.14 for an individual who indicated they would decrease their donations. The resulting data are used to estimate the crowding out effect defined in Chapter 3.

### 4.3.5. Oyster consumption (Section E)

Near the end of the survey, questions were asked about oyster and other seafood consumption. The first question asked how often, if ever, a respondent ate half-shell oysters. Then, two CV questions were asked; one asked whether respondents would be WTP a given price premium for a single half shell oyster and the other question asked about WTP for a premium on a quart of

[48] A number of laboratory studies have examined this hypothesis of public goods crowding-out charitable donations (Adams, B. and M. Schmitz [1978], [1984]; C. T. Clotfelter [1985]; Andreoni [1989; 1993]).

shucked oysters. Both questions labeled the oysters as "having been grown in the Chesapeake Bay". An example of the CV question is shown in figure 4.15.

A certified Chesapeake Bay oyster would convey to the consumer otherwise unobservable information about the positive environmental impacts from nitrogen removal. A recent Connecticut consumer preference survey for eco-labeled seafood found that 47% of respondents felt that an eco-label was important (Roheim, C. and R.J. Johnston [2005]).[49] The oyster question in this survey parallels previous CV studies on WTP for ecolabeled products but is the first study to focus on oysters grown in the Chesapeake Bay. The resulting data will be used to estimate the ecolabeled premium in Chapter 5 using the model constructed in Chapter 3.

The last question in this part of the survey asks the respondent to report how much ecolabeled seafood they eat (figure 4.16). The combination of the contingent valuation questions and ecolabeled seafood purchases will provide new information about 1) consumer demand for oysters, 2) consumer demand for the process in which they are grown and 3) consumers knowledge about ecolabeled seafood.

### 4.3.6. Demographics (Section F)

In the last section of a survey it is common to ask demographic questions. Age, gender, education level, household size, and income can all help to explain heterogeneity in preferences (Krupnick and Adamowicz [2007]). In particular, income is one variable that usually enters all conceptual models of willingness to pay. The survey also asked three questions about proximity to the Chesapeake Bay, farmland and wastewater treatment plants. One of these questions is shown in figure 4.17. These questions can provide evidence to help identify the decision strategy used by the respondents (Krupnick and Adamowicz [2007]). The responses from these questions may

[49] Their definition of an eco-label means "no overfishing."

also help identify a relationship between a favored removal process and proximity to certain amenities.

### 4.4. Survey treatments

The development of this survey involved generating several alternative treatments by blocking the survey into two different versions as well as randomizing three separate survey questions. The benefits of having multiple treatments of the survey are to reduce bias, provide theoretical justification for certain statistical tests, and provide more efficient estimates (Alpizar et al [2001] and Hanley et al [1998]). A discussion of each treatment strategy is provided in the following subsections.

#### 4.4.1. Blocking

Blocking is a common strategy when designing a choice experiment survey. Blocking is necessary when the choice sets are too large to show to each subject. In this case, there were 16 choice sets and instead of showing each respondent all 16 choice sets, one block was used to show each respondent eight choice sets. Most of the literature on choice experiments uses a similar form of blocking to reduce survey fatigue from too many choice sets (Louviere, et al [2008], Birol and Cox [2007], Carlsson, et al [2003], Boxall and Macnab [2000], Bullock et al [1998]). The block began with dividing the choice sets into two sets of 8 using the %MktBlock marco discussed previously. This resulted in half the surveys being block one and half block two.

#### 4.4.2. Cage vs. Wild

Each block was divided into two different versions of the survey, “wild” and “cage”. For the “cage” version, the description is paying oyster growers to grow and harvest more cage oysters from the Bay. This is the version of the question shown in figure 4.7. The “wild” version of the

survey describes increasing the wild oyster population by creating sanctuaries and planting oyster spat (baby oysters). The difference in wording is reflected in both the descriptive warm-up questions and the choice experiment questions. To illustrate, here are two different descriptions:

Wild Oyster Text:

*… Another way to improve water quality in the Bay would be to increase the wild oyster population by creating sanctuaries and planting oyster spat. ("Spat are baby oysters"). Oysters remove some nitrogen from the water and use it to build their shells. This is a natural process. It is perfectly safe to eat these oysters.*

*Would you support a water quality program if it involved paying for restoration efforts to increase the wild oyster population?*

Cage Oyster Text:

*… Another way to improve water quality in the Bay would be pay oyster growers to grow more oysters in the Bay. These oysters would be submersed in cages until they mature at which point they would be harvested. Oysters remove some nitrogen from the water and use it to build their shells. This is a natural process. It is perfectly safe to eat these oysters.*

*Would you support a water quality program if it involved paying oyster growers to grow more oysters in the Bay?*

The reason for including the wild treatment is to test whether individuals are willing to pay more for a particular type of restoration effort. A difference in WTP estimates would be important to organizations like the Chesapeake Bay Foundation who explicitly ask individuals for donations to improvement efforts like oyster reef restoration. Furthermore, a difference in WTP would benefit state and federal policymakers who are considering options for oyster

restoration. Oyster aquaculture is being considered as one of the options for oyster restoration because previous efforts to restore native oyster populations have proved to be ineffective.[50]

### 4.4.3. Randomization

Once each block and sub-block had been constructed, specific questions were randomly varied to create a unique survey for every respondent. There were three random parts to the survey; (1) the water quality target percentage in section C, (2) the new water quality program introduced in section D; and (3) the bid levels for oysters on the half-shell and by the quart. Randomizing aspects of these questions assured that each survey would be unique. In particular, no level was more likely to be selected than any other level, and each draw is independent from all other draws. In a statistical sense, random selection serves as a check on conscious or unconscious bias on the part of the researcher and can also help to avoid any influence from uncontrolled variables, which can significantly sway responses (Babbie [1998]). Figure 4.18 outlines how the blocking strategy and randomization components fit together to produce the surveys.

Randomization was used in the water quality target question (figure 4.9), and the varying levels are shown in table 4.3. The chance of meeting the water quality target in question 14 ranged from 55% to 95%, which correspond to the different levels in the blocking diagram (figure 4.18). During pretesting, it was recommended to make this variable random to provide a consistency check on people's responses. If respondents view water quality as a normal good and understand the question, then we would expect that increasing the probability of meeting the target would increase support for the program.

In section D, the new water quality program in question 21 was randomly selected (figure 4.13) from the 16 programs described in the eight choice sets in the survey. This made a total of

[50] Oyster aquaculture requires less space, increases the uniformity and quality of the harvests, and deduces disease-related mortalities. Publically-sponsored shellfish research has the potential to significantly benefit the oyster industry (Bosch et al [2008]).

16 scenarios for each block of the survey. Because the new water quality program had an associated fee, the change in donations questions (figure 4.13), were adjusted to be centered on the cost of the new water quality program. In the example shown in figure 4.13, the new water quality fee is $60 per year per household. The new scale in figure 4.14 used $60 as the central value, with larger and smaller dollar amounts on either side.

Questions 26 and 28 were the CV questions which varied between respondents. The ten different bid amounts are illustrated in table 4.4. The bid amounts increased in the same proportion from their status quo. For example, if a survey respondent was shown a bid amount of $0.40 for a half-shell oyster (initial price of $1.50), they would receive a bid amount of $8.00 for a quart of shucked oysters (initial price of $30.00). Pretesting with focus groups helped to solidify the range of bid amounts for these questions.

Designing multiple survey treatments allowed each respondent to receive a unique survey. With a combination of blocking, cage versus wild descriptions, and randomized questions a total of 3,200 possible survey treatments were created.

### 4.5. Assembling the survey

The surveys were assembled in Microsoft Visual Basic. A Visual Basic (VB) do-loop macro was written to create the surveys and compile all the fixed and random pieces of the survey. The VB process is outlined in figure 4.19. To begin with, the VB loop required an empty word document. From there, questions 1 through 7 and 30 through 38 were added to the document. Print services required the surveys be delivered in their final format and for a booklet; this required adding the first and last questions together. A unique id was also added to the front cover of each survey. This was used as a way to contact respondents with both a reminder postcard and a second version of the survey for non-responses. Finally, the VB loop added all of

the randomized questions (figure 4.18) using random draws from a uniform distribution to define levels. Therefore, each survey was potentially unique. The full VB code is provided in Appendix C.[51]

### 4.6. Defining the sample population

The survey was mailed to a stratified random sample of 2,500 households in Virginia. The names and addresses were purchased from Survey Sampling International, LLC. The counties surveyed had to meet specific criteria in order to be included. The grey counties in figure 4.20 define the sample population. The eastern part of Virginia, otherwise known as the Coastal Plain (Tidewater) area were included first as well as the counties on the Eastern Shore. From there, the sample area was extended west into a portion of the Piedmont region.[52] This led to the final designation of counties represented by the dark line dividing the state in figure 4.20. This sample reflects not only the higher income and more populated counties in Northern Virginia but it also incorporated the agricultural and lower income coastal counties in the eastern and central portion of the state. It also included counties both in and outside of the Chesapeake Bay watershed. In order to receive a higher response rate from agricultural counties, sampling stratification was implemented in the survey sample. This meant that of the 2,500 addresses, 500 came from the eight counties shown in dark grey (figure 4.20). A list of the counties from which 2,000 names and addresses were sampled from is provided in Table 4.5. The share of Virginia's population captured in this sample represents 69%. The database used to obtain these records is from the residential white pages. This means that only households with a listed phone number

[51] There were 625 of each version in the first round and 500 of each version for the second round. The VB code was used twice, once to create the first 2,500 surveys for the first round and again to create the second round of 2,000 surveys. The surveys were numbered from 1 to 2,500 in the first round and from 2,501 to 4,450 for the second round. The VB loop created an equal amount of surveys for each of the different blocks

[52] The Piedmont region of Virginia includes the rolling hills west of the Fall Line and the land at the foot of the Blue Ridge Mountains.

are included in the sample. This is on average 60% of the households in Virginia (Markowitz [2009]). The samples of 500 and 2000 reflect the actual population density of these regions.

The reason for designing the sample to draw from the agricultural counties at a higher frequency is to measure the difference in preferences between agricultural and urban residents. In order to measure this statistically, 500 names and addresses were drawn from eight agricultural counties, which have relatively small populations. The eight counties combined make up 19% of the total market value of agricultural production for Virginia in 2007 and represent only 4% of Virginia's population. The eight agricultural counties were chosen based on their rank of total value of agricultural products for Virginia in 2007. The criteria for selection was whether or not the total value of agricultural products ranked in the top twenty for 2007. The eight counties and their rank of total value of agricultural products in Virginia are shown in table 4.6.

### 4.7. Mailing Procedures

The sampling and mail procedures use the Dillman "total design method" (TDM) (1978; 1999). The TDM construction process seeks to produce an attractive, well-organized questionnaire that looks easy to complete. The survey was presented in booklet format in order to appear more professional. The TDM also involves ordering the questions in a way that allows respondents to build a sense of continuity and flow throughout the questionnaire. It also recommends putting potentially objectionable questions, like income, at the end of the survey because respondents are less likely to stop the survey if they have already spent time working through it (Dillman [1978]).

The survey packaging consisted of a manila envelope with the respondent's name on the front label, a survey and a pre-paid return envelope inside, and Dr. Kuminoff's address as the

return address. The surveys were labeled and stamped by members of the AAEC graduate student organization on March 25th. The first round of surveys were mailed out on March 26th, 27th and 30th. A reminder post card was sent out on April 7th, a week after the initial survey was received. In addition to the reminder post card, a follow-up survey was sent to non-respondents almost three weeks later on April 23rd, 27th and 28th.

### 4.8. Conclusions

This chapter outlined the many aspects of the survey design process. The warm-up questions provide background information and get the respondent thinking about the goods being valued. The design of the actual choice questions plays a crucial role. The results from these questions will be used to estimate preference parameters and welfare estimates in chapter 5 using the econometric models presented in Chapter 3.

It is crucial that respondents understand and accurately process the information provided in the survey. That is why a key part of any choice experiment is the development of the survey design. A variety of sources were used to help create the survey instrument. Each section of the survey was designed to inform the respondent and provide them with the necessary information to make a choice. The sample population consisted of households in Virginia due to their proximity to the Chesapeake Bay. The pretesting procedures and mailing procedures followed the already established procedures set forth for stated preference valuation studies. Chapter 5 will use the results from the choice experiment survey to investigate whether process matters, whether oysters could be marketed with an ecolabel and whether a new public program to improve water quality in the Bay will crowd-out private donations.

**Figure 4.1. The important Chesapeake Bay characteristics survey question**

1) Please rate how important each of the following Chesapeake Bay characteristics is to you.

(CIRCLE ONE NUMBER FOR EACH CHARACTERISTIC)

| | Very Undesirable | Undesirable | Neither | Desirable | Very Desirable |
|---|---|---|---|---|---|
| Clear water | 1 | 2 | 3 | 4 | 5 |
| Healthy Bay grasses | 1 | 2 | 3 | 4 | 5 |
| Clean water | 1 | 2 | 3 | 4 | 5 |
| Good fishing | 1 | 2 | 3 | 4 | 5 |
| Good swimming | 1 | 2 | 3 | 4 | 5 |
| Good boating | 1 | 2 | 3 | 4 | 5 |
| Clean and safe beaches | 1 | 2 | 3 | 4 | 5 |
| Views of natural scenery | 1 | 2 | 3 | 4 | 5 |
| Healthy fish populations | 1 | 2 | 3 | 4 | 5 |
| Healthy bird populations | 1 | 2 | 3 | 4 | 5 |
| Healthy oyster populations | 1 | 2 | 3 | 4 | 5 |
| Healthy crab populations | 1 | 2 | 3 | 4 | 5 |
| Other, please explain _____ | 1 | 2 | 3 | 4 | 5 |

**Figure 4.2. The visits to the Chesapeake Bay survey questions**

3) How often do you swim in the Chesapeake Bay? (CIRCLE ONE NUMBER)

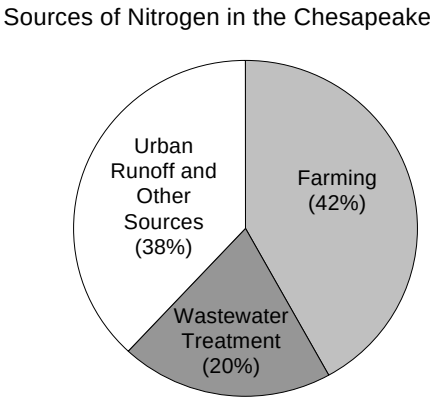
1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

4) How often do you fish in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

**Figure 4.3. Warm-up question: Pollution sources**

Water quality depends mainly on the amount of nitrogen in the water. Nitrogen is a type of nutrient and too much nitrogen decreases water quality in the bay. The nitrogen leads to the growth of algae that reduces water clarity. It also decreases the population of fish, crabs, underwater grasses, and other species. Nitrogen in the Chesapeake Bay comes from the following sources:




8) Did you know that farming is the largest source of nitrogen in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1) Yes
2) No

**Figure 4.4 Warm-up question: Water quality problems**

The Chesapeake Bay is currently on the Environmental Protection Agency (EPA) list of "dirty waters." Nitrogen is the main source of contamination. Each year roughly 300 million pounds of nitrogen enter the Bay. The amount of nitrogen would have to be cut in half to remove the Bay from the EPA's list of dirty waters.

9) Did you know that the Chesapeake Bay has serious water quality problems? (CIRCLE ONE NUMBER)

1 Yes
2 No

**Figure 4.5. The agricultural program survey question**

Nitrogen from farms is due to the manure and fertilizers that are applied to farmland. One way to improve water quality is to pay farmers to plant tall grasses on their land next to rivers and streams that flow into the Bay. This reduces runoff of manure and fertilizer during storms that lead to nitrogen in the Bay. The tall grasses would also provide new habitat for birds and other wildlife.

10) Would you support a water quality program <u>if it involved paying farmers to plant tall grasses that protect water quality in the Bay and provide wildlife habitat</u>? (CIRCLE ONE NUMBER)

1 Not likely to support the program
2 Somewhat likely to support the program
3 Very likely to support the program

**Figure 4.6. The wastewater treatment plant program survey question**

Water quality can also be improved by upgrading wastewater treatment plants. There are about 500 wastewater treatment plants that release nitrogen into the Bay. Plants with older technology release more nitrogen. These plants can be upgraded to decrease the amount of nitrogen they release. The reason this has not been done already is that the upgrades are expensive.

11 Would you support a water quality program <u>if it involved paying to upgrade wastewater treatment plants</u>? (CIRCLE ONE NUMBER)

1) Not likely to support the program
2) Somewhat likely to support the program
3) Very likely to support the program

**Figure 4.7. The oyster program survey question**

Oysters are a key species that both filter and clean water. In the 1800's oysters could filter a volume of water equal to the entire Chesapeake Bay in a single day. The oyster population has declined by over 90% since then. It would take the current oyster population more than a year to filter the entire Bay. Another way to improve water quality in the Bay would be to pay oyster growers to grow more oysters in the Bay. These oysters would be submersed in cages until they mature at which point they would be harvested. Oysters remove some nitrogen from the water and use it to build their shells. This is a natural process. It is perfectly safe to eat these oysters.

12) Would you support a water quality program <u>if it involved paying oyster growers to grow more oysters in the Bay</u>? (CIRCLE ONE NUMBER)

1 Not likely to support the program
2 Somewhat likely to support the program
3 Very likely to support the program

**Figure 4.8. The uncertainty of water quality improvement programs survey question**

The Chesapeake Bay Program (CBP) is a regional partnership between states and the federal government dedicated to restoring the Chesapeake Bay. The CBP has set a target level for water quality that would improve current habitat for fish, crabs, underwater grasses, and other species. Unfortunately, no program to improve water quality can be 100% guaranteed to meet this target. Wastewater treatment can release nitrogen unexpectedly, nitrogen runoff from farmland depends on the strength of storms, and oysters grown in the Bay can be eaten by predators.

13) Would you support a water quality program <u>if the chance of meeting the water quality target was 55%—slightly better than a coin toss—and there would be no cost to your household</u>? (CIRCLE ONE NUMBER)

1 No
2 Maybe
3 Yes

**Figure 4.9. An example of the introduction of the cost variable survey question**

In order to improve water quality in the Chesapeake Bay, the new program would have to raise money. This would be done by adding a new annual fee to the water bill of every household living in Pennsylvania, Virginia, Maryland, New York, West Virginia, Delaware, and Washington D.C. These states all have creeks, streams and rivers that flow into the Chesapeake Bay. Households on septic systems would pay an equivalent fee.

14) Would you support a water quality program if the chance of meeting the water quality target was 75% and the cost for each household was $47 per year for 10 years?
(CIRCLE ONE NUMBER)

1 No
2 Maybe
3 Yes

Explanatory note: The chance of meeting the water quality target in this question varied from 55% to 95% and was used to test whether respondents care about uncertainty.

**Figure 4.10 Example of an attribute based choice experiment survey question**

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 100% of plants | 50% of plants | 0% |
| Acres of tall grasses planted on farmland | 0 | 30,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 2.0 Billion | 1.3 Billion | 0 |
| Chance of meeting water quality target | 100% | 50% | 0% |
| Total cost per **YEAR** to my household | $80 | $60 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

**Figure 4.11 Memberships to specific organizations survey question**

18) Are you currently a member of any **organization that directly supports the Chesapeake Bay**, such as the Chesapeake Bay Foundation or the Alliance for the Chesapeake Bay?

(CIRCLE ONE NUMBER)

1 Yes
2 No
3 Don't Know

19) Are you currently a member of **any organization that directly supports farmers**, such as American Farmland Trust, Farm Aid, or 4-H?

(CIRCLE ONE NUMBER)

1 Yes
2 No
3 Don't Know

**Figure 4.12 Donations and membership fees in the last year survey question:**

20) About how much did you pay last year in membership fees and other donations to nonprofit organizations that support the following interests?

| | CIRCLE ONE NUMBER FOR EACH CATEGORY | | | | | | |
|---|---|---|---|---|---|---|---|
| Chesapeake Bay | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Farming | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Environment | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Religion | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Education | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Health | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Arts/Culture | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| International | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Other_____ | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |

**Figure 4.13 The new water quality program**

| **Water Quality Program Details** | **New Program** |
|---|---|
| Percentage of wastewater treatment plants upgraded | 75% of plants |
| Acres of tall grasses planted on farmland | 10,000 Acres |
| Number of cage oysters grown in the Bay | 0.6 Billion |
| Chance of meeting water quality target | 100% |
| Total cost per **YEAR** to my household | $60 |

Explanatory note: This new water quality program comes from one of the program alternatives in the choice questions. Consequently, there are a total of sixteen different new programs in each block.

**Figure 4.14 An example of the change in donation amount in response to new water quality program survey question**

20) How much would you decrease the amount you choose to pay in membership fees or donations to nonprofit organizations?

(CIRCLE ONE VALUE FOR EACH CATEGORY)

| | DECREASE BY | | | | | | |
|---|---|---|---|---|---|---|---|
| Chesapeake Bay | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Farming | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Environment | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Religion | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Education | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Health | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Arts/Culture | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| International | $100 | $90 | $80 | $60 | $40 | $30 | $20 |
| Other_____ | $100 | $90 | $80 | $60 | $40 | $30 | $20 |

**Figure 4.15 The contingent valuation question for certified Chesapeake Bay oysters**

26) An oyster on the half shell costs around $1.50. Would you be willing to pay **$0.90 more per oyster** if the oysters could be certified as having been grown in the Chesapeake Bay where they helped to improve water quality by removing some nitrogen from the water?
(CIRCLE ONE NUMBER)

1 Yes
2 No

**Figure 4.16 The ecolabled seafood survey question**[53]

30)
How much of the seafood that you eat has an **ecolabel**? (An Example of a seafood ecolabel includes the *Marine Stewardship Council)* (CIRCLE ONE NUMBER)

1 None
2 Less than half
3 About half
4 More than half
5 Almost all of it
6 I do not know

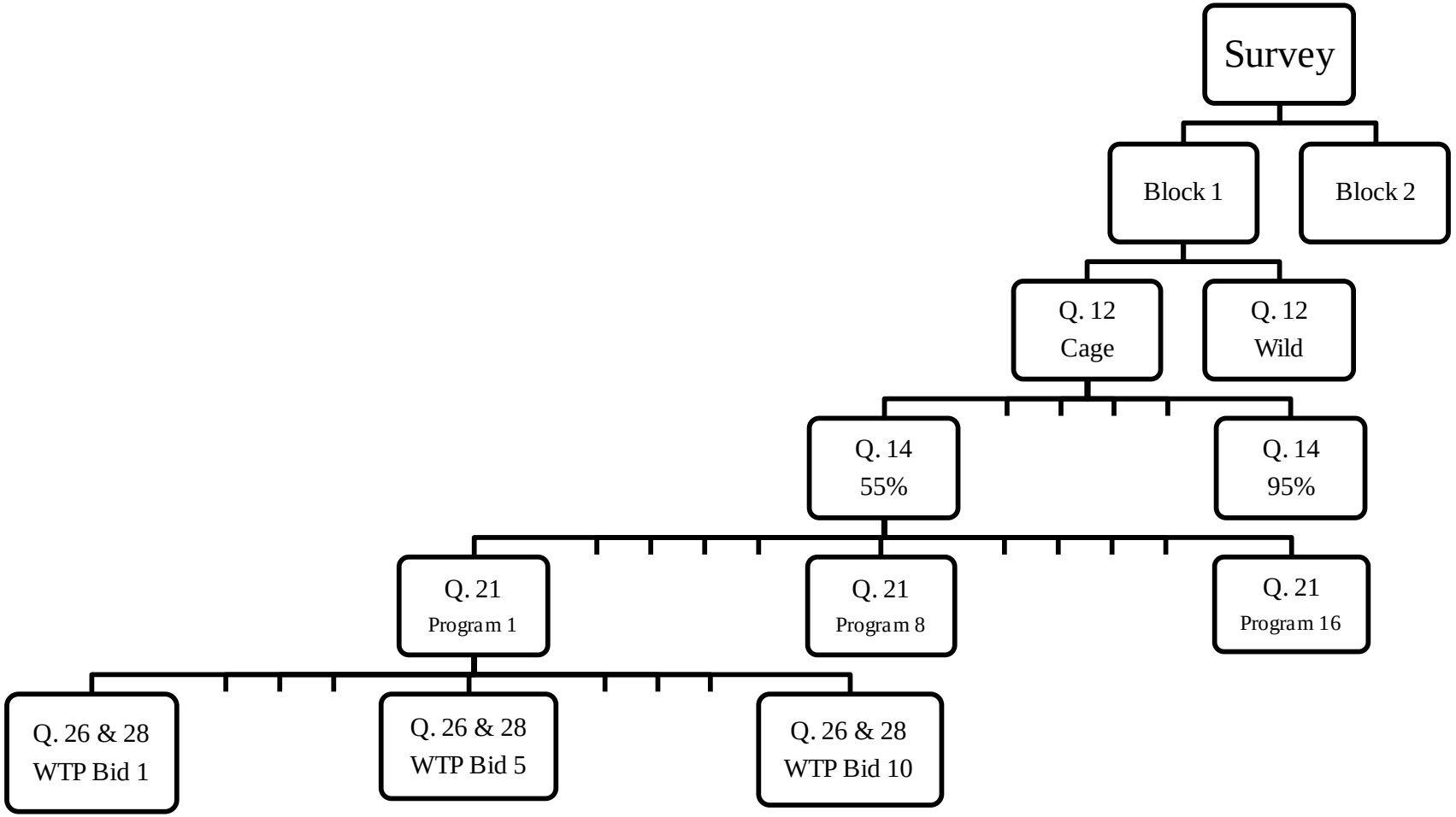
**Figure 4.17 The proximity to the Chesapeake Bay survey question**

35 How **far** is your residence from the **Chesapeake Bay**?
(CIRCLE ONE NUMBER)

1 Less than 1 mile
2 1 TO 20 miles
3 21 TO 40 miles
4 41 TO 60 miles
5 61 TO 80 miles
6 81 TO 100 miles
7 101 TO 120 miles
8 Greater than 121 miles
9 Don't know

[53] Please refer to Appendix F for permission to use.

**Figure 4.18 Blocking strategy**




Explanatory note: This figure outlines the blocking and randomized components of the survey. Once each block and sub-block had been constructed, specific questions were randomly varied to create a unique survey for every respondent. There were three random parts to the survey; (1) the water quality target percentage in section C, (2) the new water quality program introduced in section D; and (3) the bid levels for oysters on the half-shell and by the quart. Randomizing aspects of these questions assured that each survey would be unique. In particular, no level was more likely to be selected than any other level, and each draw is independent from all other draws.

**Figure 4.19. Microsoft visual basic loop for Block 2, Wild**

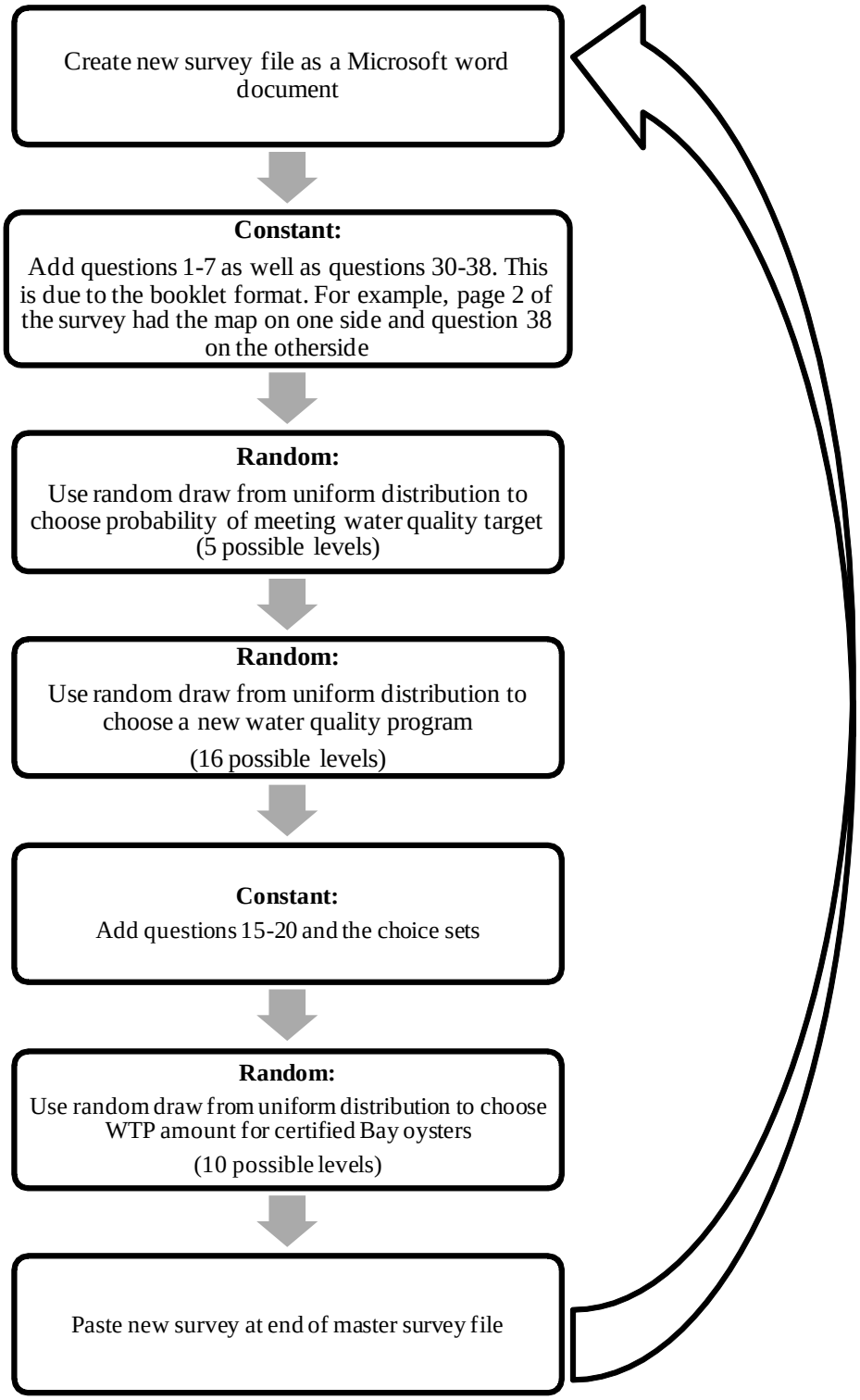
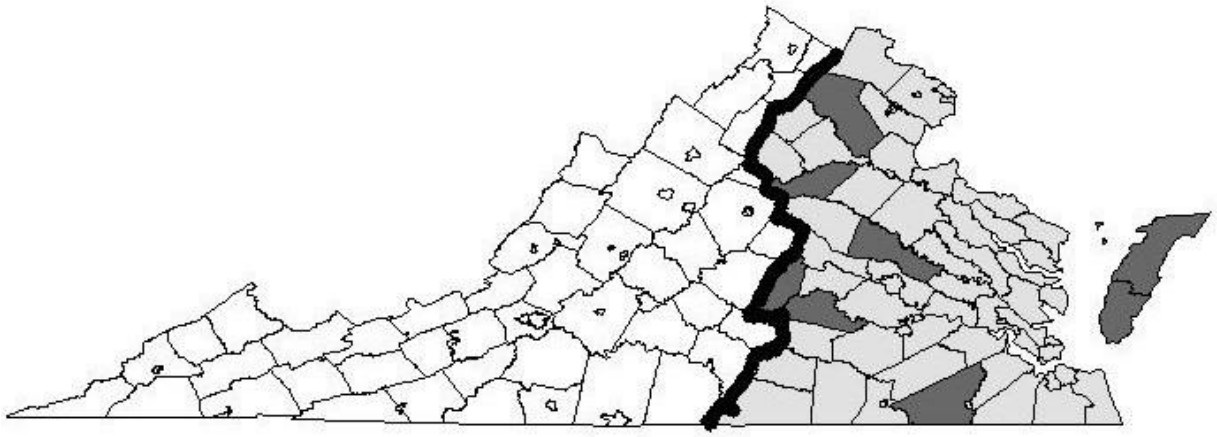


**Figure 4.20. Map of Virginia highlighting the sample population**



Explanatory note: The light grey counties represent the sample area of 2,000 respondents and the dark grey counties represent the stratified sample of counties with low populations and large agricultural sectors.

**Table 4.1. An outline of the steps used to design the choice experiment survey**

| | |
|---|---|
| 1) | Structure the Survey<br>• Identify potential program characteristics<br>• Define levels of each characteristic<br>• Develop conjoint questions<br>• Develop warm-up questions<br>• Develop questions that test crowding out<br>• Develop questions that measure WTP for ecolabeled oysters<br>• Develop questions to record sociodemographic information |
| 2) | Survey Assembly<br>• Randomization<br>• Blocking<br>• Real world constraints |
| 3) | Define the sample population |
| 4) | Administer the survey |

**Table 4.2. Attribute levels for the alternative water quality improvement programs in the choice experiment questions**

| *Attributes* | Increased Oyster | Wastewater Treatment Plants Upgraded | Acres of tall grasses planted | Chance of meeting target | Cost per household |
|---|---|---|---|---|---|
| *Levels* | 2 Billion | 100% | 60,000 | 100% | $90 |
| | 1.3 Billion | 75% | 40,000 | 90% | $80 |
| | 0.6 Billion | 50% | 30,000 | 80% | $70 |
| | 0 | 25% | 20,000 | 70% | $60 |
| | | 0% | 15,000 | 60% | $50 |
| | | | 10,000 | 50% | $40 |
| | | | 5,000 | 40% | $30 |
| | | | 0 | 30% | $20 |
| | | | | | $10 |

Explanatory note: The columns in table 4.2 are independent. They are not rows of data and simply represent the varying attribute levels independently.

**Table 4.3. The varying levels of meeting the water quality target in question 14 (figure 4.9)**

| Water Quality Target | |
|---|---|
| Level 1 | 95% |
| Level 2 | 85% |
| Level 3 | 75% |
| Level 4 | 65% |
| Level 5 | 55% |

**Table 4.4 Bid amounts for a premium on ecolabeled oysters**

| | Per Oyster | Per Quart |
|---|---|---|
| Level 1 | $1.00 | $20.00 |
| Level 2 | $0.90 | $18.00 |
| Level 3 | $0.80 | $16.00 |
| Level 4 | $0.70 | $14.00 |
| Level 5 | $0.60 | $12.00 |
| Level 6 | $0.50 | $10.00 |
| Level 7 | $0.40 | $8.00 |
| Level 8 | $0.30 | $6.00 |
| Level 9 | $0.20 | $4.00 |
| Level 10 | $0.10 | $2.00 |

**Table 4.5 Virginia counties surveyed (2,000 names and addresses)**

| Virginia Counties and Cities Surveyed | | |
|---|---|---|
| Alexandria city | Henrico County | Nottoway County |
| Arlington County | Hopewell city | Petersburg city |
| Brunswick County | Isle of Wight County | Poquoson city |
| Caroline County | James City County | Portsmouth city |
| Charles City County | Louisa County | Powhatan County |
| Chesapeake city | King and Queen County | Prince George County |
| Chesterfield County | King George County | Prince William County |
| Colonial Heights city | King William County | Rappahannock County |
| Culpeper County | Lancaster County | Richmond city |
| Dinwiddie County | Loudoun County | Richmond County |
| Emporia city | Lunenburg County | Spotsylvania County |
| Essex County | Madison County | Stafford County |
| Fairfax city | Manassas city | Suffolk city |
| Fairfax County | Manassas Park city | Surry County |
| Falls Church city | Mathews County | Sussex County |
| Franklin city | Mecklenburg County | Virginia Beach city |
| Fredericksburg city | Middlesex County | Westmoreland County |
| Gloucester County | New Kent County | Williamsburg city |
| Goochland County | Newport News city | York County |
| Greensville County | Norfolk city | |
| Hampton city | Northumberland County | |

Explanatory note: These counties make up the light grey counties in figure 4.20.

**Table 4.6 The total value of agricultural products**

| | Rank |
|---|---|
| Accomack County | 3 |
| Northampton County | 6 |
| Orange County | 7 |
| Amelia County | 8 |
| Fauquier County | 12 |
| Hanover County | 14 |
| Cumberland County | 16 |
| Southhampton County | 19 |

Source: 2007 Census of Agriculture. www.agcensus.usda.gov
Explanatory note: These counties are the dark grey counties in figure 4.20.

# Chapter 5: Econometric Results

## 5.1. Introduction

This chapter summarizes the survey data, estimates the three econometric models developed in chapter 3 and offers economic interpretations of the results. To begin, section 5.2 presents a statistical summary of the key survey results.[54] Then, Section 5.3 estimates a conditional logit model and uses the results to test whether process matters. The resulting parameter estimates are combined with data on costs to calculate a benefit cost ratio for each improvement process. Section 5.4 uses survey data on the reported changes in donations to test Andreoni's crowding out hypothesis. Finally, section 5.5 uses data from the contingent valuation question on the survey to estimate the average willingness to pay for ecolabeled oysters.

## 5.2. Statistical Summary of Survey Results

A total of 1,024 surveys were returned. From this total, 895 respondents replied with usable surveys, 89 surveys were returned due to wrong addresses, and 40 were sent back completely blank. This resulted in a response rate of 38%.[55] The following subsections analyze the key survey results section by section.

### 5.2.1. Chesapeake Bay Characteristics (Section A)

Table 5.1 presents a statistical summary of the important Chesapeake Bay characteristics. According to the results, *clean water* is the most important characteristic to respondents, with 79% reporting this characteristic as "very desirable".[56] Healthy aquatic species (fish, bird, oyster and crab) populations as well as clean and safe beaches were also desirable to respondents. These results provide evidence to support the hypothesis that the sample population cares about

[54] For a complete summary of the survey results, please refer to Appendix D.
[55] The response rate is adjusted for undeliverable questionnaires (i.e. incorrect addresses, sampled individual deceased, etc.).
[56] It should be noted that "Very Undesirable" has a higher percentage of responses than "Undesirable." This may be due to respondent confusion about the numbering of this survey question. One respondent caught themselves circling "1" because "we always look for the #1 to be the best" which actually meant the opposite in terms of importance.

the amenities the Bay has to offer. The results also show that respondents understood the difference between characteristics, as seen by the varying levels of desirability between amenities that are closely related such as "clean water" and "clear water".

### 5.2.2. Chesapeake Bay Recreation (Section B)

At the beginning of this section respondents were asked whether they had visited the Chesapeake Bay. The results from this question indicate that 86% of the sample population has visited the Chesapeake Bay at some point in their life (99% response rate). The sample population may be defined as "users" of the Chesapeake Bay's amenities based on their responses to several recreational activity questions. Table 5.2 presents these results. A surprising result is that *viewing wildlife* is the most popular activity, with 10% of the sample population viewing wildlife in the Chesapeake Bay more than once a month. The results also illustrate that about 10% of respondents go boating, fishing, or swimming in the Bay at least once a year.

### 5.2.3. Water quality and conjoint questions (Section C)

Overall, the sample population is well educated about the water quality problems in the Bay. When asked whether they knew that farming was the largest source of nitrogen pollution in the Bay, 54% answered "yes." And again, when asked whether they knew the Chesapeake Bay had serious water quality problems, 79% responded with a "yes". Once the background information about water quality and pollution in the Bay was presented, a variety of improvement programs were introduced. In table 5.3, we see that most of the sample population is "somewhat likely" or "very likely" to support the three water quality improvement programs: (1) paying farmers to plant tall grasses, (2) paying wastewater treatment plants to upgrade, and (3) paying oyster growers to plant more oysters or paying for oyster restoration efforts. Another interesting result is that there is virtually no difference in the way that people responded to different methods of

increasing the oyster population. People were not less supportive of oyster aquaculture, even though this process is not as "natural" as oyster reef restoration.[57]

Table 5.4 provides evidence that people care about the probability of meeting the water quality goals. There is a direct relationship between the probability of meeting the water quality target and the respondent's willingness to support the new water quality program. As the probability of meeting the target increases, so does the support of the water quality program. For example, 46% of respondents would support a new water quality program if the chance of meeting the water quality target were 55% compared to a support rate of 57% if the chance of meeting the target were 95%.[58] The results from this question provide strong evidence that people *do* care about risk.

The response rates from the subsequent conjoint questions reveal that respondents did not become fatigued with the number of choice questions. The response was consistent throughout the eight conjoint questions at a rate of 95% or higher. Choice question six had the highest response rate (97%). As discussed in chapter 3, a major decision in designing the choice experiment surveys is the appropriate number of choice sets. A decreased response rate would have indicated that respondents had become fatigued and this would have reduced confidence in the reliability of the responses to the later choice questions. In the debriefing questions, reactions to the choice questions were mixed. Some of the comments for why respondents choose "No Program" indicated that "there was already enough tax money available" or that

[57] The comments from a few respondents exhibit stark differences in their support of the two alternative programs. Comments from respondents who received a "cage" survey version include; "they get paid when they sell the oysters" or "why would they need to be paid unless no one wanted to buy the product (oysters)" followed by "oyster growers helped pay for this survey?" This feeling of animosity towards the oyster grower was not reciprocated when a respondent received a "wild" survey version. The comments related to the "wild" survey version included phrases like "only native Chesapeake Bay oysters," or "a much better way to go (than the alternative two programs)."

[58] Some respondents were not pleased with the wording of this question nor were they receptive to the idea of a fee being added to their water bill. The comments ranged from "No Way!" to "important that my grandchildren use the Bay like I did."

"water quality was not worth that much" or they simply "could not increase expenses." There were also some respondents who acknowledged that "we need a cleaner Bay and understand it takes expenses." Finally, a few respondents commented that the choice questions were confusing, which may have been why the response rate was less than 100%.

### 5.2.4. Impact on donations (Section D)

The subsequent survey section focused on contributions to nonprofit organizations. The results reveal that more respondents were members of organizations that support the Chesapeake Bay (8%) than farm organizations (5%). One explanation is that the definition of a "Chesapeake Bay" organization may relate to a broader spectrum of charitable organizations relative to those which are considered "farm" organizations.

Following the organizational membership questions, respondents were asked to report how much they donated in the past year. Table 5.5 presents these results. Respondents donated the most to religious organizations while health and education also had relatively high donations. After the initial donation question, a new program to improve water quality was introduced. The results from this question provide the data used to test for crowding out in section 5.4. Overall, 74% of respondents answered "No" this new annual fee would not change the amount they donated.

### 5.2.5. Oyster consumption (Section E)

Table 5.6 presents the results on respondent's seafood and oyster consumption habits.[59] The results provide new information about consumer demand for oysters and seafood as well as their knowledge about ecolabeled seafood. Over half of the sample population has never eaten oysters

[59] The response rate to these questions began to decline to around 60%. This may have been due to survey fatigue from the choice questions or inapplicable information because respondents who do not eat oysters ignored this section entirely. One way that may have increased responses would have been to start with the seafood consumption question rather than oyster consumption because of the low number of respondents who actually consume oysters.

and no one eats oysters more than once a week. As expected, respondents are more likely to have eaten seafood other than oysters. For ecolabeled seafood, 60% of respondents do not know how much seafood they eat has an ecolabel.[60] This result indicates that the sample population is relatively unaware of ecolabels when purchasing seafood products.

#### 5.2.6. Demographics (Section F)

The sample had a slightly larger proportion of males (57%). The median household income was between $80 and $89 thousand. This is more than 25% higher than the projected median household income for Virginia ($61,481) in 2009 dollars (U.S. Census Bureau [2000]) but only slightly higher than the median household income for the study region between ($62,000 and $77,000).[61] The average age of the sample population was 55 years old, with a range of 18 to 95 years old. The median household size was 2 people, which is consistent with U.S. Census Bureau data on household size in Virginia (reported as 2.54 for the average household size in 2000). The sample population was well educated, with almost 60% having completed a bachelors degree or higher.

### 5.3. Does WTP for Improved Water Quality Depend on Process Attributes?

The objective of this section is to use data from the discrete choice questions to examine the economic implications of a proposed water quality improvement program in the Chesapeake Bay. The foundation for modeling discrete choice behavior has been discussed in Chapter 3, where it was made clear that the logit model is appropriate to examine the choices among alternatives. STATA 10.1 was used to estimate the standard conditional logit model using clustered standard errors.

#### 5.3.1. Summary statistics for explanatory variables

[60] The purpose of including this question is to see whether consumers respond to labeling of seafood, and if so, perhaps a similar label could be applied to oysters in the Chesapeake Bay.
[61] Converted to 2009 dollars using the estimated 2009 CPI.

Table 5.7 reports summary statistics for the data used in the estimation. All three choices are broken down into the five attributes that describe the alternative programs. For example, *Program A wastewater* represents the varying percentage levels for upgrades to wastewater treatment plants in Program A. The same framework follows for program B. *No Program* is used to represent the "No Program" or "opt-out" option. *Income per person* was calculated as total household income after taxes divided by the number of people per household. Education is coded as a dummy variable representing whether a respondent has a college degree, *college*, or not. Dummy variables for a household's proximity to specific amenities are also included in this model. These categories include: less than 1 mile, 1 to 20 miles, 21 to 40 miles and more than 40 miles from either the Chesapeake Bay, farmland or wastewater treatment plants. The *wild* dummy variable differentiates between people who received surveys describing oyster reef restoration efforts or oyster aquaculture. Finally, notice that the sample size needed to be adjusted to reflect the number of observations per choice question. Moving from the 895 usable surveys to a total of 7,160 observations reflects each respondent's answers to the 8 choice questions.

Effects coding was used to improve interpretation of the results. Effects coding is an alternative to dummy coding where the effects are uncorrelated with the intercept (Bech and Hansen [2004]). Effects coding uses a -1 as the reference level, rather than a 0. Table 5.8 provides an example of effects coding for two levels. In a dummy variable treatment, the coefficient on the excluded variable is correlated with any information contained in the intercept term. The coefficient for the omitted variable under effects coding is the negative of the sum of the included variable coefficients. In contrast to dummy variable coding, the coefficient on the excluded effects coded variable is uncorrelated with the intercept coefficient and is directly

comparable with the coefficients of the included variables (Stewart and Kahn [2006]). Effects coding was used in place of all of the dummy variables in table 5.7. For example, a survey was coded with a 1 if the survey respondent received a version of the survey describing oyster restoration efforts as *wild* and a -1 if the survey described oyster aquaculture.

### 5.3.2. Econometric Model

As discussed in section 3.3.2, random utility maximization (RUM) models estimate the preference parameters by assuming that the conditional indirect utility function associated with a particular choice attribute is a function of the attribute levels of the alternative (Mansfield et al [2008]). In the econometric model, the program attributes in the choice questions include: the probability of meeting the program target (*u*) which is the measure of expected water quality, the share of wastewater treatment plants upgraded (*p*), the acres of tall grasses planted (*g*), the billions of oysters planted (*o*), cost (*c*) and the no program alternative (*n*). The following model is used for the econometric analysis:

$$
\begin{aligned}
V_{ij} = {} & \alpha \cdot u_j + \delta_1 \cdot p_j + \delta_2 \cdot g_j + \delta_3 \cdot o_j + \gamma \cdot c_j + \chi \cdot n_j \\
& + \varphi \cdot \mathbf{HHInc}_i + \nu \cdot \mathbf{College}_i + \vartheta \cdot \mathbf{Farmland}_i \quad , \\
& + \theta \cdot \mathbf{Plant}_i + \eta \cdot w_i + \varepsilon_{i,j}
\end{aligned}
\tag{5.1}
$$

where $\alpha$ represents preferences for water quality, $\delta$ represents the preference parameters for program processes, and $\gamma$ represents the marginal utility of income. **HHInc** and **College** are both vectors of the interactions between program attributes and an individual's household income and education level. **Farmland** is a vector of variables describing the proximity to farmland, while **Plant** is a vector of variables describing the proximity to wastewater treatment plants. Finally, *w* is a dummy variable for the "wild" oyster treatment. Respondents will choose the program that provides the highest level of utility.

### 5.3.3. Results for two model specifications

This sub-section reports estimation results for two model specifications. Each model is estimated using the conditional logit model with "clustered" standard errors. The purpose of using clustered standard errors is to account for the possibility of autocorrelation between the error terms. Because multiple observations came from each individual, it is plausible that the standard errors may not be independent. Therefore, each model was estimated using STATA's vce(cluster) option. Table 5.9 presents the results from the two different specifications.[62]

Column [1] presents the coefficient estimates for model 1. This model includes only the choice question program attributes and does not allow preferences to vary across people. When interpreting the coefficients, a positive and significant coefficient indicates that respondents are more likely to choose scenarios having higher levels of the attribute (Stewart and Kahn [2006]). Not surprisingly, the coefficients on upgrading wastewater treatment plants (*w*), planting tall grasses (*g)*, increasing oyster populations (*o*) and higher chances of meeting program targets (*u*) are positive, the coefficient on cost (*c*) is negative, and all five are economically important and statistically significant at conventional levels. The "opt-out" option is positive and significant. The significance of the opt-out option may indicate that respondents have substitutable options which they believe would improve water quality better than the two programs being presented in the conjoint questions. Another hypothesis is that respondents have a better use for their money and value something else besides improving water quality in the Chesapeake Bay. Results from this model can be interpreted as average effects because they do not allow preferences to differ across people. Model [2] adds sociodemographic interactions with the program attributes, making it possible to model variation in individual preferences.

[62] In order for the results from the model to representative of the entire watershed population, the stratified sample requires weighted estimation techniques. This could be accomplished using the "weighted" option in STATA and is left for future research. Preliminary model results included "distance to farmland" interactions and were not found to be significant. This may be one indication that stratifying the sample would have little effect on the estimation results.

Column [2] presents the results from the conditional logit estimation after including socioeconomic variables. All of the parameter estimates for program process continue to have the same sign. For example, people continue to have strong preferences for the oyster filtration process. As expected, the interactions between the program attributes and income are positive. However, the only statistically significant result from these interactions is that higher income people have stronger preferences for the probability of meeting the program target. Therefore, higher income respondents place a higher value on risk than respondents with lower incomes. The coefficient on the interaction term between education and the probability of meeting the program target is also positive and statistically significant. These results indicate that as education and income increase, people prefer water quality programs with less risk or a higher certainty of meeting the proposed target.

An interesting result in column [2] is the negative coefficient on the interaction between education and planting tall grasses. A less educated person has stronger preferences for planting tall grasses than those individuals with a college degree. Intuitively, as one becomes more educated, they are less likely to choose a program that involves planting tall grasses on farmland. This finding is consistent with the previous results because planting tall grasses on farmland is the riskiest water quality improvement mechanism.

The "proximity to farmland" fixed effects are insignificant, while the fixed effect for "less than 1 mile" to a wastewater treatment plant is significant. Intuitively, this means that people who live closest to wastewater treatment plants are more likely to choose an improvement program that upgrades wastewater treatment plants. This result is consistent with the hypothesis that people who live close to a wastewater treatment plant are more likely to experience the disamenities from the plant.

The *wild* dummy variable has virtually no impact. This result is consistent with the results in table 5.3 where the "wild" vs. "cage" wording had no effect on whether someone would support a new program to increase oyster populations.

In further model specifications, additional interaction terms were added to model [2]. These additional interactions included gender, age, whether a respondent ate oysters and memberships in organizations that support the Chesapeake Bay. Because of the lack of statistical significance and low magnitude of the coefficients, these interactions were dropped from the overall model.

### 5.3.4. Welfare measures

The interpretation of the coefficient values in table 5.9 is not straightforward, except for their significance and sign. Therefore, the marginal rates of substitution between the attributes were calculated using the cost coefficient as the numeraire.[63] The resulting ratios can be interpreted as average marginal WTP for a change in each attribute (Hanemann [1994]). As discussed in Chapter 2, this welfare measure includes both use and nonuse values. The first column in table 5.10 presents the dollarized ratio of preference parameters. For ease of interpretation, the preference parameters can be translated into a 1% increase from the current level of each attribute.

The second column in table 5.10 presents the results for a 1% increase from current levels. The results in table 5.10 show that increasing *the probability of meeting the target* clearly benefits respondents, with a MWTP of $2.72 per household.[64] The *probability of meeting the target* is used as a measure for the value respondents place on water quality.

[63] Refer back to chapter 3, equation (3.17), for MWTP.
[64] These estimates appear lower than previous studies in table 2.3, but these results are not directly comparable since this study only measures a 1% reduction in total nitrogen whereas previous studies are looking at different pollutants (fecal coliform) or larger improvements (from unacceptable to acceptable for swimming).

Next, marginal willingness to pay (MWTP) for each process attribute is calculated separately. Wastewater treatment plants have a MWTP of $0.024 for a 1% increase from the current levels.[65] Intuitively, this low MWTP amount is expected because improving wastewater treatment plants does not include a secondary attribute such as increasing wildlife habitat. For planting tall grasses, the MWTP for a 1% increase (400 acres) is $0.23.[66] This relatively high MWTP suggests that respondents value the environmental amenities from farmland such as increased wildlife habitat. The benefit of increasing the native oyster population by 1% has a positive but minimal MWTP of less than 1/100$^{th}$ of a cent for an increase of 70,000 oysters. The units for the oyster coefficient must be taken into consideration with a 1% increase from the current levels. The oyster attribute in the survey uses changes in *billions* of oysters. In comparison, there were only 7 million oysters sold in 2007 (Bosch et al [2008]). As discussed in Chapter 4, it is not unreasonable to consider oyster harvest levels in the billions based on historic harvest rates.

### 5.3.5. Benefit Cost Analysis

To put the results in perspective, a benefit cost analysis is conducted for a 1 million pound decrease in nitrogen loading. A one million pound decrease is equivalent to a .34% decrease in total nitrogen (Figure 2.8). This decrease in nitrogen is also roughly equal to meeting 1% of the target reduction. To begin, the change in probability of meeting the target was calculated using a ratio similar to the DEQ nutrient trading ratio of 2:1 for nonpoint source and point source polluters. We consider wastewater treatment plants to be point source polluters and runoff from agricultural land to be nonpoint source pollution. Therefore, using 100% of the MWTP for the probability of meeting the target reductions added $27.47 million in benefits to upgrading

[65] For wastewater treatment plants, 10 plants have already installed the improvement technology (Chesapeake Bay Foundation [2003]).
[66] There are around 40,000 acres of streambank buffers in Virginia (VANRCS [2008]).

wastewater treatment plants ($2.72 per household multiplied by 10.1 million households in the Chesapeake Bay Watershed). Next, 50% of the total MWTP for improved water quality was added to planting tall grasses. Finally, 75% of the total $27 million was added to increasing oyster populations.[67] Notice that this approach to estimating benefits assumes that the average person in the sample has the same MWTP as the average person in the rest of the study region. As mentioned in Chapter 2, Morgan and Owens (2001) point out, this can cause the total WTP to be either over or under estimated.

In order to calculate the benefit cost ratio approximate program costs were also needed. First, it costs $6.50 to remove one pound of nitrogen by planting tall grasses (DNREC [2008]). This cost was multiplied by the number of pounds removed (1 million) to get the total cost of $6.5 million reported in row [3]. Second, to remove one pound of nitrogen by upgrading wastewater treatment plants, it costs $11.06 (DEQ [2007]). Thus, to remove 1 million pounds of nitrogen it costs $11.06 million. Third, oyster aquaculture is the most expensive process and costs $248 to remove 1 lb of nitrogen (Bosch et al [2009]). This implies to a total cost of $248 million. It must be noted that the current cost calculations for increasing oyster populations are derived using 2007 oyster levels (7 million). Extrapolating this cost out to include billions of oysters may be overestimating the costs because, with economies of scale, an increase in output may cause a decrease in the per oyster cost.

A conventional benefit cost ratio, row [4], was calculated by dividing the approximate WTP for each improvement process by the cost. A ratio greater than 1 indicates a positive net benefit from improved water quality. The benefit-cost ratio for a water quality improvement program that upgrades wastewater treatment plants is almost 2.5 to 1. This result provides some

[67] As mentioned previously, the cost of increasing oyster populations already has a degree of certainty calculated into it. Therefore, a higher probability of meeting the target was used, though it could not be calculated as 100% because of catastrophic events like hurricanes wiping out entire populations.

justification for increasing the extent of publicly supported wastewater treatment plants and providing larger budgets for upgrades. The benefit cost ratio for improving water quality by planting tall grasses is a little more than 2:1. This suggests that planting tall grasses is also an efficient strategy to improve water quality in the Chesapeake Bay. Oyster aquaculture clearly fails the benefit-cost test due to the high program costs.

The "conventional" benefit cost figures do not take into account the process used to improve water quality. It is only focused on the change in the probability of meeting the water quality target. A central theme of this thesis is that consumers may care about the *process* used to improve water quality, not just the probability of meeting the target itself. The results for the conventional benefit cost analysis represent people who are "process neutral". That is, the estimated benefits from a change in the probability of meeting the target (row [2]) holds the process constant and assumes that there is no added utility from a process that includes positive externalities. But, if people value environmental externalities like improved wildlife habitat, then this calculation should be adjusted to include those values. A benefit cost ratio that incorporates the WTP for process externalities would capture this effect. The following calculation is used for the adjusted benefit cost ratio:

$$\textit{Adjusted B-C Ratio} = \frac{\textit{(WTP for } \Delta \textit{ in Prob. + WTP for process externality)}}{\textit{Total cost}}$$

Row [6] of table 5.11 presents the adjusted benefit cost ratio for a 1 million pound decrease in total nitrogen. The approximate WTP for the process externalities was calculated from the household WTP for a 1 million pound decrease in total nitrogen multiplied by the number of households in the Chesapeake Bay watershed (10.1 million). As we see in row [5], households are WTP much more for processes that include environmental benefits such as increased wildlife habitat and oyster populations.

The results from the adjusted benefit cost analysis, row [6], support the hypothesis that people values the different *processes* used to improve water quality.[68] Because the process of upgrading wastewater treatment plants does not have a substantial positive externality, we would expect to find less of a change between the ratios in row [4] and row [6]. The results are consistent with this expectation as shown by the slight difference between the ratios in row [4] and [6] for wastewater treatment plants. In contrast, there is a huge difference in the ratios for planting tall grasses. The adjusted benefit cost ratio for a water quality improvement program that plants tall grasses is now over 20:1. This indicates a high value for processes with positive environmental externalities. Likewise, the high WTP for increasing oyster populations indicates that people place a high value on restoring the native oyster population following the large drop in historic harvest rates. Yet, we still find that not all potential programs have benefits that exceed their costs. The adjusted benefit cost ratio indicates that even though there is a high WTP for increasing oyster populations, the current cost makes it too expensive to pass a benefit-cost test. We also see that the approximate WTP for increasing oyster populations is relatively high compared to the approximate WTP for upgrades to wastewater treatment plants. Therefore, if the operating expenses of increasing oyster populations were similar to planting tall grasses, we would expect to find this process to have a high benefit-cost ratio.

### 5.4. Will a tax to improve water quality crowd out private donations?

This section presents the econometric model used to test whether a new tax to improve water quality will crowd out private donations. As previously stated, a problem with increasing taxes for a public good, like water quality, is that it may crowd out private donations to the public good (Andreoni [1993]). One way to test this hypothesis is by asking how much respondents donated

[68] This adjusted benefit cost ratio should be considered an exercise comparing the benefits and costs as if the study region represents the entire watershed.

over the past year, introduce a new water quality improvement program with a fee and see whether the new program will change the amount a respondent chooses to donate.

### 5.4.1. Summary statistics for explanatory variables

Table 5.12 presents a summary of reported donations to all nonprofit organizations. *Religious* organizations had the highest number of donators, followed by *health* and *educational* organizations. Approximately 30% of the sample population who donated to the Chesapeake Bay would decrease their donations in response to a new program. This suggests that many people are donating to the Bay based on egoistic motives. For the remaining charitable organizations, less than 20% of donators will change the amount they currently donate.

It is important to discuss the difference between people who donate and those who don't because the econometric model is estimated only for those who donate. Only 122 out of the 895 respondents donate to organizations that support the Chesapeake Bay (table 5.12). This represents 14% of the sample population. Therefore, the results from the econometric model provide little scope for crowding out. In Andreoni (1989), all individuals are assumed to initially donate a positive amount to the public good. This assumption is clearly not valid for the survey respondents.

Summary statistics for the variables used in the estimation are presented in table 5.13. The *cost* of the new program ranged from $10 to $80 a year, with an average of $50. *College* is a dummy variable and is represented by a 1 if a respondent has a college degree and a 0 otherwise. Sixty six percent of the sample population who donated to the Chesapeake Bay has a college degree or higher. Donators to Chesapeake Bay organizations are slightly older than the entire survey population, with the mean age reported as 56 years old. *Gender* is another dummy

variable, coded as 1 if a respondent is male and 0 otherwise. Overall, more men (68%) donated to organizations that support the Chesapeake Bay.[69]

### 5.4.2. Basic econometric model

As discussed in Chapter 3, a change in donations $g_i$ may result from changes in taxes $\tau_i$ or the interactions between taxes $\tau_i$ and demographics or program characteristics.

(5.2) $$\Delta g_i = \theta_i \tau_1, \text{ where } \theta_i = \theta_1 w_i + \theta_2 g_i + \theta_3 o_i + \theta_4 u_i + \theta_5 c_i + \theta_6 a_i + \theta_7 s_i$$

Here, *w*, *g*, *o* and *u* parallel the variables in equation (5.1) and represent the program attributes for wastewater, grasses, oysters, and probability of meeting the target. College (*c*), age (*a*) and gender (*s*) are the three demographic characteristics included in this model. Equation (5.2) suggests two separate research questions which in turn lead to two separate model specifications. The first research question concerns the magnitude of the crowding out parameter, $\theta_i$. Using data on donations before and after the tax, one can estimate the magnitude of $\theta_i$. If $\theta_i = 0$, then the average individual is perfectly egoistic. If $\theta_i$ is between 0 and -1, then the average individual would be considered altruistic to some extent because a new tax has a negative effect on the amount they donate. The second research question addresses how demographics and individual preferences will affect the magnitude of $\theta_i$.

### 5.4.3. Econometric Results

The estimation results are presented in table 5.14. In model [1], the crowding out parameter is estimated without demographics. As expected, the results indicate a new tax would have a significant and negative effect on donations to organizations that support the Chesapeake Bay. A $1 increase in the cost of a new program will cause a $0.16 decrease in donations to

[69] Previous versions of the model included additional interaction terms such as income and proximity to the Chesapeake Bay but adding these variables increased the number of missing observations therefore decreasing the sample size. These variables were also found to be statistically insignificant at conventional levels.

organizations that support the Chesapeake Bay, *ceteris paribus*. Because $\hat{\theta}_i$, which is the crowding out parameter in model [1], is between 0 and -1 individuals should be considered altruistic to some extent because the new tax has a negative effect on the amount they donate.

The results from model [2] measure how changes in donations vary with demographic characteristics such as age and gender. The sample size decreases with the inclusion of the new interaction terms. As anticipated, cost is still negative and significant. The interactions between cost and age, cost and gender as well as cost and increasing oyster populations are all significant at the 10% level. The magnitude of $\hat{\theta}_i$ (model [1] coefficient) increases with the inclusion of these demographic characteristics.

The significant variables in model [2] imply that men, older people, and programs to increase oyster populations tend to exhibit less crowding out. For oysters, this may be the result of donators' previous knowledge of the current low populations of oysters in the Bay. Those who donate to Chesapeake Bay organizations may see increasing oyster populations as one of the major goals to improving water quality and habitat restoration in the Bay.

The result from the *gender* coefficient indicates that men are giving based on more egoistic motives. Therefore, a tax on men may produce less of a crowding out effect. This information adds to the gender preference literature where the results on gender differences are mixed; some studies find that men contribute more toward a public good, others find the opposite effect, and some find no significant differences (Croson and Gneezy [2009]). The results from the *age* coefficient suggest that a tax on older people will have less of a crowding out effect. Intuitively, this result may imply that as people age, they assume more moral responsibility to provide help in situations of need.

Model [1] was also estimated for changes in donations to other charitable organizations.[70] These results are shown in table 5.15. An interesting result is that the cost of a new water quality improvement program decreases donations to all types of charitable organizations. The largest effect is for Chesapeake Bay organizations, which is to be expected. Another interesting result is the relative magnitudes of the coefficients. Intuitively, one would expect to see higher magnitudes for organizations that are closer substitutes for Chesapeake Bay organizations. For example, we would expect organizations that support the environment to have a higher crowding out effect relative to artistic and cultural organizations. As seen in table 5.15, this is not the case. One explanation is the budget constraint effect. With the introduction of a new fee, respondents will have less disposable income, which in turn decreases the amount they can donate. As shown in table 5.5, more donations were made to artistic and cultural organizations than were made to environmental organizations. If the budget constraint effect is used to partially explain the big change in donations, then we would expect to see a larger magnitude on the coefficients for organizations that had more donations to begin with.[71]

### 5.4.4. Policy Implications

To put the crowding out effect in perspective, the results from table 5.15 can be applied to the hypothetical benefit-cost analysis from table 5.11. The crowding out effect for each charitable organization is calculated by taking the total cost of each new water quality improvement program in table 5.11, multiplying it by the share of people in the Chesapeake Bay watershed who donated to each organization, and finally multiplying this result by the coefficient from table 5.15. Table 5.16 reports the resulting crowding out effects.

[70] Model [2] was also run for all types of donations but demographic interactions were only found to be significant for changes in health organization donations.

[71] The crowding out experiment for this survey was conducted during a recession when many people were unsure about the economy and may have been cutting back on spending. The size of the crowding out effect may be different once the economy improves.

The largest crowding out effect is no longer for Chesapeake Bay organizations. For example, health organizations would exhibit a decrease in donations of approximately $0.37 million following for a new water quality program that reduces nitrogen by 1%. The reason for this shift can been seen from table 5.12, which gives the number of people who donated to each organization. Even though the econometric crowding out parameter was larger for Chesapeake Bay organizations, less people are donating to these organizations.

The last two rows in table 5.16 compare total program revenue with the total decrease in donations. The total program revenue represents the total amount of tax revenue raised for improving water quality. The net amount of money spent to improve water quality is only slightly smaller than the gross amount of money raised. The total program revenue from each of the new water quality improvement programs far exceeds the decrease in donations to Chesapeake Bay organizations. Therefore, if Chesapeake Bay organizations were to receive 2% of the revenue from the new water quality improvement program, the crowding out effect would dissolve. Yet, crowding out would still be present and much larger for alternative charitable organizations. A program to improve water quality using increased oyster populations has the potential to decrease donations to health, religious or cultural organizations by approximately $8.2 million, $5 million and $12.3 million, respectively. This result is important for policymakers because a new water quality program will unintentionally crowd out donations to organizations unrelated to the overall goal of the program.

The results in table 5.16 deviate from Andreoni's theory because not everyone donates. The new tax cannot change the amount an individual donates if that individual does not donate to begin with. Therefore, there is less scope for crowding out to organizations that have a small number of donators such as the Chesapeake Bay Foundation and farm organizations. Finally,

recall that Andreoni's model assumes a $1 donation to nonprofits leads to the same improvement in water quality as a $1 increase in taxes. Yet, people may have different perceptions about the relative efficiency of non-profit organizations versus governmental organizations. The results in table 5.16 do not reveal anything about how people perceive the tradeoffs between public and private production of improved water quality. The figures in table 5.16 are simply measuring the net change in donations.

### 5.5. Are consumers willing to pay a premium for ecolabeled oysters?

Throughout this thesis it has been suggested that oysters have the potential to be marketed as a "green" good. Instead of using a public program to improve water quality, now consider the effects of introducing a green market. An ecolabel could be used to convert oysters from a private good into an impure public good. In section E of the survey, households were told that oysters on the half-shell cost around $1.50. Households were then asked the following: Would you be willing to pay $X more per oyster if the oysters could be certified as having been grown in the Chesapeake Bay where they helped to improve water quality by removing some nitrogen from the water? Yes/No. The same basic wording was used to ask about the WTP for shucked oysters. All respondents were asked the same two questions, in the same order regardless of their answer to the first question. The closed-ended or dichotomous choice format simply asked the person if they would pay a given dollar amount for the certified oyster. The respondent has only to decide if the value to him or her is worth at least this price (Loomis and Gonzalez-Caban [1998]).

#### 5.5.1. Summary statistics for ecolabeled oysters

The ten different bids for half-shelled oysters ranged from $0.10 to $1.00. As discussed in Chapter 4, the bids for shucked oysters varied by the same percentage increase from their initial

price ($2.00 to $20.00). Since the bids varied across the sample, the dichotomous choice format allows one to statistically trace out a demand-like relationship between the probability of a "yes" response and the dollar amount (Hanemann et al. [1991]). The response rate for these questions decreased the sample size from 895 observations to 294 and 311, respectively. Figure 5.1 presents the results from the CV question on half-shelled oysters. The range of bids captures most of the aggregate demand curve. This is shown by the reversal in the ratio of yes/no responses between $0.10 and $1.00. Figure 5.2 shows responses to the CV question for a quart of shucked oysters. The results in this figure again demonstrate that the range of bid amounts capture most of the aggregate demand curve.

### 5.5.2. Basic econometric model

A conventional logit model was used to estimate mean WTP, following Hanemann et al. (1991). The models are estimated using maximum likelihood, based on the logistic cdf. Half-shell and shucked oysters were modeled separately. Table 5.17 presents the coefficient estimates for the single-bounded logit model. The coefficients in table 5.17 are used to estimate the WTP for certified half-shell and shucked oysters following the linearized model of WTP from Hanemann et al. (1991):

(5.3) $$WTP^* = a/b$$

where $a$ is the slope and $b$ is the intercept. Equation (5.3) is an estimate for both the mean and median WTP. Again following Hanemann et al. (1991), the truncated mean is

(5.4) $$WTP^+ = \ln(1+e^a)/b.$$

The truncated mean WTP calculates the expected value of WTP by numerical integration of the logit model from 0 to the maximum bid (Lee at al [2009]). This may be the preferred method

because it satisfies consistency with theoretical constraints, statistical efficient, and the ability to be aggregated (Duffield and Patterson [1991]).

### 5.5.3. Consumer's willingness to pay for ecolabeled oysters

The estimates from table 5.17 yield values for the mean and median WTP of $0.74 while the truncated mean is $0.87. For shucked oysters, the mean WTP is $8.08 per quart and the truncated mean is $11.53. These results support the hypothesis that consumers are willing to pay a premium for ecolabeled oysters. This result is consistent with previous ecolabeled seafood studies which all have shown positive and significant premiums for ecolabeled seafood products (Roheim and Johnston [2005]).

Oysters on the half-shell generally cost $1.50. Therefore, the WTP premium of $0.87 represents a 58% markup for ecolabeled half-shell oysters. As for shucked oysters, the markup percentage is much smaller, only 38% for a quart of shucked oysters (original price of $30.00). The markup percentages between the two oyster categories require further explanation. One hypothesis is the income effect for oysters on the half-shell. Oysters on the half-shell are considered gourmet and are sold at a more expensive price per oyster as compared to shucked oyster prices. Therefore, half-shell oysters are more readily consumed by higher income people who have more disposable income to spend on water quality, as well as oysters. Another hypothesis to explain the difference between the two percentage markups is that the demand for an oyster's ecosystem service is downward sloping. Because there are approximately 45 shucked oysters in a quart, a quart of shucked oysters provides 45 times more water quality services than a single half-shell oyster. If consumers eat oysters based on their water filtration services, then we would expect to see a decrease in WTP as more water quality improvements are made.

Krinsky and Robb's Monte Carlo simulation technique was used in order to obtain confidence intervals for the point estimates of WTP (Hanemann et al. [1991]). STATA has a command that performs the Krinsky-Robb technique to calculate confidence intervals for mean and median willingness to pay, *wtpcikr* (Wilner [2007]). The 95% confidence interval and a random draw of 20,000 sets of the coefficient estimates were specified prior to running this command. Table 5.18 shows the point estimates and confidence intervals for both half-shell and shucked oysters. The upper and lower bounds for half-shell oysters indicate a WTP range of $0.60 to $0.98. This is good news for the half-shell oyster industry. The upper bound estimate represents a 65% markup from current oyster prices in Virginia. As for the shucked oysters, their range is between $4.64 and $10.36. The upper bound estimate is about a 34% markup from current prices on a quart of shucked oysters.

Green markets have been expanding into many sectors of the economy in response to a willingness-to-pay for environmental benefits (Bjørner et al. [2003] and Kotchen [2006]). The results from the CV questions in this survey indicate a high willingness to pay for ecolabeled oysters due to their water quality improvement services. However, going back to the results from question 30 in table 5.7, we know that 60% of the sample population does not know how much seafood they eat has an ecolabel. Due to the lack of consumer knowledge about ecolabeled seafood, oyster growers in the Chesapeake Bay would first need to educate consumers about the benefits of buying ecolabeled oysters before they would be able to receive the price premium.[72]

## 5.6. Conclusions

[72] Kotchen (2006) has suggested that while green markets have the potential to improve environmental quality, the introduction of a green market may actually discourage private donations. Therefore, the new oyster ecolabel program presents another crowding out problem. However, so few people eat oysters and donate that the scope for crowding out appears to be very small.

The data from the survey provided interesting results for all three models presented in this thesis. A conventional benefit cost calculation demonstrated that consumers are willing to pay for improved water quality, especially when the technology has a high probability of success. The benefits from upgrading wastewater treatment plants and planting tall grasses were more than double the cost of the programs. In order to determine whether process matters, approximate willingness to pay for process externalities were added to the original ratio. The adjusted benefit cost ratios revealed that process *does* matter to consumers when choosing a new water quality improvement program. With the additional willingness to pay for process externalities, the benefits of improving water quality by planting tall grasses increased to 20 times the cost.

A new water quality program has the potential to crowd out private donations to charitable organizations. However, the scope for crowding out is small. Only 14% of the sample population donated to organizations that support the Chesapeake Bay. For these households, the crowding out parameter revealed that a $1 tax increase for a new water quality program would lead to a $0.16 decrease in donations. Therefore, a $1 tax increase for a new water quality program would crowd out approximately 2% of all donations to Chesapeake Bay organizations within the study region. For example, consider a new water quality program that would plant tall grasses to decrease nitrogen by 1 million pounds. Operating such a program would require approximately $6.5 million. The crowding out effect for Chesapeake Bay organizations would be approximately $0.14 million. In principle, this decrease could be offset by sharing some of the tax revenue with Chesapeake Bay organizations. However, there is also a crowding out effect for other nonprofit organizations. Health organizations had an even larger crowding out effect because of the large number of donators and a high level of total donations. A new water quality program that planted tall grasses would crowd out about $0.21 million in

donations to health organizations. This indicates the need for policymakers to consider the crowding out effect for all types of charitable organizations, not just those considered to be close substitutes for donations to the Chesapeake Bay.

Finally, the CV survey results suggest a positive and significant WTP premium for ecolabeled oysters. Consumers are willing to pay a 58% premium for half-shell oysters and a 38% premium for shucked oysters. This suggests that there is some potential for creating a "green" market for certified Chesapeake Bay oysters.

**Table 5.1 Summary of how respondents ranked the important Chesapeake Bay Characteristics**

| Important Chesapeake Bay amenities | Very Undesirable | Undesirable | Neither | Desirable | Very Desirable | Number of Obs. |
|---|---|---|---|---|---|---|
| Clean Water | 3% | 1% | 2% | 16% | 79% | 852 |
| Healthy Fish Populations | 3% | 1% | 3% | 24% | 69% | 859 |
| Healthy Crab Populations | 3% | 1% | 5% | 22% | 68% | 858 |
| Healthy Oyster Populations | 3% | 1% | 7% | 25% | 63% | 857 |
| Clean and Safe Beaches | 3% | 1% | 6% | 28% | 62% | 855 |
| Healthy Bird Populations | 3% | 1% | 6% | 30% | 61% | 857 |
| Clear Water | 2% | 1% | 6% | 33% | 57% | 856 |
| Healthy Bay Grasses | 3% | 0% | 7% | 33% | 57% | 849 |
| Other | 4% | 1% | 27% | 13% | 55% | 161 |
| Views of Natural Scenery | 2% | 1% | 6% | 37% | 54% | 856 |
| Good Fishing | 3% | 1% | 16% | 35% | 45% | 851 |
| Good Swimming | 3% | 2% | 17% | 37% | 41% | 854 |
| Good Boating | 3% | 1% | 21% | 40% | 35% | 850 |

Explanatory note: These characteristics have been reordered and have the most important listed first.

**Table 5.2 Summary of responses to the use values in the Chesapeake Bay**

| | Never | Once Every Few Years | Once a Year | Once Every Few Months | Once a Month | More Than Once a Month | Number of Obs. |
|---|---|---|---|---|---|---|---|
| 3. Bay Swimming | 48% | 27% | 10% | 9% | 1% | 4% | 783 |
| 4. Bay Fishing | 49% | 25% | 10% | 10% | 2% | 5% | 785 |
| 5. Bay Boating | 44% | 29% | 11% | 9% | 2% | 4% | 784 |
| 6. Viewing wildlife | 18% | 31% | 18% | 18% | 4% | 11% | 785 |
| 7. Bay Hiking | 59% | 21% | 8% | 8% | 2% | 2% | 786 |

**Table 5.3 Willingness to support a new water quality improvement program in the Chesapeake Bay**

| | Not Likely to Support the Program | Somewhat Likely to Support the Program | Very Likely to Support the Program | Number of Obs. |
|---|---|---|---|---|
| 10. Paying farmers to plant tall grasses | 10% | 43% | 46% | 882 |
| 11. Paying to upgrade wastewater treatment plant | 11% | 47% | 41% | 874 |
| 12. Pay for an increase in the oyster population: | 14% | 38% | 46% | |
| A: Paying for oyster restoration efforts | 13% | 36% | 51% | 428 |
| B: Paying oyster aquaculturists | 15% | 41% | 44% | 446 |

**Table 5.4 Willingness to support a new water quality program with varying chances of meeting water quality target levels**

| Chance of meeting water quality target | Yes | Maybe | No | Number of Obs. |
|---|---|---|---|---|
| 55% | 46% | 36% | 18% | 129 |
| 65% | 47% | 36% | 16% | 192 |
| 75% | 53% | 32% | 15% | 240 |
| 85% | 52% | 32% | 16% | 146 |
| 95% | 57% | 32% | 11% | 145 |

**Table 5.5 Donation payments to nonprofits over the last year (percentile)**

| | Min | 10th | 25th | 50th | 75th | 90th | Max | Number of Obs |
|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 0 | 0 | 0 | 0 | 0 | 50 | over 500 | 621 |
| Farming | 0 | 0 | 0 | 0 | 0 | 0 | over 500 | 598 |
| Environment | 0 | 0 | 0 | 0 | 25 | 100 | over 500 | 618 |
| Religion | 0 | 0 | 0 | 250 | over 500 | over 500 | over 500 | 709 |
| Education | 0 | 0 | 0 | 50 | 250 | over 500 | over 500 | 657 |
| Health | 0 | 0 | 0 | 50 | 250 | over 500 | over 500 | 685 |
| Arts/Culture | 0 | 0 | 0 | 0 | 100 | 250 | over 500 | 632 |
| International | 0 | 0 | 0 | 0 | 0 | 100 | over 500 | 593 |
| Other | 0 | 0 | 0 | 0 | 250 | over 500 | over 500 | 391 |

Examples of what respondents wrote for "Other":

State tags, sports, stray pets, police and rescue, shelters, professional

**Table 5.6 The oyster and other seafood consumption habit results**

| | Never | Less than once a year | A few times a year | About Once a Month | About once a week | More than once a week | Number of Obs. |
|---|---|---|---|---|---|---|---|
| 25. Consume half-shell oysters | 55% | 15% | 26% | 2% | 1% | 0% | 537 |
| 27. Consume shucked oysters | 52% | 16% | 29% | 3% | 1% | 0% | 533 |
| 29. Consume seafood (other than oysters) | 4% | 3% | 16% | 26% | 36% | 15% | 537 |
| | None | Less than half | About half | More than half | Almost all of it | I do not know | Number of Obs. |
| 30. Consume Ecolabeled seafood | 18% | 8% | 5% | 2% | 7% | 60% | 532 |

**Table 5.7 Summary statistics for the variables used in the conditional logit model**

| Variable | Units | No. of Obs. | Min | Mean | Median | Max | Std. Dev |
|---|---|---|---|---|---|---|---|
| Program A Wastewater | (%) | 7160 | 0 | 40.01 | 50 | 100 | 27.70 |
| Program A Grasses | thousand acres | 7160 | 0 | 23.22 | 20 | 60 | 15.21 |
| Program A Oysters | billions | 7160 | 0 | 0.79 | 0.6 | 2 | 0.60 |
| Program A Prob of meeting target | (%) | 7160 | 40 | 72.93 | 70 | 100 | 18.11 |
| Program A Cost | ($) | 7160 | 10 | 37.86 | 30 | 80 | 17.29 |
| Program A "No Program" | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| Program B Wastewater | (%) | 7160 | 25 | 59.16 | 50 | 100 | 25.76 |
| Program B Grasses | thousands | 7160 | 0 | 15.86 | 15 | 40 | 11.62 |
| Program B Oysters | billions | 7160 | 0 | 1.16 | 1.3 | 2 | 0.67 |
| Program B Prob of meeting target | (%) | 7160 | 40 | 57.80 | 50 | 100 | 19.52 |
| Program B Cost | ($) | 7160 | 20 | 52.38 | 50 | 70 | 12.61 |
| Program B "No Program" | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program Wastewater | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program Grasses | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program Oysters | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program Prob of meeting target | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program Cost | - | 7160 | 0 | 0 | 0 | 0 | 0 |
| No Program | - | 7160 | 1 | 1 | 1 | 1 | 0 |
| Income per person | dollars | 6136 | 0.83 | 41.39 | 34.27 | 200 | 28.39 |
| College | dummy | 7000 | 0 | 0.60 | 1 | 1 | 0.49 |
| Less than 1 mile to farmland | dummy | 6656 | 0 | 0.29 | 0 | 1 | 0.46 |
| 1 to 20 miles to farmland | dummy | 6656 | 0 | 0.45 | 0 | 1 | 0.50 |
| 21 to 40 miles to farmland | dummy | 6656 | 0 | 0.16 | 0 | 1 | 0.37 |
| More than 40 miles to farmland | dummy | 6656 | 0 | 0.10 | 0 | 1 | 0.29 |
| Less than 1 mile to wastewater plant | dummy | 6640 | 0 | 0.04 | 0 | 1 | 0.19 |
| 1 to 20 miles to wastewater plant | dummy | 6640 | 0 | 0.61 | 1 | 1 | 0.49 |
| 21 to 40 miles to wastewater plant | dummy | 6640 | 0 | 0.11 | 0 | 1 | 0.31 |
| More than 40 miles to wastewater plant | dummy | 6640 | 0 | 0.24 | 0 | 1 | 0.43 |
| Wild oyster survey | dummy | 7160 | 0 | 0.49 | 0 | 1 | 0.50 |

**Table 5.8 Comparison of effects coding versus dummy coding**

| No. of Levels | Levels | Dummy Code 1 | Dummy Code 2 | Effects Code 1 | Effects Code 2 |
|---|---|---|---|---|---|
| 2 | 1 | 0 | | -1 | |
| | 2 | 1 | | +1 | |
| 3 | 1 | 0 | 0 | -1 | -1 |
| | 2 | 1 | 0 | +1 | 0 |
| | 3 | 0 | 1 | 0 | +1 |

Source: Bech and Hansen (2004)

## Table 5.9 Random utility parameter estimates from the conditional logit model

| Variable | [1] | [2] |
|---|---|---|
| wastewater (p) | 0.0028 ** | 0.0012 |
| | (0.0012) | (0.0025) |
| grasses (g) | 0.0066 *** | 0.0014 |
| | (0.0025) | (0.0052) |
| oysters (o) | 0.1308 *** | 0.1333 *** |
| | (0.0267) | (0.0463) |
| Prob of meeting target (u) | 0.03155 *** | 0.0282 *** |
| | (0.0013) | (0.0023) |
| cost ( c) | -0.0116 *** | -0.0116 *** |
| | (0.0020) | (0.0023) |
| opt-out (n) | 0.8482 *** | 0.8132 *** |
| | (0.1488) | (0.1655) |
| HH Inc. x p | | 0.0001 |
| | | (0.0001) |
| HH Inc. x g | | 0.0001 |
| | | (0.0001) |
| HH Inc. x o | | 0.0002 |
| | | (0.0010) |
| HH Inc. x u | | 0.0001 ** |
| | | (0.0001) |
| College x p | | -0.0013 |
| | | (0.0012) |
| College x g | | -0.0062 ** |
| | | (0.0025) |
| College x o | | -0.0224 |
| | | (0.0286) |
| College x u | | 0.0047 *** |
| | | (0.0013) |
| Less than 1 mile to farmland | | -0.0005 |
| | | (0.0036) |
| 1 to 20 miles to farmland | | 0.0013 |
| | | (0.0033) |
| 20 to 40 miles to farmland | | 0.0006 |
| | | (0.0040) |
| Less than 1 mile to wastewater treatment plant | | 0.0044 * |
| | | (0.0024) |
| 1 to 20 miles to wastewater treament plant | | -0.0006 |
| | | (0.0016) |
| 20 to 40 miles to wastewater treatment plant | | -0.0008 |
| | | (0.0026) |
| Wild oyster Survey | | -0.0084 |
| | | (0.0401) |
| Pseudo $R^2$ | 0.19488 | 0.22667 |
| N | 20600 | 17800 |

Legend: * p< .1; ** p< .05; *** p< .01
Option vce(cluster) specified: Clustered standard errors

Explanatory note: The standard errors of each estimate are shown in parentheses.

**Table 5.10 Marginal willingness to pay for a 1% increase from current program levels**

| | dollarized ratio of preference parameters | Marginal WTP (1% increase from current levels) |
|---|---|---|
| Probability of Meeting Target | $2.72 per 1% increase | $2.72 |
| Wastewater treament plants | $0.24 per 1% increase | $0.024 |
| Planting tall grasses | $0.000571 per acre | $0.23 |
| Increase Oyster Populations | $0.0000113 per 1,000 oysters | $0.00079 |

**Table 5.11 Benefit cost calculations for a 1million lb decrease in total nitrogen**

| | | | Wastewater treatment plants (7 plants) | Planting tall grasses (22,000 acres) | Increase Oyster Populations (798 million) |
|---|---|---|---|---|---|
| [1] | Δ in Probability of meeting target | (%) | +1 | +0.5 | +0.75 |
| [2] | Approx WTP for Δ in Probability | $ million | $27.47 | $13.74 | $20.6 |
| [3] | Approx Program Cost | $ million | $11.06 | $6.5 | $248.68 |
| [4] | Conventional Benefit-Cost Ratio: [2]/[3] | | 2.48 | 2.11 | 0.08 |
| | **Process Externality** | | | | |
| [5] | Approx WTP for Process Externality | $ million | $1.81 | $124.89 | $90.91 |
| [6] | Adjusted Benefit-Cost Ratio: ([2]+[5])/[3] | | 2.65 | 21.33 | 0.45 |

Explanatory note: Row [1] is somewhat consistent with the DEQ nutrient trading ratio of 2:1 for nonpoint and point source polluters.

**Table 5.12 Respondents changes in donations to all charitable organizations**

| Donation Organization | Number of people who: | | |
|---|---|---|---|
| | Currently Donate | Say the tax would **not** change their donations | Say the tax would **decrease** their donations |
| Chesapeake Bay | 122 | 94 | 28 |
| Farm | 49 | 42 | 7 |
| Enviro | 194 | 169 | 25 |
| Religion | 399 | 373 | 26 |
| Education | 351 | 312 | 39 |
| Health | 359 | 315 | 44 |
| Arts | 229 | 201 | 28 |
| International | 109 | 99 | 10 |

Explanatory note: Due to respondent confusion, a number of observations were dropped from those who currently donate. Unusable responses where those that either answered "no change" in donations and then proceeded to change both increasing and decreasing amounts as well as those that answered "increase" or "decrease" donations in response to the new program fee but had not donated anything to the specific organization to begin with. The amount of dropped observations is as follows: CB (3), Farm (6), Enviro (26), Religion (74), Education (48), Health (53), Arts (26), and International (20). Therefore, the resulting table produces the results after the data was adjusted.

**Table 5.13 Summary Statistics for changes in Chesapeake Bay (CB) donations**

| | All Responses | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | Units | Obs | Min | Mean | Median | Max | Std. Dev. |
| Donation Change | ($) | 122 | 0 | 7.38 | 0 | 100 | 18.30 |
| Cost | ($) | 122 | 10 | 45.16 | 50 | 80 | 16.97 |
| Wastewater | (%) | 122 | 0 | 51.23 | 50 | 100 | 28.72 |
| Grasslands | 1,000 acres | 122 | 0 | 19.34 | 17.5 | 60 | 14.62 |
| Oysters | billions | 122 | 0 | 1.06 | 1.3 | 2 | 0.71 |
| Prob of meeting target | (%) | 122 | 40 | 62.05 | 60 | 100 | 19.20 |
| College | dummy | 119 | 0 | 0.66 | 1 | 1 | 0.47 |
| Age | year | 118 | 28 | 55.86 | 56.5 | 95 | 12.75 |
| Gender | dummy | 119 | 0 | 0.68 | 1 | 1 | 0.47 |

**Table 5.14 Econometric results for the crowding out effect on Chesapeake Bay organizations**

| Variable | Model [1] | Model [2] |
|---|---|---|
| *Cost* | -0.1558 *** | -1.042 *** |
| | (0.034) | (0.276) |
| *Interactions with Cost* | | |
| *wastewater* | | 0.0025 |
| | | (0.002) |
| *grasses* | | 0.0049 |
| | | (0.005) |
| *oysters* | | 0.0974 * |
| | | (0.056) |
| *Prob of meeting program target* | | 0.0024 |
| | | (0.002) |
| *college* | | 0.03534 |
| | | (0.079) |
| *age* | | 0.00493 * |
| | | (0.003) |
| *gender* | | 0.1405 * |
| | | (0.074) |
| $R^2$ | 0.1461 | 0.2525 |
| No. of observations | 122 | 118 |

Legend: * p< .1; ** p< .05; *** p< .01

Explanatory note: The standard errors are shown in parentheses. In model [1] the crowding out parameter means that a $1 increase in taxes will decrease donations to organizations that support the Chesapeake Bay by $0.16. The results in model [2] shown a much larger crowding out effect but this is not necessarily the case once the significant interaction terms have been calculated into the crowding out effect.

**Table 5.15 Econometric results for changes in donations to all charitable organizations**

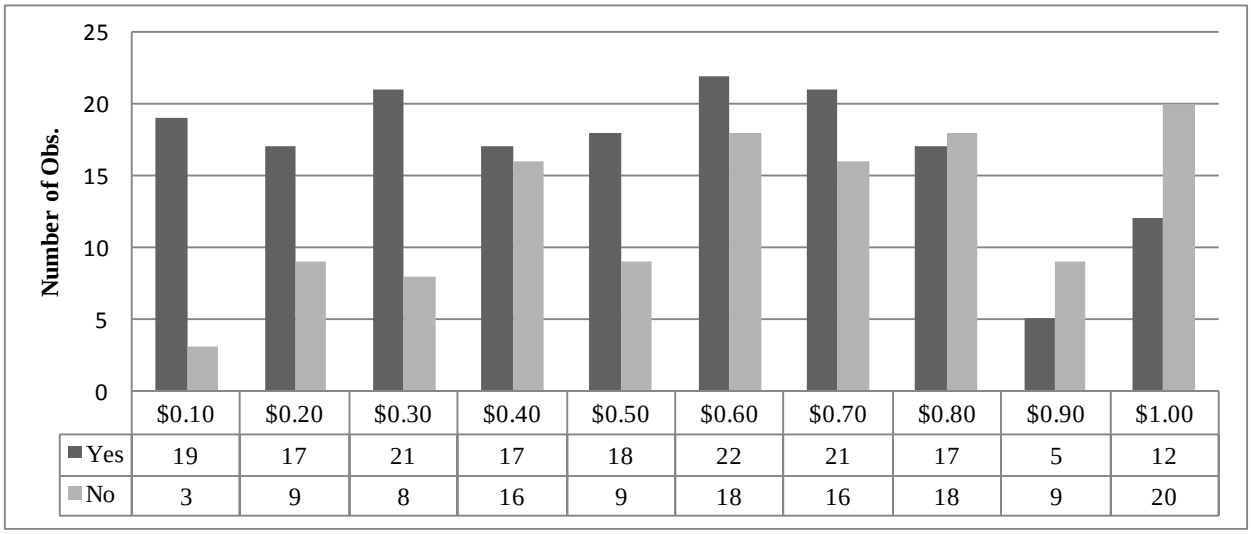
| Organization | Model [1] | $R^2$ | Number of Obs. |
|---|---|---|---|
| *Chesapeake Bay* | -0.1558 *** | 0.146 | 122 |
| | (0.034) | | |
| *Farm* | -0.0986 *** | 0.094 | 49 |
| | (0.044) | | |
| *Environment* | -0.0891 *** | 0.099 | 194 |
| | (0.019) | | |
| *Religious* | -0.0449 *** | 0.036 | 399 |
| | (0.012) | | |
| *Health* | -0.0842 *** | 0.085 | 359 |
| | (0.015) | | |
| *Arts/Culture* | -0.1233 *** | 0.091 | 229 |
| | (0.026) | | |
| *International* | -0.0776 *** | 0.097 | 110 |
| | (0.023) | | |

Legend: * p< .1; ** p< .05; *** p< .01

**Table 5.16 Crowding out effect for programs to decrease N by 1 million lbs (table 5.11)**

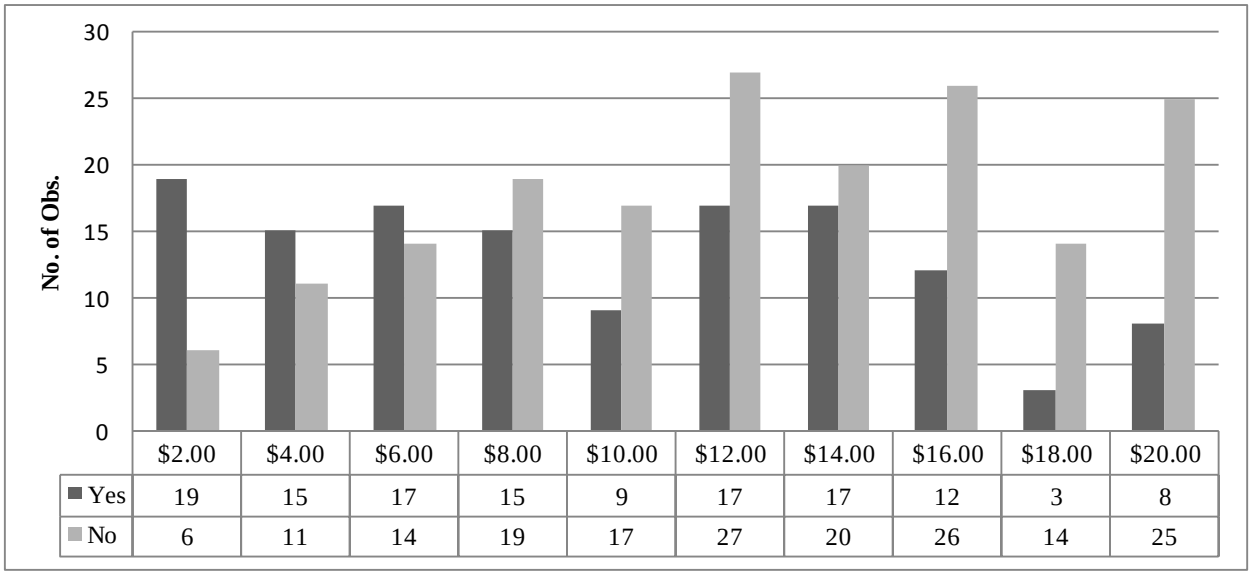
| Organization | ($ million) | Wastewater treatment plants (7 plants) | Planting tall grasses (22,000 acres) | Increase Oyster Populations (798 million) |
|---|---|---|---|---|
| *Chesapeake Bay* | | $0.23 | $0.14 | $5.27 |
| *Farm* | | $0.06 | $0.04 | $1.34 |
| *Environment* | | $0.21 | $0.13 | $4.79 |
| *Religious* | | $0.22 | $0.13 | $4.96 |
| *Health* | | $0.37 | $0.21 | $8.19 |
| *Arts/Culture* | | $0.55 | $0.32 | $12.27 |
| *International* | | $0.22 | $0.13 | $4.92 |
| *Total Program Revenue* | | $11.06 | $6.50 | $248.00 |
| *Total Decrease in Donations* | | $1.86 | $1.09 | $41.74 |

**Figure 5.1 Response to bids for a premium on ecolabeled half-shell oysters (N=295)**




| | $0.10 | $0.20 | $0.30 | $0.40 | $0.50 | $0.60 | $0.70 | $0.80 | $0.90 | $1.00 |
|---|---|---|---|---|---|---|---|---|---|---|
| Yes | 19 | 17 | 21 | 17 | 18 | 22 | 21 | 17 | 5 | 12 |
| No | 3 | 9 | 8 | 16 | 9 | 18 | 16 | 18 | 9 | 20 |

**Figure 5.2 Response to bids for a premium on ecolabeled shucked oysters (N=311)**




| | $2.00 | $4.00 | $6.00 | $8.00 | $10.00 | $12.00 | $14.00 | $16.00 | $18.00 | $20.00 |
|---|---|---|---|---|---|---|---|---|---|---|
| Yes | 19 | 15 | 17 | 15 | 9 | 17 | 17 | 12 | 3 | 8 |
| No | 6 | 11 | 14 | 19 | 17 | 27 | 20 | 26 | 14 | 25 |

**Table 5.17 Coefficient estimates for single-bounded logit models from the contingent valuation survey questions**

| | Intercept | Slope |
|---|---|---|
| | ($\hat{a}$) | ($-\hat{b}$) |
| **Half-shell** | | |
| coefficent | 1.33 | -1.8 |
| z statistic | (4.51) | (3.89) |
| Pseudo $R^2$ | 0.04 | |
| **Shucked** | | |
| coefficent | 0.84 | -0.104 |
| z statistic | (3.10) | (4.61) |
| Pseudo $R^2$ | 0.05 | |

**Table 5.18 Estimates of willingness to pay for ecolabeled oysters**

| | **Half-shell** | **Shucked** |
|---|---|---|
| Mean/Median WTP | $0.74 | $8.08 |
| Truncated Mean WTP | $0.87 | $11.53 |
| 95% Confidence Interval on Mean/Median WTP | $0.60-$0.98 | $4.64-$10.36 |

# Chapter 6: Summary and Future Research

## 6.1. Summary and Overview of Key Results

The Chesapeake Bay is a valued resource. Over the last century the Bay has been plagued by pollution, disease, and overharvesting of key species. As a result, the Bay has been the focus of substantial research and the beneficiary of numerous environmental programs. Previous work has suggested that people are willing to pay for improved water quality in the Chesapeake Bay. For policymakers, the key challenge is to determine how to allocate scarce funds across alternative regulatory and subsidy programs. This thesis has investigated three new research questions that relate to the policymaker's problem. First, does willingness to pay for a given water quality improvement depend on the process used to obtain that improvement? Second, will introducing a publicly funded program to improve water quality crowd out private donations to charitable organizations like the Chesapeake Bay Foundation? Third, because of their water filtration services, could oysters in the Chesapeake Bay be successfully marketed as a "green" good? Each question was analyzed separately using data gathered from a choice experiment survey.

### 6.1.1. Survey Results

The choice experiment survey was sent to 2,500 households in Virginia who live within 120 miles of the Chesapeake Bay. Of these 2,500 households, 38% replied with a useable survey. It was clear that these people are users of the Bay, with 10% viewing wildlife in the Bay more than once a month and 86% having visited the Chesapeake Bay at some point in their life. Respondents indicated that water quality was particularly important to them (79% viewed *clean water* in the Chesapeake Bay as "very desirable") and seemed to be reasonably well educated on the issues. When asked whether they knew that farming was the largest source of nitrogen pollution in the Bay, 54% answered "yes." And again, when asked whether they knew the Chesapeake Bay had serious water quality problems, 79% responded with a "yes". Respondents'

demographic characteristics were relatively consistent with the underlying population of Virginia and provided a representative sample of the study region.

### 6.1.2. Econometric Results

Each research question was investigated using a separate econometric model. First, a conditional logit model was used to test whether willingness to pay for improved water quality varies across alternative processes. The coefficients on upgrading wastewater treatment plants, planting tall grasses, increasing oyster populations and higher chances of meeting program targets were positive and the coefficient on cost was negative. All of these coefficients were economically important and statistically significant at conventional levels. Adding demographic characteristics to the model revealed that wealthier and more educated people have stronger preferences for reducing uncertainty about our ability to meet the water quality target and less educated people have stronger preferences for planting tall grasses.

The question of whether a new publicly funded water quality program would crowd out donations to nonprofit organizations was addressed using a first-differenced regression. The results indicated that a new tax would have a significant and negative effect on donations to Chesapeake Bay organizations. A $1 increase in the cost of a new water quality program will lead to a $0.16 decrease in donations for people who currently donate. However, the scope for this crowding out effect is relatively small because only 14% of respondents currently donate to Chesapeake Bay organizations. A second model was used to test the crowding out effect on other charitable organizations such as religions organizations, health organizations, and organizations that support the arts. The results suggest that a $1 tax increase for a new water quality program will cause between a $0.05 and $0.12 decrease in donations to these organizations.

Finally, the willingness to pay for ecolabeled oysters was calculated using the coefficient estimates from a logit model. The results suggest positive price premiums of 58% for half-shell oysters and 34% for shucked oysters. The Krinsky-Robb simulation technique produced 95% confidence intervals on WTP of $0.60-$0.98 for half-shell oysters and $4.64-$10.36 for shucked oysters.

### 6.1.3. Policy Implications

To put the econometric results in perspective a benefit cost analysis was conducted for three hypothetical programs that would decrease nitrogen by 1 million pounds. First, a conventional benefit cost ratio was used to compare the benefits of meeting the proposed water quality target with the costs of each technology (wastewater treatment, planting tall grasses, and planting oysters). This analysis suggested that upgrading wastewater treatment plants and planting tall grasses both have relatively similar benefit cost ratios (around 2:1). However, this "conventional" benefit cost analysis did not take into account the positive externalities associated with the process used to improve water quality. Therefore, an "adjusted" benefit cost ratio was calculated that included the value of the externalities associated with each process. In this case, planting tall grasses was the most efficient alternative, with a benefit-cost ratio of almost 20:1. Oyster aquaculture also had large benefits but the extremely high costs outweighed the benefits. Policy makers interested in developing new water quality programs may find these results useful. In particular, the results indicate that people value the process used to improve water quality such as increasing oyster populations and planting acres of tall grasses.

Likewise, my results on the crowding-out effect for private donations may be relevant for nonprofit environmental groups like the Chesapeake Bay Foundation. Respondents may consider donating less to programs like the Chesapeake Bay Foundation if they perceive the fee

from the new water quality program to be a substitute for their donations. For example, the benefit-cost analysis indicated that it would cost approximately $6.5 million to pay farmers to plant enough tall grasses to decrease nitrogen by 1 million pounds. In this case, donations to Chesapeake Bay organizations would decrease by approximately $0.23 million. A more surprising result was the magnitude of crowding out to organizations that seem unlikely to be close substitutes for Chesapeake Bay organizations. Donations to arts and cultural organizations would decrease by approximately $0.32 million, for example.

Results on the potential price premium for oysters may be important to commercial oyster growers. Labeling Chesapeake Bay oysters to show that they provide filtration services would create the opportunity to collect a large price premium. In addition, the results indicate that the willingness to pay for a public program that would increase the native oyster population does **not** depend on whether the oysters would be grown through aquaculture or planted on the reef bottom. This information is important because states have been using reef restoration to attempt to improve native oyster populations without much success (NMFS [2008], Alford [1975]). If, instead, aquaculturists were to receive a share of these funds, they might have success in increasing oyster populations.

### 6.2. Future Research

The results from each of the three models have implications for future policy analysis. First, the conditional logit estimates demonstrated that consumers are willing to pay for improved water quality, especially when the technology has a high probability of success. Second, using first-differenced regression, the new water quality program was found to crowd out private donations to charitable organizations. Third, the CV results implied a positive and significant willingness to

pay premium for ecolabeled oysters. The findings for all three models also provide opportunities for future research.

### 6.2.1. Relax the IIA Assumption

The primary objective of this thesis was to use data from the discrete choice questions on the survey to examine the economic implications of a proposed water quality improvement program in the Chesapeake Bay. The results from the conditional logit model imply that individuals value process and that they may in fact value the process used to improve water quality more than the water quality improvement. One issue that can arise from using the conditional logit model is that this model automatically assumes that the IIA assumption holds. It may be preferable to consider a model where the IIA assumption can be relaxed. A common practice in the choice experiment literature is to test whether the IIA assumption holds by using a nested logit model (Louviere et al. [2000], Hanley et al. [2002], Mansfield et al. [2008]). The nested logit model recognizes that the two program alternatives may have a greater degree of similarity than the opt-out alternative. The Hausman and McFadden (1984) test for the IIA property can be used to indicate whether to reject it. If the IIA assumption were rejected, the model would be recast to first consider two choice levels: option 1 "opt-out", option 2 "Program A or B". If option 2 is chosen, a second level of options would be considered: option 1 "Program A", option 2 "Program B" (Hanley et al [2002]). At each level there are only two choice alternatives and the IIA assumption is no longer imposed.

### 6.2.2. Subdivide Respondents

The conditional logit model can also be adjusted to consider differences between respondents. This is important because the mean willingness to pay for improved water quality can vary substantially between users and nonusers (Desvousges et. al. [1987]). One possibility for future

research would be to divide the sample into "user" and "non-user" groups and then estimate the conditional or nested logit model separately for each group. We would expect "users" to have a higher willingness to pay for improved water quality than "nonusers." Another difference in willingness to pay may be found between rural versus urban residents. Intuitively, rural residents may benefit the most from improved water quality in rivers and streams because they live closer to these amenities. Rural residents may also be involved in some type of agriculture. This would imply stronger preferences for programs that involve paying farmers to plant tall grasses because rural residents may be recipients of this type of subsidy or stronger preferences for this type of program because rural residents benefit from these improved amenities. Estimating the model separately for different groups would allow the utility function coefficients on non-price attributes to vary systematically across different types of users (Mansfield et al [2008]).

### 6.2.3. Test for crowding out using revealed preference data

One of the key results from this thesis is that crowding out would occur with the introduction of a new water quality improvement program in the Chesapeake Bay. A caveat to this result is that the survey question used to generate the data may have been cognitively difficult to process because respondents were asked to think about future changes in donations. One way to test the validity of my stated preference results on crowding out would be to conduct a quasi-experimental analysis using data on actual changes in donations to Chesapeake Bay organizations following the introduction of a new water quality improvement tax. For example, one could collect data on donations to the Chesapeake Bay Foundation before and after the Maryland Flush tax was implemented. The researcher could then use a first-difference model to test the crowding out effect from the Maryland flush tax. The results would provide a simple

revealed preference test of crowding out for individuals in Maryland that would be comparable to the stated preference results from this thesis.

#### 6.2.4. Explain how the demand for ecolabeled oysters depends on demographics

Finally, the results from the logit model suggest that consumers are willing to pay for ecolabeled oysters. An admonition to the current approach to estimation is that it assumes the willingness to pay does not vary with demographic characteristics. For instance, we would expect higher income households to have a higher willingness to pay for ecolabeled oysters. Likewise, the willingness to pay may differ between consumers of ecolabeled seafood and consumers of non-ecolabeled seafood. We might also expect willingness to pay to differ between generations. There has been a general decline in oyster consumption in the Chesapeake Bay region because of the declining supply and new health concerns associated with eating raw seafood. This may present a generational gap between older people who grew up eating oysters and younger people who are not accustomed to it. Stated preference data on respondent's demographic characteristics from the choice experiment survey could be used to test these hypotheses.

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# Appendix A. Chesapeake Bay Choice Experiment Survey

Virginia Tech

**Department of Agricultural and Applied Economics**

VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

College of Agriculture and Life Sciences (0401)
Blacksburg, Virginia 24061
(540) 231-5382; Fax: (540) 231-7417

March 25, 2009

Dear Virginia Resident:

To better understand how Virginia residents like yourself will react to decisions about the management of the Chesapeake Bay, we have selected a sample of households to give their opinions. We want to learn what Virginia residents think about different ways to improve water quality, wildlife habitat, and recreation opportunities in the Chesapeake Bay.

Your responses are very important to us because you are one of a small number of residents who have been selected to represent all of the people living in your state.

Your responses are confidential and your name will not be revealed. Information from the surveys will only be reported in statistical terms, such as "15 percent of Virginia residents went fishing in the Chesapeake Bay in 2008". There is an identification number on your questionnaire only so that we can send reminders to people who forget to return their questionnaires.

We request that the person in your household who pays the food bills fill out the questionnaire. When you have completed the questionnaire, please return it in the enclosed postage-paid envelope. We hope that you find this questionnaire interesting to fill out and we appreciate your help in this study.

Sincerely,

Nicolai V. Kuminoff Anna Harris

**1**

**Public Opinion Questionnaire on the Chesapeake Bay**


**The Chesapeake Bay**

Section A. In this section we would like to learn what you think are important characteristics of the Chesapeake Bay.

1. Please rate how important each of the following Chesapeake Bay characteristics is to you.

(CIRCLE ONE NUMBER FOR EACH CHARACTERISTIC)

| | Very Undesirable | Undesirable | Neither | Desirable | Very Desirable |
|---|---|---|---|---|---|
| Clear water | 1 | 2 | 3 | 4 | 5 |
| Healthy Bay grasses | 1 | 2 | 3 | 4 | 5 |
| Clean water | 1 | 2 | 3 | 4 | 5 |
| Good fishing | 1 | 2 | 3 | 4 | 5 |
| Good swimming | 1 | 2 | 3 | 4 | 5 |
| Good boating | 1 | 2 | 3 | 4 | 5 |
| Clean and safe beaches | 1 | 2 | 3 | 4 | 5 |
| Views of natural scenery | 1 | 2 | 3 | 4 | 5 |
| Healthy fish populations | 1 | 2 | 3 | 4 | 5 |
| Healthy bird populations | 1 | 2 | 3 | 4 | 5 |
| Healthy oyster populations | 1 | 2 | 3 | 4 | 5 |
| Healthy crab populations | 1 | 2 | 3 | 4 | 5 |
| Other, please explain | 1 | 2 | 3 | 4 | 5 |

Section B. In this section we would like to learn if you visit the Chesapeake Bay.

2. Have you ever visited the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Yes
2 No → Skip to Section C.

3. How often do you swim in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

4. How often do you fish in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

5. How often do you go recreational boating (not fishing) in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

6. How often do you view wildlife in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

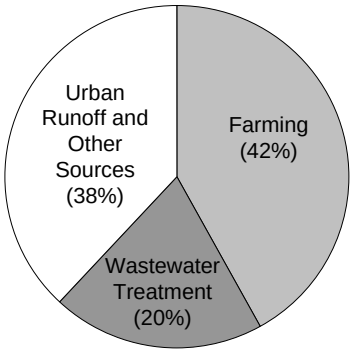
7. How often do you hike around the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Never
2 Once every few years
3 Once a year
4 Once every few months
5 Once a month
6 More than once a month

Section C. In this section we would like to learn whether you would support a new program to improve water quality in the Chesapeake Bay.

Water quality depends mainly on the amount of nitrogen in the water. Nitrogen is a type of nutrient and too much nitrogen decreases water quality in the bay. The nitrogen leads to the growth of algae that reduces water clarity. It also decreases the population of fish, crabs, underwater grasses, and other species. Nitrogen in the Chesapeake Bay comes from the following sources:

Sources of Nitrogen in the Chesapeake Bay




8. Did you know that farming is the largest source of nitrogen in the Chesapeake Bay? (CIRCLE ONE NUMBER)

1 Yes
2 No

The Chesapeake Bay is currently on the Environmental Protection Agency (EPA) list of "dirty waters." Nitrogen is the main source of contamination. Each year roughly 300 million pounds of nitrogen enter the Bay. The amount of nitrogen would have to be cut in half to remove the Bay from the EPA's list of dirty waters.

9. Did you know that the Chesapeake Bay has serious water quality problems? (CIRCLE ONE NUMBER)

   1 Yes
   2 No

Nitrogen from farms is due to the manure and fertilizers that are applied to farmland. One way to improve water quality is to pay farmers to plant tall grasses on their land next to rivers and streams that flow into the Bay. This reduces runoff of manure and fertilizer during storms that lead to nitrogen in the Bay. The tall grasses would also provide new habitat for birds and other wildlife.

10. Would you support a water quality program <u>if it involved paying farmers to plant tall grasses that protect water quality in the Bay and provide wildlife habitat</u>? (CIRCLE ONE NUMBER)

   1 Not likely to support the program
   2 Somewhat likely to support the program
   3 Very likely to support the program

Water quality can also be improved by upgrading wastewater treatment plants. There are about 500 wastewater treatment plants that release nitrogen into the Bay. Plants with older technology release more nitrogen. These plants can be upgraded to decrease the amount of nitrogen they release. The reason this has not been done already is that the upgrades are expensive.

11. Would you support a water quality program <u>if it involved paying to upgrade wastewater treatment plants</u>? (CIRCLE ONE NUMBER)

1 Not likely to support the program
2 Somewhat likely to support the program
3 Very likely to support the program

Oysters are a key species that both filter and clean water. In the 1800's oysters could filter a volume of water equal to the entire Chesapeake Bay in a single day. The oyster population has declined by over 90% since then. It would take the current oyster population more than a year to filter the entire Bay. Another way to improve water quality in the Bay would be to increase the wild oyster population by creating sanctuaries and planting oyster spat. ("Spat" are baby oysters). Oysters remove some nitrogen from the water and use it to build their shells. This is a natural process. It is perfectly safe to eat these oysters.

12. Would you support a water quality program <u>if it involved paying for restoration efforts to increase the wild oyster population</u>? (CIRCLE ONE NUMBER)

1 Not likely to support the program
2 Somewhat likely to support the program
3 Very likely to support the program

The Chesapeake Bay Program (CBP) is a regional partnership between states and the federal government dedicated to restoring the Chesapeake Bay. The CBP has set a target level for water quality that would improve current habitat for fish, crabs, underwater grasses, and other species. Unfortunately, no program to improve water quality can be 100% guaranteed to meet this target. Wastewater treatment can release nitrogen unexpectedly, nitrogen runoff from farmland depends on the strength of storms, and oysters grown in the Bay can be eaten by predators.

13. Would you support a water quality program <u>if the chance of meeting the water quality target was 55%—slightly better than a coin toss—and there would be no cost to your household</u>? (CIRCLE ONE NUMBER)

    1 No
    2 Maybe
    3 Yes

In order to improve water quality in the Chesapeake Bay, the new program would have to raise money. This would be done by adding a new annual fee to the water bill of every household living in Pennsylvania, Virginia, Maryland, New York, West Virginia, Delaware, and Washington D.C. These states all have creeks, streams and rivers that flow into the Chesapeake Bay. Households on septic systems would pay an equivalent fee.

14. Would you support a water quality program <u>if the chance of meeting the water quality target was 85% and the cost for each household was $47 per year for 10 years?</u> (CIRCLE ONE NUMBER)

    1 No
    2 Maybe
    3 Yes

Now we would like to ask you eight questions. Each question shows you two different programs to improve water quality in the Chesapeake Bay. We would like you to think about each of the programs in the questions and choose the program you prefer. You can also choose not to have a program to improve water quality in the Chesapeake Bay. If you choose not to have a program there will be no cost to your household, but there will also be no improvement in water quality.

All of the programs we ask you to consider are realistic. Please answer each question as if the program choices in the question are the only ones available to you.

A sample question is shown below. It shows two programs to improve water quality in the Chesapeake Bay, Program A and Program B. It shows the actions that will be taken to improve water quality, the chances of each program meeting the Chesapeake Bay Program's water quality target, and how much each program will cost your household. We would like you to indicate which program you prefer by circling one of the three numbers. If your preferred choice is Program A then this is the program you would choose by circling "1".

SAMPLE CHOICE QUESTION:

*Do you prefer Program A, Program B, or No Program*? *Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 25% of plants | 75% of plants | 0% |
| Acres of tall grasses planted on farmland | 30,000 Acres | 10,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 0.6 Billion | 1.3 Billion | 0 |
| Chance of meeting water quality target | 80% | 40% | 0% |
| Total cost per **YEAR** to my household | $30 | $70 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q1. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 100% of plants | 50% of plants | 0% |
| Acres of tall grasses planted on farmland | 0 | 30,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 2.0 Billion | 1.3 Billion | 0 |
| Chance of meeting water quality target | 100% | 50% | 0% |
| Total cost per **YEAR** to my household | $80 | $60 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q2. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 0% of plants | 100% of plants | 0% |
| Acres of tall grasses planted on farmland | 40,000 Acres | 0 | 0 Acres |
| Number of wild oysters planted in the Bay | 0 | 2.0 Billion | 0 |
| Chance of meeting water quality target | 80% | 70% | 0% |
| Total cost per **YEAR** to my household | $10 | $60 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q3. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 50% of plants | 75% of plants | 0% |
| Acres of tall grasses planted on farmland | 10,000 Acres | 5,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 1.3 Billion | 0.6 Billion | 0 |
| Chance of meeting water quality target | 90% | 40% | 0% |
| Total cost per **YEAR** to my household | $60 | $70 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q4. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 75% of plants | 50% of plants | 0% |
| Acres of tall grasses planted on farmland | 10,000 Acres | 20,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 0.6 Billion | 2.0 Billion | 0 |
| Chance of meeting water quality target | 70% | 40% | 0% |
| Total cost per **YEAR** to my household | $50 | $40 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q5. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 0% of plants | 25% of plants | 0% |
| Acres of tall grasses planted on farmland | 60,000 Acres | 40,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 0 | 1.3 Billion | 0 |
| Chance of meeting water quality target | 70% | 100% | 0% |
| Total cost per **YEAR** to my household | $10 | $50 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q6. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 50% of plants | 25% of plants | 0% |
| Acres of tall grasses planted on farmland | 15,000 Acres | 30,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 0.6 Billion | 0 | 0 |
| Chance of meeting water quality target | 50% | 40% | 0% |
| Total cost per **YEAR** to my household | $30 | $20 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q7. Do you prefer Program A, Program B, or No Program? Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 25% of plants | 50% of plants | 0% |
| Acres of tall grasses planted on farmland | 20,000 Acres | 30,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 0.6 Billion | 2.0 Billion | 0 |
| Chance of meeting water quality target | 70% | 60% | 0% |
| Total cost per **YEAR** to my household | $40 | $60 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

*Q8. Do you prefer Program A, Program B, or No Program*? *Please answer this question as if these are the only three choices you can make.*

| **Water Quality Program Details** | **Program A** | **Program B** | **No Program** |
|---|---|---|---|
| Percentage of wastewater treatment plants upgraded | 25% of plants | 50% of plants | 0% |
| Acres of tall grasses planted on farmland | 15,000 Acres | 20,000 Acres | 0 Acres |
| Number of wild oysters planted in the Bay | 1.3 Billion | 0.6 Billion | 0 |
| Chance of meeting water quality target | 40% | 90% | 0% |
| Total cost per **YEAR** to my household | $30 | $50 | $0 |
| ***I would choose……..*** (CIRCLE ONE NUMBER) | *1* | *2* | *3* |

15. Did you choose "No Program" on every single one of the previous eight questions? (CIRCLE ONE NUMBER/FILL IN THE BLANK)

1 Yes→
WHY_____
2 No

16. Did you choose "Program A" on every single one of the previous eight questions? (CIRCLE ONE NUMBER/FILL IN THE BLANK)

1 Yes→
WHY_____
2 No

17. Did you choose "Program B" on every single one of the previous eight questions? (CIRCLE ONE NUMBER? FILL IN THE BLANK)

1 Yes→
WHY_____
2 No

Section D. In this section we would like to learn about your contributions to nonprofit organizations.

18. Are you currently a member of any **organization that directly supports the Chesapeake Bay**, such as the *Chesapeake Bay Foundation* or the *Alliance for the Chesapeake Bay*? (CIRCLE ONE NUMBER)

1 Yes
2 No
3 Don't know

19. Are you currently a member of any **organization that directly supports farmers,** such as *American Farmland Trust*, *Farm Aid*, or *4-H*?
(CIRCLE ONE NUMBER)

1 Yes
2 No
3 Don't know

20. About how much did you pay last year in membership fees and other donations to nonprofit organizations that support the following interests?

CIRCLE ONE NUMBER FOR EACH CATEGORY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Chesapeake Bay | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Farming | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Environment | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Religion | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Education | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Health | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Arts/Culture | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| International | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |
| Other_____ | $0 | $25 | $50 | $100 | $250 | $500 | over $500 |

21. Suppose the following water quality program is introduced next year.

| **Water Quality Program Details** | **New Program** |
|---|---|
| Percentage of wastewater treatment plants upgraded | 25% of plants |
| Acres of tall grasses planted on farmland | 40,000 Acres |
| Number of wild oysters planted in the Bay | 1.3 Billion |
| Chance of meeting water quality target | 100% |
| Total cost per **YEAR** to my household | $50 |

22. Would having to pay this annual fee change the amount you would choose to pay in membership fees or donations to nonprofit organizations?
(CIRCLE ONE NUMBER)

1 No → SKIP TO SECTION F

2 Yes, it would decrease the amount I would pay
→ SKIP TO QUESTION 23

3 Yes, it would increase the amount I would pay
→ SKIP TO QUESTION 24

23. How much would you decrease the amount you choose to pay in membership fees or donations to nonprofit organizations?

(CIRCLE ONE VALUE FOR EACH CATEGORY)

| | DECREASE BY: | | | | | | |
|---|---|---|---|---|---|---|---|
| Chesapeake Bay: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Farming: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Environment: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Religion: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Education: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Health: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Arts/Culture: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| International: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Other_____ | $90 | $80 | $70 | $50 | $30 | $20 | $10 |

24. How much would you increase the amount you choose to pay in membership fees or donations to nonprofit organizations?

(CIRCLE ONE VALUE FOR EACH CATEGORY)

| | INCREASE BY: | | | | | | |
|---|---|---|---|---|---|---|---|
| Chesapeake Bay: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Farming: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Environment: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Religion: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Education: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Health: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Arts/Culture: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| International: | $90 | $80 | $70 | $50 | $30 | $20 | $10 |
| Other_____ | $90 | $80 | $70 | $50 | $30 | $20 | $10 |

Section E. In this section we would like to learn about your consumption of oysters and other seafood.

25. How often do you eat **half-shell oysters**? (CIRCLE ONE NUMBER)

1 Never → SKIP TO QUESTION 27
2 Less than once a year
3 A few times a year
4 About once a month
5 About once a week
6 More than once a week

26. An oyster on the half shell costs around $1.50. Would you be willing to pay **$0.30 more per oyster** if the oysters could be certified as having been grown in the Chesapeake Bay where they helped to improve water quality by removing some nitrogen from the water? (CIRCLE ONE NUMBER)

1 Yes
2 No

27. How often do you eat **shucked oysters?** (CIRCLE ONE NUMBER)

1 Never → SKIP TO QUESTION 29
2 Less than once a year
3 A few times a year
4 About once a month
5 About once a week
6 More than once a week

28. A quart of fresh shucked oysters costs around $30.00. Would you be willing to pay **$6.00 more per quart** if the oysters could be certified as having been grown in the Chesapeake Bay where they helped to improve water quality by removing some nitrogen from the water? (CIRCLE ONE NUMBER)

1 Yes
2 No

29. How often do you eat seafood other than oysters? (CIRCLE ONE NUMBER)

1 Never
2 Less than once a year
3 A few times a year
4 About once a month
5 About once a week
6 More than once a week

30. How much of the seafood that you eat has an **ecolabel**? (An example of a seafood ecolabel includes the *Marine Stewardship Council)* (CIRCLE ONE NUMBER)[73]


1 None
2 Less than half
3 About half
4 More than half
5 Almost all of it
6 I do not know

[73] Please refer to Appendix F for permission to use

Section F. In this section we would like to ask you some questions about your background that will help us compare your answers to those of other people. All of your answers are strictly confidential.

31. What is your **gender**? (CIRCLE ONE NUMBER)

1 male
2 female

32. What is your **age**? (FILL IN THE BLANK)

_____ years

33. What is your level of **education**? (CIRCLE ONE NUMBER)

1 Less than 12 years
2 12 years but no high school degree
3 high school graduate
4 some college education, but no bachelor degree
5 bachelor degree
6 masters degree or higher

34. How many **people** live in your **household**? (FILL IN THE BLANK)

_____ people

35. How **far** is your residence from the **Chesapeake Bay**?
(CIRCLE ONE NUMBER)

1 Less than 1 mile
2 1 TO 20 miles
3 21 TO 40 miles
4 41 TO 60 miles
5 61 TO 80 miles
6 81 TO 100 miles
7 101 TO 120 miles
8 Greater than 121 miles
9 Don't know

36. How **far** is your residence from the **nearest farmland**?
(CIRCLE ONE NUMBER)

1 Less than 1 mile
2 1 TO 20 miles
3 21 TO 40 miles
4 41 TO 60 miles
5 61 TO 80 miles
6 81 TO 100 miles
7 101 TO 120 miles
8 Greater than 121 miles
9 Don't know

37. How **far** is your residence from the **nearest wastewater treatment plant**?
(CIRCLE ONE NUMBER)

1 Less than 1 mile
2 1 TO 20 miles
3 21 TO 40 miles
4 41 TO 60 miles
5 61 TO 80 miles
6 81 TO 100 miles
7 101 TO 120 miles
8 Greater than 121 miles
9 Don't know

38. Please circle the response that comes closest to your **total household income** after taxes in 2008. (CIRCLE ONE NUMBER)

| | | | |
|---|---|---|---|
| 1 | LESS THAN $ 5,000 | 11 | $ 50,000 TO $ 59,999 |
| 2 | $ 5,000 TO $ 9,999 | 12 | $ 60,000 TO $ 69,999 |
| 3 | $ 10,000 TO $ 14,999 | 13 | $ 70,000 TO $ 79,999 |
| 4 | $ 15,000 TO $ 19,999 | 14 | $ 80,000 TO $ 89,999 |
| 5 | $ 20,000 TO $ 24,999 | 15 | $ 90,000 TO $ 99,999 |
| 6 | $ 25,000 TO $ 29,999 | 16 | $ 100,000 TO $ 124,999 |
| 7 | $30,000 TO $ 34,999 | 17 | $ 125,000 TO $ 149,999 |
| 8 | $35,000 TO $ 39,999 | 18 | $ 150,000 TO $ 174,999 |
| 9 | $ 40,000 TO $ 44,999 | 19 | $ 175,000 TO $ 199,999 |
| 10 | $ 45,000 TO $ 49,999 | 20 | $ 200,000 OR MORE |

**Thank you for completing this questionnaire!**

# Reminder Post Card

College of Agriculture and Life Sciences (0401)
Blacksburg, Virginia 24061
(540) 231-5382; Fax: (540) 231-7417

April 2009

Dear Virginia Resident,

Last week we mailed you a survey to better understand how Virginia residents like yourself will react to decisions about the management of the Chesapeake Bay. If you have already returned the survey, we sincerely thank you. If you have not completed and returned it, please take a few minutes to do so today. When you have completed the questionnaire, please return it in the enclosed postage-paid envelope. Your response will make a valuable contribution to the accuracy of this study.

If by some chance you did not receive a survey or misplaced it, please contact me at 540-231-5382 or by email at kuminoff@vt.edu. I will put another one in the mail to you. Thank you.

Sincerely,

Nicolai V. Kuminoff
Assistant Professor

Anna Harris
Research Assistant

# Follow-up Cover Letter

Virginia Tech

**Department of Agricultural and Applied Economics**

VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

College of Agriculture and Life Sciences (0401)
Blacksburg, Virginia 24061
(540) 231-5382; Fax: (540) 231-7417

April 24, 2009

Dear Virginia Resident:

Three weeks ago, we sent you a survey to better understand how Virginia residents like yourself will react to decisions about the management of the Chesapeake Bay. If you have already completed this survey, we sincerely thank you. If you have not, please complete this survey as soon as possible. We will not contact you again.

Your responses are very important to us because you are one of a small number of residents who have been selected to represent all of the people living in your state. ***Your responses are confidential and your name will not be revealed***. Information from the surveys will only be reported in statistical terms, such as "15 percent of Virginia residents went fishing in the Chesapeake Bay in 2008". There is an identification number on your questionnaire only so that we can send reminders to people who forget to return their questionnaires.

We request that the person in your household who pays the food bills fill out the questionnaire. When you have completed the questionnaire, please return it in the enclosed postage-paid envelope. We hope that you find this questionnaire interesting to fill out and we appreciate your help in this study.

Sincerely,

Nicolai V. Kuminoff
Assistant Professor

Anna Harris
Research Assistant

**3001**

# Appendix B. SAS Code to Design Choice Sets

The code below is used to create the choice experiment sets. Any wording with an astric (*) in front of it is considered a direction for the code written below. The directions are there to act as a guide throughout the entire code. The-if then constraints were based on previous knowledge and represent the real world constraints for this study. In order to use this code, you will need to copy and paste it into SAS. SAS 9.1 was used to conduct this experiment. The filename of the trial folder and temporary work file will need to be adjusted for your own personal computer. The trial fold should be labeled 'SAS' and the first temporary file should be labeled 'Choice.first' while the second should be labeled 'Choice.second.'

```
options nodate pageno=1 formdlim='~';
title 'Anna';
* Macro to find n;
%mktruns(9 8 8 4 5);
run;
* Macros to create choice matrix;
%mktex(9 8 8 4 5, n=11520, seed=400)
%mktlab(data=design, vars=Cost Cert Habitat Opop Plant, int=f1-f5);
run;
*label the variable levels;
 proc format;
value cf 1='$10' 2='$20' 3='$30' 4='$40' 5='$50' 6='$60' 7='$70' 8='$80'
9='$90';
value ef 1='100%' 2='90%' 3='80%' 4='70%' 5='60%' 6='50%' 7='40%' 8='30%';
value hf 1='6Mil' 2='4mil' 3='3mil' 4='2mil' 5='1.5mil' 6='1mil' 7='.5mil'
8='0';
value of 1='2bil' 2='1.3bil' 3='.6bil' 4='0';
value pf 1='100%' 2='75%' 3='50%' 4='25%' 5='0';
run;
*Save it in a Trial folder;
libname Choice 'D:\SAS';
run;
*permenant file from a temporary work file;
data Choice.first;
set final;
format Cost cf. Cert ef. Habitat hf. Opop of. Plant pf.;
run;
proc print; run;
* deleting rows based on if-then constraints;
data Choice.second;
set Choice.first;
if Cost=1 & Opop=1 then delete;
if Cost=1 & Opop=2 then delete;
if Cost=1 & Opop=3 then delete;
if Cost=1 & Habitat=5 then delete;
if Cost=1 & Habitat=6 then delete;
if Cost=1 & Habitat=7 then delete;
if Cost=1 & Habitat=8 then delete;
if Cost=1 & Cert=1 then delete;
if Cost=1 & Cert=2 then delete;
if Cost=1 & Plant=1 then delete;
if Cost=1 & Plant=2 then delete;
if Cost=1 & Plant=3 then delete;
```

```
if cost=1 & Plant=4 then delete;
if Cost=8 & Opop=3 then delete;
if Cost=8 & Opop=4 then delete;
if Cost=8 & Habitat=1 then delete;
if Cost=8 & Habitat=2 then delete;
if Cost=8 & Habitat=3 then delete;
if Cost=8 & Habitat=4 then delete;
if Cost=8 & Habitat=5 then delete;
if Cost=8 & Habitat=6 then delete;
if Cost=8 & Cert=4 then delete;
if Cost=8 & Cert=5 then delete;
if Cost=8 & Cert=6 then delete;
if Cost=8 & Cert=7 then delete;
if Cost=8 & Cert=8 then delete;
if Cost=8 & Plant=3 then delete;
if Cost=8 & Plant=4 then delete;
if Cost=8 & Plant=5 then delete;
if Cost=9 & Opop=2 then delete;
if Cost=9 & Opop=3 then delete;
if Cost=9 & Opop=4 then delete;
if Cost=9 & Habitat=1 then delete;
if Cost=9 & Habitat=2 then delete;
if Cost=9 & Habitat=3 then delete;
if Cost=9 & Habitat=4 then delete;
if Cost=9 & Habitat=5 then delete;
if Cost=9 & Habitat=6 then delete;
if Cost=9 & Habitat=7 then delete;
if Cost=9 & Cert=2 then delete;
if Cost=9 & Cert=3 then delete;
if Cost=9 & Cert=4 then delete;
if Cost=9 & Cert=5 then delete;
if Cost=9 & Cert=6 then delete;
if Cost=9 & Cert=7 then delete;
if Cost=9 & Cert=8 then delete;
if Cost=9 & Plant=2 then delete;
if Cost=9 & Plant=3 then delete;
if Cost=9 & Plant=4 then delete;
if Cost=9 & Plant=5 then delete;
run;
* Creates a choice design with the smaller matrix;
%choiceff(data=Choice.Second, model=class(plant cert habitat opop cost),
nsets=16, flags=f1-f2, beta=zero, seed=155, maxiter=500);
run;
*blocking a choice design instead of blocking the linear version of a choice
design;
%mktblock(data=best, nalts=2, nblocks=2, factors=cost cert habitat opop
plant, seed=155);
run;
```

# Appendix C. Random Survey Generator in Visual Basic

This code was written in Microsoft visual basic using Microsoft Word 2007. To begin with, Developer must be accessed from the toolbar in Word or by downloading it from Microsoft.com. Under the Developer tab there is a function for Visual Basic (VB), click on it to open. Once visual basic is open you can begin to copy and paste this code into the new directory.

The first part of this code finds the drive and determines the location of the files you need to create the surveys. When using Word 2007 VB had a hard time finding .docx files, so this macro finds the location of the drives without you having to switch all the files into .doc format.

Example:

```
Sub SurveyCreation()
ChDrive ("C")
ChDir "C:\Users\Anna\Documents\ThesisResearch\Survey"
MsgBox "The current directory is " & CurDir
End Sub
```

To replicate this study you need to create a folder in your C: drive.

The following codes are used to make the surveys. It can be pasted in after the example code. First, name the code. Naming the code (which in turn names the macro) to correspond with the type of survey you are creating helps when you need to access the macro at a later date. All of the Filenames in all four macros will need to be changed in order to be compatible with your personal computer. I used the C: drive and created a folder labeled "Survey." When creating new folders and files to run through this macro it is a good idea to not use spaces between the Filenames. This visual basic loop has a hard time finding Filenames where there are spaces between them.

As for the survey pages itself, the random portion of the survey should be held in files with sequential names. For instance, the first random part of this survey is the water quality target which ranges from 55% to 95%. This file is labeled as A, AA, AAA and so on. This format should be used for each random portion of the survey.

Another important part of this macro is to add a new test string ID for each portion of the randomized process in the survey. If you do not use a new ID, you will have correlation between the random parts of the survey. For example, the random portion of the survey should with a string of Filenames matching a letter of the alphabet, in this case X.

Example:

```
NumX = Rnd(j)
IDX = Int((10 * NumX) + 1)
testX = String(IDX, "X")
```

Also, if you want to put in a unique id on the cover page of the survey you must first insert a bookmark and name it, which in this case is "Number." Once all the random and constant portions of the survey have been created, a blank document labeled NewDoc1.docx should be created. This code will create a full survey in this NewDoc1. You can change the name to Blank or New but be sure to change the Filename in the code too. Once you run the code with the appropriate Filename changes, you should use SAVE AS when saving the new document. The NewDoc1 should be left blank so that you can use it again and again to create new versions of the survey.

```
Sub SurveyCreation()
ChDrive ("C")
ChDir "C:\Users\Anna\Documents\ThesisResearch\Survey"
MsgBox "The current directory is " & CurDir
End Sub

Sub B1Wild() \Block One Wild Oysters\
For j = 1 To 624  \Print services could not handle more than 50 copies of the survey, so it is advisable to use 1 To 50; 51 To 100 and so on\
   Documents.Open \ Opens the document below\
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1WildConstant1.docx", _ \you will need to create your own directory in your C drive and paste the extension here\
   ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.GoTo What:=wdGoToBookmark, Name:="Number" \you will need to create a bookmark on the survey cover page and label it Number in order to get a unique identification number on the cover page\
   Selection.Font.Bold = wdToggle
   Selection.TypeText Text:=j
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
   OpenAndRepair:=False, _
   DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
   Selection.PasteAndFormat (wdPasteDefault)
   NumA = Rnd(j) \label this after the document you plan to randomize\
   IDA = Int((10 * NumA) + 1)
   testA = String(IDA, "A")
   Documents.Open FileName:=testA, _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
```

```
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    NumB = Rnd(j)
    IDB = Int((16 * NumB) + 1)
    testB = String(IDB, "B")
    Documents.Open FileName:=testB, _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1WildConstant2.docx", _
    ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
    OpenAndRepair:=False, _
    DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Next j
    End Sub
```

```
Sub SurveyCreation1()
ChDrive ("C")
ChDir "C:\Users\Anna\Documents\ThesisResearch\Survey"
MsgBox "The current directory is " & CurDir
End Sub

Sub B1Cage()  \Block One Cage Oysters\

For j = 625 To 1249

   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1WildConstant1.docx", _
   ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.GoTo What:=wdGoToBookmark, Name:="Number"
   Selection.Font.Bold = wdToggle
   Selection.TypeText Text:=j
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
   OpenAndRepair:=False, _
   DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
   Selection.PasteAndFormat (wdPasteDefault)
   NumA = Rnd(j)
   IDA = Int((10 * NumA) + 1)
   testA = String(IDA, "A")
   Documents.Open FileName:=testA, _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
```

```
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    NumC = Rnd(j)
    IDC = Int((16 * NumC) + 1)
    testC = String(IDC, "C")
    Documents.Open FileName:=testC, _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1CageConstant2.docx", _
    ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
    OpenAndRepair:=False, _
    DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Next j

End Sub
```

```
Sub SurveyCreation2()
ChDrive ("C")
ChDir "C:\Users\Anna\Documents\ThesisResearch\Survey"
MsgBox "The current directory is " & CurDir
End Sub

Sub B2Wild()  \Block Two Wild Oysters\

For j = 1250 To 1874

   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1WildConstant1.docx", _
   ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.GoTo What:=wdGoToBookmark, Name:="Number"
   Selection.Font.Bold = wdToggle
   Selection.TypeText Text:=j
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
   OpenAndRepair:=False, _
   DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
   Selection.PasteAndFormat (wdPasteDefault)
   NumA = Rnd(j)
   IDA = Int((10 * NumA) + 1)
   testA = String(IDA, "A")
   Documents.Open FileName:=testA, _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
```

```
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    NumD = Rnd(j)
    IDD = Int((16 * NumD) + 1)
    testD = String(IDD, "D")
    Documents.Open FileName:=testD, _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B2WildConstant2.docx", _
    ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
    OpenAndRepair:=False, _
    DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Next j

End Sub
```

```
Sub SurveyCreation3() ‘Use the correct C drive’
ChDrive ("C")
ChDir "C:\Users\Anna\Documents\ThesisResearch\Survey"
MsgBox "The current directory is " & CurDir
End Sub

Sub B2Cage()    \Block 2 Cage Oysters\

For j = 1875 To 2500

   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B1WildConstant1.docx", _
   ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.GoTo What:=wdGoToBookmark, Name:="Number"
   Selection.Font.Bold = wdToggle
   Selection.TypeText Text:=j
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
   OpenAndRepair:=False, _
   DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
   Selection.PasteAndFormat (wdPasteDefault)
   NumA = Rnd(j)
   IDA = Int((10 * NumA) + 1)
   testA = String(IDA, "A")
   Documents.Open FileName:=testA, _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
   WritePasswordDocument:="", WritePasswordTemplate:="", _
   Format:=wdOpenFormatAuto, XMLTransform:=""
   Selection.WholeStory
   Selection.Copy
   ActiveWindow.Close (wdDoNotSaveChanges)
   Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
   ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
   PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
```

```
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    NumE = Rnd(j)
    IDE = Int((16 * NumE) + 1)
    testE = String(IDE, "E")
    Documents.Open FileName:=testE, _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\B2CageConstant2.docx", _
    ConfirmConversions:=False, ReadOnly:=True, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, XMLTransform:=""
    Selection.WholeStory
    Selection.Copy
    ActiveWindow.Close (wdDoNotSaveChanges)
    Documents.Open
FileName:="C:\Users\Anna\Documents\ThesisResearch\Survey\NewDoc1.docx", _
    ConfirmConversions:=False, ReadOnly:=False, AddToRecentFiles:=False, _
    PasswordDocument:="", PasswordTemplate:="", Revert:=False, _
    WritePasswordDocument:="", WritePasswordTemplate:="", _
    Format:=wdOpenFormatAuto, Encoding:=False, Visible:=True, _
    OpenAndRepair:=False, _
    DocumentDirection:=True, NoEncodingDialog:=False, XMLTransform:=""
    Selection.PasteAndFormat (wdPasteDefault)
    Selection.InsertBreak Type:=wdPageBreak
    Next j

End Sub
```

# Appendix D. Full Survey Results

This appendix presents a summary of the full survey results. The structure and presentation of results parallel the structure of the survey in Appendix A. The question number and instructions are given before the results are presented.

**Section A. In this section we would like to learn what you think are important characteristics of the Chesapeake Bay.**

**Question 1: Important Chesapeake Bay Characteristics**

Please rate how important each of the following Chesapeake Bay characteristics is to you.

| Important Chesapeake Bay amenities | Very Undesirable | Undesirable | Neither | Desirable | Very Desirable | Number of Obs. |
|---|---|---|---|---|---|---|
| Clean Water | 3% | 1% | 2% | 16% | 79% | 852 |
| Healthy Fish Populations | 3% | 1% | 3% | 24% | 69% | 859 |
| Healthy Crab Populations | 3% | 1% | 5% | 22% | 68% | 858 |
| Healthy Oyster Populations | 3% | 1% | 7% | 25% | 63% | 857 |
| Clean and Safe Beaches | 3% | 1% | 6% | 28% | 62% | 855 |
| Healthy Bird Populations | 3% | 1% | 6% | 30% | 61% | 857 |
| Clear Water | 2% | 1% | 6% | 33% | 57% | 856 |
| Healthy Bay Grasses | 3% | 0% | 7% | 33% | 57% | 849 |
| Other | 4% | 1% | 27% | 13% | 55% | 161 |
| Views of Natural Scenery | 2% | 1% | 6% | 37% | 54% | 856 |
| Good Fishing | 3% | 1% | 16% | 35% | 45% | 851 |
| Good Swimming | 3% | 2% | 17% | 37% | 41% | 854 |
| Good Boating | 3% | 1% | 21% | 40% | 35% | 850 |

Examples of what respondents wrote for other:
Cultural heritage, balanced ecosystems, clean air quality, less construction, teach recycling to children

Explanatory note: These characteristics have been reordered to have the most important listed first.

**Section B. In this section we would like to learn if you visit the Chesapeake Bay**

**Question 2:**

| | Yes | No | Number of Obs. |
|---|---|---|---|
| Percent of respondents who visted the Chesapeake Bay | 86% | 14% | 885 |

**Question 3 through 7: How often respondents use specific amenities in the Chesapeake Bay**

| | Never | Once Every Few Years | Once a Year | Once Every Few Months | Once a Month | More Than Once a Month | Number of Obs. |
|---|---|---|---|---|---|---|---|
| 3. Bay Swimming | 48% | 27% | 10% | 9% | 1% | 4% | 783 |
| 4. Bay Fishing | 49% | 25% | 10% | 10% | 2% | 5% | 785 |
| 5. Bay Boating | 44% | 29% | 11% | 9% | 2% | 4% | 784 |
| 6. Viewing wildlife | 18% | 31% | 18% | 18% | 4% | 11% | 785 |
| 7. Bay Hiking | 59% | 21% | 8% | 8% | 2% | 2% | 786 |

**Section C. In this section we would like to learn whether you would support a new program to improve water quality in the Chesapeake Bay.**

**Questions 8 and 9: Prior knowledge of nitrogen pollution in the Chesapeake Bay**

| Did you know farming is the largest source of nitrogen pollution? | Yes | No | Response Rate |
|---|---|---|---|
| | 54% | 46% | 99% |

| Did you know that the Chesapeake Bay has serious water quality problems? | Yes | No | Response Rate |
|---|---|---|---|
| | 79% | 21% | 99% |

**Questions 10 through 12: Willingness to support alternative water quality improvement programs**

| | Not Likely to Support the Program | Somewhat Likely to Support the Program | Very Likely to Support the Program | Number of Obs. |
|---|---|---|---|---|
| 10. Paying farmers to plant tall grasses | 10% | 43% | 46% | 882 |
| 11. Paying to upgrade wastewater treatment plant | 11% | 47% | 41% | 874 |
| 12. Pay for an increase in the oyster population: | 14% | 38% | 46% | |
| A: Paying for oyster restoration efforts | 13% | 36% | 51% | 428 |
| B: Paying oyster aquaculturists | 15% | 41% | 44% | 446 |

Explanatory note: Question 12 is broken into two sections to show the distinction between the "wild" and "cage" survey versions.

**Question 13: Would you support a water quality program with a 55% chance of meeting the target goal and no cost to your household?**

| | No | Maybe | Yes |
|---|---|---|---|
| 55% Chance of meeting water quality target | 8% | 22% | 69% |

**Question 14: Willingness to support a new water quality program with varying chance of meeting water quality target levels**

| Chance of meeting water quality target | Yes | Maybe | No | Number of Obs. |
|---|---|---|---|---|
| 55% | 46% | 36% | 18% | 129 |
| 65% | 47% | 36% | 16% | 192 |
| 75% | 53% | 32% | 15% | 240 |
| 85% | 52% | 32% | 16% | 146 |
| 95% | 57% | 32% | 11% | 145 |

**Choice questions 1 through 8: Response rates for the choice questions:**

| Choice Questions | Number of Obs. |
|---|---|
| 1 | 859 |
| 2 | 850 |
| 3 | 848 |
| 4 | 848 |
| 5 | 863 |
| 6 | 865 |
| 7 | 858 |
| 8 | 860 |

**Questions 15 through 17: Debriefing questions following the choice questions**

| | Yes | No | Number of Obs. |
|---|---|---|---|
| 15. Only No Program | 8% | 92% | 790 |
| 16. Only Program A | 4% | 96% | 760 |
| 17. Only Program B | 3% | 97% | 760 |

Examples of what respondents wrote for justification of picking a certain program:

I choose A in all but one because it had the highest water quality percentage, Want best chance to work, minimal costs with improvements, C/B ratio, the % of success, taxes are too high, we need to do something, highest chance of meeting goal plus lowest cost, everyone has to do their part, I am for what you are doing, other approaches, please plant oysters

**Section D. In this section we would like to learn about your contributions to nonprofit organizations.**

**Questions 18 and 19: Organizational memberships**

| **Member of a CB organization:** | Yes | No | Don't Know | Number of Obs. |
|---|---|---|---|---|
| | 8% | 85% | 4% | 871 |

| **Member of a farm organization:** | Yes | No | Don't Know | Number of Obs. |
|---|---|---|---|---|
| | 5% | 91% | 3% | 875 |

**Question 20: Donations and membership fees to nonprofit organizations (percentile)**

| | Min | 10th | 25th | 50th | 75th | 90th | Max | Number of Obs |
|---|---|---|---|---|---|---|---|---|
| Chesapeake Bay | 0 | 0 | 0 | 0 | 0 | 50 | over 500 | 621 |
| Farming | 0 | 0 | 0 | 0 | 0 | 0 | over 500 | 598 |
| Environment | 0 | 0 | 0 | 0 | 25 | 100 | over 500 | 618 |
| Religion | 0 | 0 | 0 | 250 | over 500 | over 500 | over 500 | 709 |
| Education | 0 | 0 | 0 | 50 | 250 | over 500 | over 500 | 657 |
| Health | 0 | 0 | 0 | 50 | 250 | over 500 | over 500 | 685 |
| Arts/Culture | 0 | 0 | 0 | 0 | 100 | 250 | over 500 | 632 |
| International | 0 | 0 | 0 | 0 | 0 | 100 | over 500 | 593 |
| Other | 0 | 0 | 0 | 0 | 250 | over 500 | over 500 | 391 |

Examples of what respondents wrote for "Other":

State tags, sports, stray pets, police and rescue, shelters, professional

**Question 21, 22, 23 and 24: Reactions to the new program fee**

| Donation Organization | Currently Donate | No Change | Decrease |
|---|---|---|---|
| Chesapeake Bay | 122 | 94 | 28 |
| Farm | 49 | 42 | 7 |
| Enviro | 194 | 169 | 25 |
| Religion | 399 | 373 | 26 |
| Education | 351 | 312 | 39 |
| Health | 359 | 315 | 44 |
| Arts | 229 | 201 | 28 |
| Interational | 109 | 99 | 10 |

Explanatory note: These represent the number of respondents who either did not change or decreased their donations

**Section E. In this section we would like to learn about your consumption of oysters and other seafood.**

**Questions 25, 27, 29 and 30: Oyster and Seafood consumption habitats**

| | Never | Less than once a year | A few times a year | About Once a Month | About once a week | More than once a week | Number of Obs. |
|---|---|---|---|---|---|---|---|
| 25. Consume half-shell oysters | 55% | 15% | 26% | 2% | 1% | 0% | 537 |
| 27. Consume shucked oysters | 52% | 16% | 29% | 3% | 1% | 0% | 533 |
| 29. Consume seafood (other than oysters) | 4% | 3% | 16% | 26% | 36% | 15% | 537 |
| | None | Less than half | About half | More than half | Almost all of it | I do not know | Number of Obs. |
| 30. Consume Ecolabeled seafood | 18% | 8% | 5% | 2% | 7% | 60% | 532 |

**Question 26 and 28: Willingness to pay for oysters having been certified as being grown in the Chesapeake Bay:**

Half-Shell

| WTP Bid | Yes | No | Number of Obs. |
|---|---|---|---|
| $0.10 | 19 | 3 | 22 |
| $0.20 | 17 | 9 | 26 |
| $0.30 | 21 | 8 | 29 |
| $0.40 | 17 | 16 | 33 |
| $0.50 | 18 | 9 | 27 |
| $0.60 | 22 | 18 | 40 |
| $0.70 | 21 | 16 | 37 |
| $0.80 | 17 | 18 | 35 |
| $0.90 | 5 | 9 | 14 |
| $1.00 | 12 | 20 | 32 |
| | | | 295 |

Shucked

| WTP Bid | Yes | No | Number of Obs. |
|---|---|---|---|
| $2.00 | 19 | 6 | 25 |
| $4.00 | 15 | 11 | 26 |
| $6.00 | 17 | 14 | 31 |
| $8.00 | 15 | 19 | 34 |
| $10.00 | 9 | 17 | 26 |
| $12.00 | 17 | 27 | 44 |
| $14.00 | 17 | 20 | 37 |
| $16.00 | 12 | 26 | 38 |
| $18.00 | 3 | 14 | 17 |
| $20.00 | 8 | 25 | 33 |
| | | | 311 |

**Section F. In this section we would like to ask you some questions about your background that will help us compare your answers to those of other people.**

## Questions 31 through 38: Demographic Characteristics

| | Male | Female | Number of Obs. |
|---|---|---|---|
| 31. Gender | 57% | 41% | 882 |

| | Mean | Min | Max | Median | Number of Obs. |
|---|---|---|---|---|---|
| 32. Age | 55 | 18 | 95 | 54 | 833 |

| | Less than 12 yrs | 12 yrs but no HS degree | HS graduate | Some College | Bachelor Degree | Masters or higher | Number of Obs. |
|---|---|---|---|---|---|---|---|
| 33. Education | 3% | 1% | 11% | 26% | 30% | 29% | 875 |

| | Mean | Min | Max | Median | Number of Obs. |
|---|---|---|---|---|---|
| 34. Household size | 3 | 1 | 8 | 2 | 836 |

| Proximity to: | >1 | 1 to 20 | 21 to 40 | 41 to 60 | 61 to 80 | 81 to 100 | 101 to 120 | <121 | Don't know | Number of Obs. |
|---|---|---|---|---|---|---|---|---|---|---|
| 35. Chesapeake Bay | 5% | 15% | 10% | 17% | 16% | 11% | 7% | 6% | 6% | 836 |
| 36. Farmland | 28% | 42% | 12% | 3% | 1% | 0% | 0% | 0% | 7% | 835 |
| 37. Treatment plant | 4% | 57% | 8% | 2% | 0% | 0% | - | 0% | 21% | 833 |

| | Min | Max | Median | Number of Obs. |
|---|---|---|---|---|
| 38. Income | > $5,000 | < $200,000 | $80,000-$89,999 | 771 |

# Appendix E. Permission to use Chesapeake Bay maps

This appendix contains the permission to use the maps from the Chesapeake Bay Program's website. The disclaimer from the CBP website and personal communication with the Program are included. Figures 2.1, 2.10, and 2.11 have been copied and pasted from the Chesapeake Bay Program website at <www.chesapeakebay.net>.

## Chesapeake Bay Disclaimer:

*Information presented on this web site is considered public information and may be distributed or copied. All documents and information may be freely distributed and used for non-commercial, scientific and educational purposes. Commercial use of the documents available from this server may be protected under the U.S. and foreign copyright Laws. Individual documents on this web site may have different copyright conditions that will be noted in those documents. Any communication or material transmitted to this web site by electronic mail or otherwise, including any data, questions, comments, suggestions or the like will be treated as public information.*

## Email Communications with the Chesapeake Bay Program:

Hello Chesapeake Bay Program Personal,

My name is Anna Harris and I am a master's student at Virginia Tech in the Agricultural and Applied Economics dept. I am currently working on my thesis entitled "Willingness to Pay for Alternative Programs to Improve Water Quality in the Chesapeake Bay." Part of the research process involves creating GIS maps of the Chesapeake Bay including land use, wastewater treatment plant locations and counties in Chesapeake Bay watershed. I have found wonderful sources on your website and would like to inquire about using some of the maps available on the CBP website to incorporate into my thesis. Of course I would use proper citation and source information but I wanted to check if there were any copy write issue with using maps for an educational purpose like a master's thesis.
I would appreciate some clarification since I read that not all the information on your website is in the public domain.

Sincerely,
Anna Harris

## Reply:

Anna,

Feel free to use any of the maps posted on our website for your thesis.

See http://www.chesapeakebay.net/termsofuse.htm for additional information.

John Wolf
GIS Team Leader
Chesapeake Bay Program
410 Severn Ave., Suite 109
Annapolis, ND 21403
(410) 267-5739
(410) 267-5777 (fax)
jwolf@chesapeakebay.net

# Appendix F. Permission to use the Marine Stewardship Council

This appendix contains the permission to use the Marine Stewardship's Council logo and confirmation to display it in this document. The disclaimer is from personal communication with the Communications Manager-America at the MSC.

## Email Communication with the Marine Stewardship Council:

To Whom it May Concern,

My name is Anna Harris and I am a master's student finishing up my thesis at
Virginia Tech. I am requesting permission to use the MSC's logo as an example of a seafood ecolabel. I conducted an attribute based choice experiment survey of residents in Virginia to see if they would be willing to pay more for an oyster that had been certified as "having been grown in the Chesapeake Bay." Therefore, I am requesting to use your logo as an example of an existing ecolabel on seafood. I had read over the rules and hope that this request
fits within the established guidelines.

Sincerely,
Anna Harris

## Reply: MSC Non-Commercial Logo Usage Agreement

Thank you for your interest in the MSC. I am happy to grant permission for the display of the MSC ecolabel in your publication as set out below. Please note that the MSC ecolabel is a logo that is trademark protected by law and use of the ecolabel demonstrates your acceptance of the terms in this email.
Please make a new request to the MSC if you wish to use our ecolabel for any purpose other than the one outlined in this email.
Terms of use
Licensee: Anna Harris at Virginia Polytechnic and State University
Position: AAEC Graduate Student
Publication for which logo will be used: Willingness to Pay for Alternative Water Quality Improvement Programs in the Chesapeake Bay.
Date or period of publication/distribution: September, 2009
Email: aharri15@vt.edu
The ecolabel must not be redrawn, distorted or altered in any way from the original master artworks.

Best wishes,
Lisa M. Bailey

Communications Manager-Americas

Marine Stewardship Council