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**RECREATIONAL BOATERS' AWARENESS AND RESPONSES TO
LOW LAKE MICHIGAN WATER LEVELS**

By

Tzu-Ching Chang

A DISSERTATION

Submitted to

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ABSTRACT

**RECREATIONAL BOATERS' AWARENESS AND RESPONSES TO
LOW LAKE MICHIGAN WATER LEVELS**

By

Tzu-Ching Chang

Boating is an extremely important recreation activity and tourism industry in the Great Lakes. In 2001, over 2-million recreation watercraft were registered in Michigan, Wisconsin, Indiana and Illinois. Great Lakes water levels regularly fluctuate and periods of extreme low and high water reduce boating quality and accessibility and negatively impact the boating industry by increasing cost and reducing revenues. While several recent studies have focused on the impacts of low Great Lakes water levels on boating, they did not improve understanding of whether and how boaters incorporate low water as part of their decision making on whether to boat, how much to boat, and where to boat. A better understanding of how low water influences boaters and boating will aid boating agencies and businesses reach decisions on long-term (e.g., locating and re-locating facilities) and short-term (e.g., dredging, boater education) strategies to mitigate the negative impacts of water level fluctuations, which may actually become even more extreme because of climatic changes.

The purposes of this study are to develop and evaluate five LOGIT models designed to identify various factors, which influence recreation boaters' awareness and responses to low Lake Michigan water levels. The five LOGIT models focus on factors that influence (1) boater awareness of Lake Michigan water levels, (2) their perceptions

of the extent that water levels had dropped, (3) if concerns relating to low water actually influence boaters and more specifically, (4) whether boaters reduce their amount of boating in response to low water, and (5) if boaters change the locations where they boat because of low water.

The results of the LOGIT models indicate that boater's awareness of water levels is influenced by their socioeconomic characteristics, and also as would be expected on whether and how much they operate their boats on Lake Michigan. Boater's perceptions about the degree to which water levels have dropped are related to the type of boats they own and where they store these boats during the boating season. There is a relationship between the probability that boaters are influenced by the low water and where they store their boats and whether they acquired information about water levels. Boat characteristics and the locations they operate their boats are related to the likelihood they will change their boating locations in response to low water levels. The probability that boaters will change boating locations varies depending on the type of boats they own and the locations where they operate these boats. The probability that a boater will respond to low water by reducing their amount of boating is related to the number of different locations and the number of days they boat.

The results indicate that the LOGIT models can be used to calculate the probabilities of recreational boaters' awareness, assessments, and different coping responses to low water levels given boat types and boater characteristics. This study demonstrates some of the potential benefits of modeling boater awareness and responses to environmental factors, and the need to expand modeling to include other types of environmental factors including water quality, access, aesthetics and crowding.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The Great Lakes including Lake Superior, Lake Michigan-Huron, Lake St.Clair, Lake Erie and Lake Ontario form the largest fresh surface water system on earth, covering more than 94,000 square miles and draining more than twice as much land (The Great Lakes Information Network, 2002). Lake Michigan is the third largest Great Lake, surrounded by four states: Michigan, Wisconsin, Indiana and Illinois. This system greatly affects the way of life, as well as all aspects of the natural environment, from weather and climate to wildlife and habitat. Many outdoor recreational activities and outstanding tourism opportunities are available on and near Lake Michigan.

From 1996 to 2000, the number of registered watercraft in Michigan increased by 5.7 % (National Marine Manufacturers Association, 2001). In 2001, there were 1.1 million watercraft on the Michigan Secretary of State's registration list of which 825,260 were currently registered for operation. It is estimated that registered boaters logged more than 22 million days of boating in 2001 (Planning & Zoning Center, Inc. et al., 2002). Recreational boaters support a major industry that includes boat manufacturers, retailers and builders, marina operators, maintenance services and marine business suppliers. Recreational boating also has a direct connection to sport fishing and accounts for one billion dollars of regional economic impact. More than 600 marinas (public,

commercial, and private clubs) and 450 boat dealerships are in Michigan. A conservative estimate of spending by recreational boaters in 2002 is estimated to be \$2.24 billion including \$860 million on boating trips, \$502 million in annual watercraft spending¹, and \$880 million in boat sales² (Mahoney et al., 2003). Talhem et al. (1998) estimated that local expenditures by boaters who rented seasonal slips in Michigan marinas were about \$7,000 per boat, or \$200 million in Michigan. Lee (1999) estimated that total spending by owners of registered boats was approximately \$635 million on trips in 1998 within Michigan.

The Great Lakes have a close relationship with the economy and lifestyle of those in Michigan, and elsewhere throughout the U.S. which has more than 3,000 miles of coastline and more than 30,000 jobs depend on the Great Lakes-St. Lawrence water transportation system (Kurth, 2002). Lake Michigan's tourism and recreational boating industry is dependent both on water quality and quantity.

Fluctuations in Great Lakes Water Levels and Impacts on Boating

Over the past five years Lake Michigan has experienced lake levels that have approached the all-time recorded low received in 1964. The Great Lakes Environmental Research Laboratory (2001) reported "Lake Michigan and Lake Huron are experiencing the lowest water levels in 35 years. These water levels have adversely affected recreational boaters, marinas, commercial navigation and hydropower" (Sellinger, 2002).

¹ The annual watercraft spending includes the spending on equipment/accessories, marina slip rental fess, repair and maintenance, put-in and haul-out fees, insurance, and storage (off-season).

² The boat sales are the spending by Michigan registered boat owners on new and pre-owned boats in 2002 and include new watercraft and engine sales, pre-owned watercraft sales, and new trailer sales.

From 1997 to 2001, the water levels in Lake Michigan and Lake Huron dropped by 3.4 feet. Although the water levels of Lake Michigan and Lake Huron were lower than those experienced in several decades, the water levels of 1999 through 2001 were still not the lowest experienced during this century and were several feet above a calculated potential extreme low³ (Planning & Zoning Center, Inc. et al.⁴, 2001).

Great Lakes water levels can change seasonally each year and even vary over longer periods. Short-term changes are generally of greater magnitude than the monthly averages. The range of seasonal water level fluctuations from low levels in winter to high levels in summer on the Great Lakes averages 12 to 18 inches. Long-term fluctuations occur over periods of continuous years. Over the last century, the range from extreme high to extreme low water levels has been nearly 4 feet for Lake Superior and between 6 and 7 feet for the other Great Lakes (Keillor, 2002).

Two primary factors, which could cause major changes in Great Lakes water levels, are a long period of heavy or low precipitation and evaporation rates. For example, low Lake Michigan water level during 1999 to 2001 was caused by the natural cycles of precipitation within the watershed and from a combination of factors such as lower precipitation, lower runoff, higher evaporation and higher air temperatures during 1997, 1998, 1999, 2000, and 2001 (The Great Lakes Information Network, 2002).

³ The extreme low water defined by Lake Michigan Potential Damages Study (LMPDS) is projected to be 574.3 feet.

⁴ This study was conducted by Planning & Zoning Center, Inc., department of Park, Recreation and Tourism Resources of Michigan State University and EPIC-MRA and is a partial study of Lake Michigan Potential Damages Study funded by U.S. Army Corps of Engineers, Detroit District.

The quantity and the timing of rain or snow can affect water levels. Water levels rise in the spring when rain combines with melting snow. Therefore, in an average year, each of the Great Lakes receives its peak water supply between March and May. For example, the heavy snow of 1995 and 1996 caused the water levels to reach close to maximum records on most lakes in 1997. From 1998, drought conditions emerged in the Great Lakes and basin and water levels changed from near record highs on each of the upper lakes to their lowest levels in 35 years in 2000 (Sellinger, 2002).

Figure 1.1 illustrates the variability in precipitation that has occurred over the past seven years on Lakes Superior and Michigan-Huron. Precipitation on Lakes Superior and Michigan-Huron provided long-term supplies throughout the system.

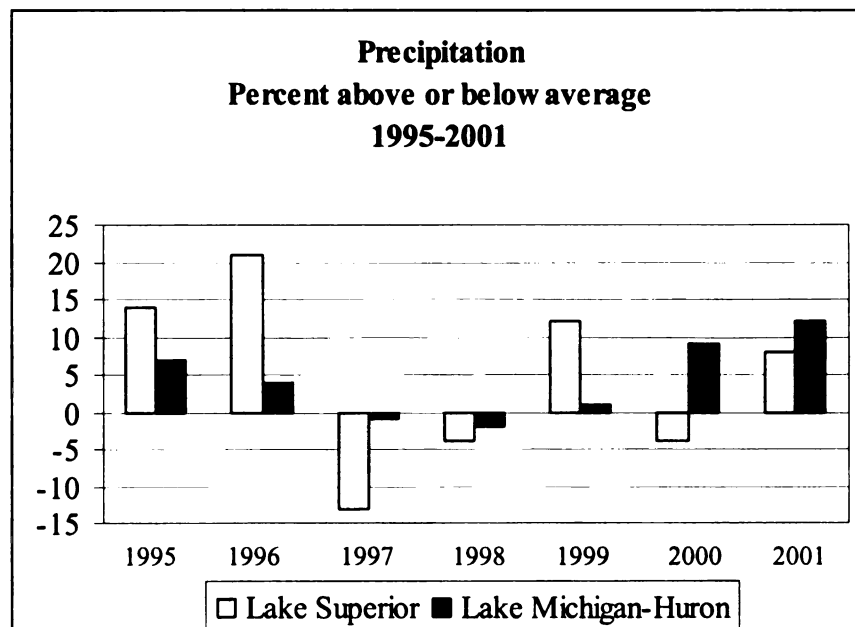


Figure 1.1. The variability of the water precipitation in Lake Superior and Lake Michigan-Huron from 1995 to 2001.

Source: U.S. Army Corps of Engineers, Detroit District, 2002

The other primary factor causing water level changes is evaporation. During the peak evaporation months (September to December), the Great Lakes can lose one to two inches of water per week. Evaporation occurs when cold dry air hangs over the warm lake bodies. The temperatures in summer that warm the lake water affect the rate at which a lake evaporates. When the cool autumn temperatures are over the warmer lake surfaces, evaporation begins in earnest. With the warm air temperatures over the past four years, water temperatures on all the Great Lakes also have been above average precipitation to decrease water levels steadily (U.S. Army Corps of Engineers, Detroit District, 2002).

The fluctuating water levels not only affect to the environment but also the local economy or related business industry such as boating (Planning & Zoning Center, Inc. et al., 2002). For example, the fluctuating water levels can affect the extent of flooding, shoreline erosion and shoreline property damage, wetland acreage, depth of navigation channels, hydroelectric power output, water quality, and aquatic ecosystem. Moreover, both low and high water levels can have significant financial impacts on Lake Michigan businesses and communities such as commercial navigation, recreation boating, marinas, beaches, fishing, cottage, and homeowners.

The Lake Michigan Potential Damages Study (LMPDS) categorized the impacts of low water levels to three types (Planning & Zoning Center, Inc. et al., 2002). First, the potential social impacts could be land use management and shoreline management influence. U.S. Environmental Protection Agency officials reported that falling levels will lead to shifts in currents and depths that may cause some intakes and create problems with water taste, odor and even public health. Second, water level changes can bring the

environmental impacts to archaeological and special natural features, habitat biodiversity, fisheries or threatened and endangered species. Third, there can be the financial impacts on the related recreation boating industry and boating tourism business. For example, extreme fluctuations in lake levels can limit recreational boating (e.g., launch, navigation) because low (or high) water levels may make some areas inaccessible for boat launches and some navigation channels inaccessible to boaters.

Marinas located in the Great Lakes coastal counties spend millions to dredge boat slips, channels, and harbors to sustain the use, but may still lose customers. For example, during 1999 and 2000 private boat owners were affected through reduced use of their boats because of loss of access to some marina slips, and fewer boat launching opportunities at public ramps (Planning & Zoning Center, Inc. et al., 2001). Not only private marinas, but also federal harbors located at the mouth of a river or along a coastline need dredging to keep the water level deep enough for watercraft. Without dredging, most rivers and harbors would be inaccessible for recreational boating and commercial navigation.

The impacts of low water levels have been of concerns to legislators, recreational boating organizations, and many Lake Michigan communities. Because Lake Michigan has serious erosion problems and was the most damaged lake during the previous high water periods in the 1970s and 1980s, U.S. Army Corps of Engineers started to conduct the Lake Michigan Potential Damages Study (LMPDS) to assess potential damages due to extreme low and high water levels (a range over 9 feet) since 1996. The objective of the LMPDS is to create a modeling procedure to estimate financial effects of lake level changes and related social, environmental, and cultural consequences. The main focus of

the LMPDS is the financial effects and influences caused by low Lake Michigan water levels, which are assessed for residential, commercial, industrial, and institutional uses and include recreational boating, municipal water supply and wastewater treatment, and navigation. The LMPDS only provided information regarding the revenue losses on the marina industry and boat dealers, assessed for Lake Michigan coastal counties in 2000 and 2001 because of low Lake Michigan water levels.

Based on a series of studies from the LMPDS completed in 2000 and 2001, Mahoney et al. concluded that “there is a need for a continuing, coordinated effort to identify and profile Great Lakes marinas and evaluate their vulnerability to fluctuating water levels; better understand Great Lake boater behavior and likely response to changes in boating opportunities; and estimate the financial impacts of different levels of boating activity on local communities” (Planning & Zoning Center, Inc. et al., 2002, p56). Because water levels differ between years and areas, and the boating market and behavior of boaters can change significantly within a year, only data gathered during the same boating season can be used to estimate the potential impacts of low water correctly.

1.2 Problem Statement

Studies conducted by Mahoney et al. (2001 and 2002) for the Lake Michigan Potential Damages Study (LMPDS) mainly focused on the revenue and cost impacts of low water on marinas and boat dealerships. Those included unusable slips, slips that could not accommodate the size boats they were designed to accommodate, dredging, and services such as fueling made inaccessible because their fixed positions were inaccessible

(because of increasingly inadequate water depth in relation to boat draft). That study documented that Lake Michigan water levels (both low and high water) had a negative financial impact on recreational boating.

That study estimated that there would be around \$12 million to \$28 million losses in the 297 marinas⁵, located in the 34 coastal counties, depending on the decrease in Lake Michigan water levels. Some commercial marinas had or were likely to go out of business because of dropping water levels. This situation will further reduce boating access and the availability of support services (Planning & Zoning Center, Inc. et al., 2002, p4). The same study also reported increased repair and maintenance costs related to low water caused damages. Besides the financial impacts on marinas and dealerships, Lake Michigan low water level also affected the use of the boating infrastructure such as boat launch ramps, which was important to sustain the recreational boating industry.

In the 2001 LMPDS report, 24% of mail survey respondents and 18% of telephone survey respondents reported boating more days in 2000 than in 2001. For the boaters who responded boating fewer days, 23% of them cited low water as a primary reason. If Lake Michigan water levels were to drop one, two, or three feet below the 2001 levels, 40%, 60% or 70% of respondents believed that low water would force them to find alternative launch sites. That report not only concluded that decreases of these magnitudes would result in substantial reduction in the number of people who go boating or buy boats but also suggested that the boating industry should consider carefully the

⁵ The estimated number was based on the 297 marinas responding to the 2001 survey. They are also located in Lake Michigan coastal counties in four states. The financial impacts included the financial loss from the unusable wet slips, wet slips that could not handle the size boats they were designed for, dredging cost, damage to docks, piers, break walls, replacement and repairs cost, inaccessibility cost, the cost of new or rebuilt facilities, and other damage/impacts/losses because of low water levels.

perceptions of recreation boaters about low or high water levels (Planning & Zoning Center, Inc. et al., 2002, p60).

While those studies have been useful to the boating industry in helping them win passage of helpful legislation (e.g., low interest dredging loans) and by providing information about the financial impacts in boating and tourism industries, they failed to provide a comprehensive understanding of the impacts of low water levels on recreational boaters. Some boaters who were surveyed were aware of the changing of water levels, but others were very unaware. The behaviors of some boaters were affected or influenced in different ways by low water. Low water induced behavioral changes included boating fewer days, going to different locations or stopping boating. Those are still unresolved aspects, which are also pointed to in the LMPDS conclusion (2002): “There needs to be a continuing coordinated effort to, thus ... better understand Great Lakes boater behavior and likely response to changes in boating opportunities” (Planning & Zoning Center, Inc. et al., 2002, p56).

This study focuses on the questions that have not been adequately addressed or answered in previous studies including (1) what is the awareness and perceptions among recreational boaters of water level changes in Lake Michigan, (2) what boaters are more likely to be affected by low water concerns, and (3) what types and degree of boating behavioral changes are induced by low water levels. Estimation of the potential impacts and influences of fluctuations in Lake Michigan water levels cannot be complete without understanding recreational boaters’ awareness and perceptions relating to water levels, the size and types of boats/boaters most likely to be impacted by low water levels, and the types of behavioral changes induced by low water such as decreased boating activity,

different boating locations, and changing where boats are stored during the boating season.

Purposes of This Study

This study has the following three purposes:

1. Previous lake level studies have only focused on the cost and revenue impacts on boating related business industry such as marinas and boat dealerships. The analyses have focused primarily on supply side impacts and do not provide significant information on the relationships between low water levels and the “demand” for Lake Michigan boating. While impact assessment serves an important purpose, the recreational boating industry and boating agencies also require information on the potential short-term and long-term influences of low water levels (and other environment related factors) on boating “demand.” Projecting the type and range of the potential impacts of future changes in water levels on recreational boating require a more complete understanding of boater awareness and responses.
2. To produce a better understanding of how recreational boaters perceive and assess water levels, and whether and how they adjust their volume of boating days and boating locations as input to the policy, investment and management decisions by public boating authorities and agencies, and the recreational boating industry.
3. This study will provide a more comprehensive and systematic understanding of how boaters change their behaviors due to the changes in the quality and quantity of boating opportunities.

1.3 Study Objectives

Low water levels appear to have negatively impacted boating experiences and impacted boater behaviors. However the extent to which low water levels and boater awareness of water levels influences boater behaviors including how much and where they boat is not well understood. Therefore, this study is intended to test and understand the relationships between low water levels and various boater behaviors including the development of different binary LOGIT models.

Three objectives guide the conduct of this study.

Objective 1: To assess recreational boaters awareness and appraisal of the magnitude of changes in Lake Michigan water levels.

Objective 2: To identify which types of boaters are most likely to be influenced by water level changes and what factors are associated with the extent of the influence of water level changes on various boating behaviors.

Objective 3: To identify the relationships between the possible behavioral changes influenced by water level changes and boat and boater characteristics, boat storage segments and locations and boating days and locations.

1.4 Research Questions

A set of research questions is formulated for each of the three study objectives. These questions are used to determine data requirements and methods of analysis.

The research questions related to objective 1 are: “To what extent are boaters aware of the water level changes in Lake Michigan?” and “How do they assess the degree of water level changes?” These questions are answered by two binary LOGIT models with two different dependent variables: boaters’ awareness and perceptions toward the Lake Michigan water level changes and some independent variables including boater characteristics, boat characteristics, boat storage segments and locations, volume of boating days and boating locations.

The primary question related to objective 2 is “what type(s) of boaters are most likely to be influenced by water level changes?” To answer this question a binary LOGIT will be formulated with “low water influenced their boating behavior” as the dependent variable and boater characteristics, boat characteristics, boat storage segments and locations, volume of boating days and boating locations as independent variables.

The third objective will be accomplished by addressing two related questions: (1) what types of boater behavioral changes (e.g., stopped boating, decreased boating volume, changed boating locations, moved the boat to a different storage location) did change low water levels cause? and (2) does a relationship exist between different types of behavioral changes and boater and boat characteristics? Two binary LOGIT models will be developed to predict the probabilities of different types of behavioral changes for different types of boaters and boats. The possible “behavioral changes in response to low

water levels” are the dependent variables including changing the boating locations and reducing the volume of boating days for two binary LOGIT models. The independent variables are also boater characteristics, boat characteristics, boat storage segments and locations, volume of boating days and boating locations.

1.5 Study Hypotheses

Three different hypotheses are formulated and tested.

Hypothesis 1

Boater awareness and assessment of changes in Lake Michigan water levels are significantly influenced by:

1. Boater socio-economic characteristics: age, education, income, gender, permanent state of residence, and location of permanent residence.
2. Boat characteristics: length and type of their boats and number of years the boat has been owned.
3. Boat storage characteristics: boat storage type, where (state and county) the boat was stored during the boating season.
4. Boating characteristics: whether or not the boat has been operated during the past three years, where it has been operated and the volume of their boating activity.

Hypothesis 2

Boater socio-economic characteristics, boat characteristics (e.g. boat type, length and years owned), boat storage segments and locations, and boating locations and boating volume differences exist between recreational boaters who were influenced and not significantly influenced by the low water levels during the 2001 boating season.

Hypothesis 3

Behavioral changes induced by the low water levels are significantly influenced by boater socio-economic characteristics, boat characteristics (e.g. boat type, length and years owned), boat storage segments and locations, and locations where they boat and boating volume.

1.6 Study Organization

This dissertation is presented in five chapters. Chapter one defines the study problem and research questions and also presents study objectives and study hypotheses. Chapter two provides a review of some relevant literature including a series of statewide boating studies conducted over thirty years and recent studies focused on the impacts of low Great Lake water levels. In addition chapter two also reviews literature relating to development and application of the binary LOGIT model.

The methods used to collect and prepare the data used to specify the binary LOGIT models are described in chapter three including two different survey methods (e.g., study population, sampling procedures, data collection, survey instruments, and response rate). Furthermore chapter three discusses the formation of the variables that

comprise the model, the definition for the dependent and independent variables, and the modeling specifications related to three different study objectives.

Chapter four presents the results of the analyses conducted for each of three study objectives including the hypothesis testing results, the process employed to develop the binary LOGIT models, the specification of the different models, the model parameter estimations and the model evaluations and predictions of boater awareness and perceptions regarding the Lake Michigan water level changes and the influence of low water on different boater behaviors. Chapter five summarizes the study results and applications, discusses the study's limitations, and offers some conclusions and suggestions for future research.

CHAPTER 2

LITERATURE REVIEW

This literature review is divided into four sections. Since water level is an environmental factor, the first section reviews literature relating to how environmental factors influence or impact recreationist's behaviors and demand. The second section focuses on previous studies concerning the influences and impacts of low Great Lake water levels on recreational boating and the boating industry. The third section reviews previous Michigan boating studies on such topics as the economic impact (e.g., boater spending) of recreational boating, boating demand and boating patterns. The final section reviews literature relating to the binary LOGIT model with an emphasis on applications related to this study.

2.1 Environmental Factors and Their Influence on Recreation

Behavior/Demand

All people have their own ways of valuing their leisure time and many spend a great deal of it in various recreation environments. A growing number of persons are opting to live in 'planned recreational communities,' which provide them with tennis courts, swimming pools, tennis courses, and even boating and skiing in certain cases (Fisher et al., 1984). The environment in which we live influences our perceptions, attitudes or values about the environment, and the changes in the recreation environment

also influence our recreational choices and behaviors (Garden & Stern, 1996). Hanson and Hatch (1998) found that a one-foot reduction in water level in the Apalachicola-Flint-Chattahoochee River basins would result in a significant decrease in annual recreational visitation frequency (Hanson, 1998; Hanson & Hatch, 1998). A linear model created by MacGregor (1988) identified the change in boating activity related to sediment accumulation in a lake and estimated that the total value loss across all 46 of Ohio's state park lakes was over \$470,000 (MacGregor, 1988).

When studying the impact of changes in the recreation environment, psychologists frequently focus on identifying and describing the relationships between behavior and environment (Fisher et al., 1984). Conversely, economists tend to focus on how changes in the environment impact the supply of recreational opportunities and as a result on the behaviors of recreationists (Fisher et al., 1984). The following literature that is reviewed relates to how changes in the environment influence recreational behaviors.

Changes in Great Lake water levels and understanding boater sensitivities and adaptive responses are definitely related to environmental psychology. The main focus of environmental psychology is to understand better the relationships between people and their physical environment (Weigel, 1983; Howell & Laska, 1992). Heimstra and McFarling (1978) defined environmental psychology as the discipline that is concerned with the relationships between human behavior and the physical environment. Bell et al. (2001) defined environmental psychology as the study of the relationships between behavior and experiences and the built and natural environments.

The field of environmental psychology is extremely broad including identifying people's environmental perceptions, cognitions, and attitudes, the theories of environment-behavior relationship and evaluation of people's response to environment changes (Fisher et al., 1984). Current themes with the environmental psychology research include the topics about awareness and attention, perceptions and cognitive maps, preferred environments, environmental stress and coping, participation, and conservation behavior (Evans et al., 1982; Kaplan & Kaplan, 1982; Garling & Golledge, 1993).

A major field of environmental psychology involves the study of environmental awareness and attention, and assessments and perceptions. Since environmental awareness study is to understand human behavioral, it needs to start with understanding how people notice the environment (Sommer, 1972). The environmental perceptions study is to understand how people picture the natural environment and the environmental changes.

Among the factors, which may affect environmental perceptions, include personal characteristics (perceptual ability and experience), cultural and environmental effects and other effects on environmental experience. A number of studies have investigated the relationship between socio-demographic factors and differences in opinion and attitudes toward the environment (Samdahl & Robertson, 1989; Arcuy & Christianson, 1990; Lyons & Breakwell, 1994). Van Liere and Dunlap (1980) proposed some hypotheses about the determinants of environmental concern including age, social-class, residence and gender hypothesis.

Sometimes the “environment” is considered as a factor in shaping behavior in terms of a one-way cause. For example, the cause-“low water levels” has an effect on the boating environment, which might influence boaters’ behaviors. Environmental psychologists suggest that it is important to study the interrelationship of cause/effect/influence more carefully. On the other hand, most environmental psychologists argue that behaviors are not determined only by environmental factors, and people can change the way they behave or the environment in which they live, work and play (Bell et al., 2001; Tolley, 2001). For example, many boaters have the capability to change the locations where they boat if factors in the boating environment change (e.g., low water levels change the quality of the boating environment). Recognizing this fact boating business including marinas can invest in mediating low water effect through the dredging and the design of facilities and services.

Five basic assumptions underlie a significant number of environmental psychology studies and articles: (1) different groups are affected differentially by various environmental influences, (2) environmental factors have differential effects and varying extent of influence, (3) many environmental influences are unconscious, (4) representation involves mental ‘images’ and (5) space and place have different symbolic meanings for people (Tolley, 2001). For example, low water may be differentially perceived by different boaters depending on how often they boat, where they live (e.g., near the Great Lakes), or where they boat (e.g., Lake Michigan, inland lakes or other Great Lakes). Even though fluctuating Great Lake water levels have gathered a great deal of media attention, some boaters have been immune to this information and remained unaware of the extent or location of low lake levels. In other cases, boaters and

non-boaters alike form perceptions of low water (e.g., severity, impacts) over time, and often subliminally.

It is frequently difficult to determine precisely the behavioral changes that are caused by changes in the environment due to a number of intervening factors. One difficulty is where and what do we want to attempt to measure. Also the problem of representativeness is present. Real behavior happens in real time, and many behaviors are often very transient (Garden & Stern, 1996).

Three types of research methods used to conduct the environmental psychology research are: (1) experimental research (Veitch & Arkkelin, 1995; Bell et al., 2001), (2) correlation research (Bell et al., 2001), and (3) descriptive research (Fisher et al., 1984; Fransson & Garling, 1999; Bell et al., 2001). The method used in this study is correlation and descriptive research. Correlation research is to identify the relationship between situational variations and some other variables. Descriptive research is to report their characteristics or reactions in a particular situation or any environmental changes. Environmental psychologists usually use descriptive research to report reactions that occur in a particular situation. Environmental psychologists often rely on descriptive research in an attempt to identify behaviors in response to specific environmental changes. According to Fisher et al. (1984), descriptive research is common because it is not constrained by a need to infer causality or association, and it can often be generalized to other settings.

Modeling Recreation Substitutes

Descriptive research has certain advantages, but only describes and does not explain why recreationists (e.g., boaters) react in certain ways to changing environmental factors. The field of recreation modeling is developed in an effort to understand how recreationists respond to changes in recreational opportunities and environmental attributes.

A basic assumption underlying most recreation modeling is that individuals (e.g. a recreational boater) will seek to maximize the utility (value) derived from a set of possible recreational choices (Siderelis, 1995). Loomis (1995) contends that recreational utility may be affected by environmental factors that comprise the attractiveness of a recreation destination and attractiveness is a function of factors such as air quality, water quality and clarity, degree of naturalness, abundance of fish and wildlife, forest cover, etc.

If factors that comprise a recreational destination /location are diminished or taken away, recreationists may (if substitute locations/sites are available) adjust their behaviors (e.g., selection, number of visits) to maximize their utility. Iso-Ahola (1986) proposed a theory of substitutability – the tendency to substitute one recreation activity or location for another. The two primary substitution determinants are an individual: (1) perception or analysis of a reason (e.g., low water levels) for a substitution, and (2) perception or analysis of the qualities (e.g., attributes, benefits) of the leisure activity or location to be replaced compared to the available alternatives (Iso-Ahola, 1986). Thus, the first step in modeling recreational choice is to determine awareness or perception of

possible reasons to consider substitutes. The next step is to determine tendency or willingness to make a substitution decision.

According to Loomis (1995) the quality of the natural resources and environments can influence recreation choices and behaviors including: (1) participate or not participate, (2) where to recreate - site selection, (3) trip frequency, and (4) length of stay. Extending this to lake level fluctuations suggests that if boaters are aware of the magnitude and implications lake level fluctuations, this factor can influence them to stop boating, change their boating locations, and reduce the amount of boating.

Decisions whether to participate in a recreation activity, or to visit a particular recreation site, is frequently modeled as a “*zero (not participate or visit)–one (participate or visit) variable.*” A commonly used zero-one (dependent variable) model is the binary LOGIT or PROBIT model (Hof & Kaiser, 1983; Peterson et al., 1983; Stynes et al., 1984; Loomis, 1995; Lupi et al., 2000). The dependent variable in a LOGIT or PROBIT model is “one” for a decision to participate or visit, and “zero” for decision not to participate or visit. The independent variables often include personal characteristics such as physical ability, attitudes, preferences, and incomes (Loomis, 1995). When it comes to modeling recreational site/location choices, conditional or multinomial LOGIT models are usually used given that recreational site/location choices commonly involve more than two possible alternatives (Morey, 1991; Loomis, 1995; Sidererlis, 1995; Lupi et al., 2000).

Loomis (1995) developed a model for predicting trip frequency decisions based on a Travel Cost Model. The purpose is to observe how trip frequency changes in relationship to site characteristics such as visitor facilities, water quality, or wildlife abundance (Loomis, 1995). Contingent Valuation Method is frequently used to assess

the impacts of site attributes on recreational use behaviors. Hanson and Hatch (1998) developed a regression equation-relating to how water level changes on Lake Martin impacted users. The result showed that a one-foot reduction in water level would cause a decrease in annual visitation frequency per person of 4.486 days (Hanson, 1998; Hanson & Hatch, 1998). The problem was that a low R^2 value indicated that individual response varied greatly.

Summary

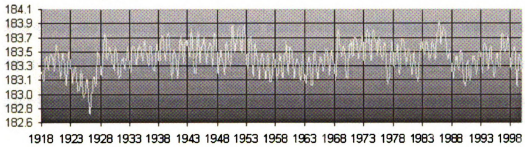
According to environmental psychology and the substitute theory of recreation behavior, the recreational user's choice/behavior is influenced by the recreation resources and environment quality. Thus the Great Lakes have a close relationship with tourism and recreational boating industry. Furthermore the Great Lakes water quality and quantity will influence the recreation boating industry and boaters' behavior. The following section of this chapter clearly identified low water level problems caused financial impacts and revenue losses to the boating business industry because of the losses of their consumers (recreational boaters).

2.2 Studies of Fluctuating Great Lakes Water Levels

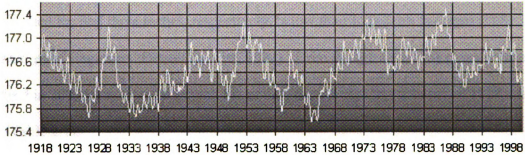
Fluctuations in Great Lake water levels, both high and low level, come in cycles but not in regular or predictable cycles (Keillor, 2002). In the twentieth century, high water levels were first experienced in the 1950s. Two other high-water periods occurred during 1973-74 and 1985-86 on the Great Lakes. Besides Great Lakes, some other areas such as Lake Minnetonka, are experiencing the low water levels simply because of climate changes. The Twin Cities area, as of April 27th (2003), has only received 4.12 inches of precipitation, compared with 8.36 inches during the same period last year and the low precipitation cause the water level in Lake Minnetonka drops below 928.6 feet above sea level. Also southwestern and eastern Ontario have experienced lowest surface water levels and driest soils recorded for several decades because of the extended periods of low rainfall and high temperatures in recent years (Ontario Ministry of Natural Resources, 2002).

Figure 2.1 provides a historical record of water levels for Lake Superior, Lake Michigan-Huron, Lake St. Clair, and Lake Erie from 1918 to 1998 (U.S. Army Corps of Engineers, 2002). It shows that the high water levels occurred coincidentally in all Great Lakes during the same periods. Low water levels occurred at different times in the various Great Lakes. For example, on Lake Superior, the low water level occurred around 1926 to 1927. Low water levels occurred on Lake Michigan during 1926-1927, 1933-1938, 1963-1965, and 1999-2001. Lake St. Clair experienced low water in 1924-25 and 1934-35. Lake Erie experienced low water in 1934 to 1935. Overall, the historical record of water level indicates that low water is a more common occurrence for Lake Michigan.

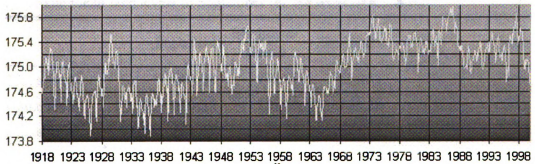
Lake Superior



Lake Michigan-Huron



Lake St. Clair



Lake Erie

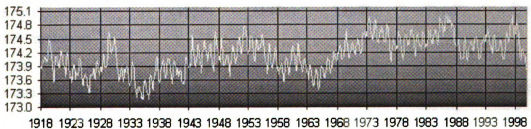


Figure 2.1. The water levels on the Great Lakes from 1918 to 1998.

Source: U.S. Army Corps of Engineers, Detroit District, 2002.

Table 2.1 reports water levels on the Great Lakes for 2000, 2001 and 2002. The table also shows the historical maximum high water level and minimum low water levels from 1918 to 2001 for the Great Lakes. Water levels during 2001 and 2002 were not as low as the historical low water level but were lower than the average levels from 1918 to 2001. Great Lakes water levels were significantly higher in 2002 than in 2001. Lake Michigan-Huron and Lake St. Clair are eight or to ten inches above the levels in 2001, but remained ten and three inches, respectively, below their long-term averages (U.S. Army Corps of Engineers, Detroit District, 2002). Even though Great Lakes water levels increased in 2002, they were still much lower than the average levels between 1918 and 2001 (Table 2.1).

Table 2.1. The mean lake levels in September for the five Great Lakes.

	Superior	Michigan-Huron	St. Clair	Erie	Ontario
2002 lake level*	601.84	578.89	573.62	570.73	244.39
2001 lake level	601.38	577.53	573.26	570.28	244.52
2000 lake level	601.67	577.85	573.91	571.19	245.43
History maximum **					
Level	603.38	582.35	577.30	573.95	246.78
(Year)	(1958)	(1986)	(1986)	(1986)	(1945)
History minimum **					
Level	600.72	576.44	571.75	568.57	242.49
(Year)	(1926)	(1964)	(1934)	(1934)	(1934)
Average lake level **	602.13	579.04	575.09	571.10	244.78

* The lake levels are measured in feet.

** The lake level of history maximum and minimum and average is for period 1918 to 2001.

Source: U.S. Army Corps of Engineers, Detroit District, 2002

The expected Great Lakes water levels in 2003 are shown in Table 2.2. In that table, the expected water levels (on June 2003) on the Great Lakes, as well as the period-of-record average levels for the Great Lakes, are given in inches above (+) or below (-) Low Water Datum (LWD), which are given on International Great Lakes Datum, 1985 (IGLD 1985¹). According to the expected water level, the Lake Ontario level on June 2003 will keep the same as the level during the 1990 to 1990. The 2003 water levels in Lake Erie, Lake St. Clair and Lake Superior will be higher than the water level of IGLD 1985 but still lower than the level during 1900 to 1990. The Lake Michigan water level on June 2003 is estimated to be almost the same as the Low Water Datum of IGLD 1985.

Table 2.2. The expected water levels in the Great Lakes in 2003.

	Lake Ontario	Lake Erie	Lake St. Clair	Lakes Michigan/Huron	Lake Superior
Period of Record Average Levels (1900-1990) June 5	+34	+31	+27	+22	+7
<i>Expected Levels June 5, 2003</i>	<i>+34</i>	<i>+25</i>	<i>+19</i>	<i>-1</i>	<i>+1</i>
Low Water Datum IGLD 1985	243.3	569.2	572.3	577.5	601.1

Source: U.S. Army Corps of Engineers, Detroit District, 2003

¹ IGLD is International Great Lakes Datum. The IGLD 1985 defined by Great Lake Information Network is 'Because of movement of the earth's crust, the 'datum' or elevation reference system used to define water levels previous within the Great Lakes-St. Lawrence River system must be adjusted every 25 to 35 years'. The current datum was known as the International Great Lakes Datum, 1955 (IGLD 1955). These briefly explain the development and impacts of the revision to this datum, known as the International Great Lakes Datum, 1985 (IGLD 1985). The date, 1985, is the central year of the period 1982-1988 during which water information was collected for preparing the datum revision.

The U.S. Army Corps of Engineers is studying the potential effects over the next 50 years of a wider range of Lake Michigan levels than those experienced in the past 30 years (Planning & Zoning Center, Inc. et al., 2002). The range of fluctuation they are anticipating is 9 feet, which would extend from a low level of 574.3' (still water without storm-induced draw down, IGLD, 1985) to a high level of 583.4'. During the last 30 years the range of fluctuation has been 6.27 feet. The lowest monthly average lake level recorded during the last 30 years (576.05 IGLD 1985 International Great Lakes Datum) occurred in March 1964. The highest monthly average lake level recorded (582.32 IGLD 1985) occurred in October 1986. The all-time-high recorded water level of Lake Michigan (582.64 IGLD 1985) occurred in June 1886.

The Review of Lake Michigan Potential Damages Study

The Lake Michigan Potential Damages Study (LMPDS) is an approximately 10-year initiative aimed at assessing the potential damages (e.g., erosion, water level fluctuations) along all of the U.S. Great Lakes shorelines. In that study, Lake Michigan was chosen to be the first study area, since it had severe erosion problems and was the most damaged lake during the previous high water periods in the 1970s and 1980s (Planning & Zoning, Inc. et al., 2002).

The LMPDS incorporates studies of the influence of water level changes on the boating industry, lake use, community and different economic sectors. Table 2.3 summarized the main focus of those different studies conducted as part of the LMPDS during 2000 and 2001.

Table 2.3. Lake Michigan Potential Damages Study projects in 2000 and 2001.

Year	Conducted by	Major Finding
2000	Christian J. Stewart Consulting	<u>Study region:</u> Grand River at Grand Haven, MI; Lake Macatawa at Holland, MI; Kalamazoo Lake and River at Saugatuck/Douglas, MI; and the Sheboygan River in Sheboygan, WI. <u>Topic:</u> Inventory and mapping of shoreline protection and boating structures in drowned river mouth areas of Lake Michigan by using Arc View GIS.
2000	NTH/WTa Joint Venture	<u>Study region:</u> Ottawa and Allegan counties in Michigan; Ozaukee, Sheboygan and Manitowoc counties in Wisconsin <u>Topic:</u> To develop an assessment of the potential damage to typical shoreline structures due to the changes of lake levels.
2000	W.F. BAIRD & Associates Ltd.	<u>Study region:</u> Lake Michigan harbors especially on Saugatuck county, MI and Manitowoc, WI. <u>Topic:</u> To assess the potential impacts of different (high and low) water level scenarios (as defined by GLERL, 2000) on the maintenance/repair costs for the harbor facilities
2001	Planning & Zoning Center, Dep. of Park, Recreation & Tourism Resources of MSU & EPIC-MRA	<u>Survey:</u> Marinas, boat dealers and charter boats <u>Topic:</u> Economic impact of Lake Michigan water levels on recreational boating and charter fishing in five counties in Michigan and Wisconsin
2001	University of Wisconsin Sea Grant Institute/Lake Information Computer Graphics Facility-University of Wisconsin-Madison	<u>Investigation region:</u> Three Wisconsin counties <u>Topic:</u> Update land use inventory and cover change analysis

Table 2.3. Lake Michigan Potential Damages Study projects in 2000 and 2001 – cont'd.

Year	Conducted by	Major Finding
2002	Planning & Zoning Center, Inc. and Wade-Trim	<u>Study Region:</u> Review the current coastal land use conditions in Michigan, Wisconsin, Illinois and Indiana. <u>Topic:</u> To evaluate whether other land use management measures currently exist in the five prototype counties that should be included in order to reduce the damages and estimate the loss to structures and property because of water level changes
2002	Planning & Zoning Center, Dep. of Park, Recreation & Tourism Resources of MSU & EPIC-MRA	<u>Study Region:</u> Michigan, Wisconsin, Indiana and Illinois. <u>Survey:</u> Marinas, dealership, and recreational Boaters <u>Topic:</u> To estimate the economic impacts of Lake Michigan low water on recreation boating industry including the financial impacts and revenues on marinas and dealerships and also the influence on recreational boaters.

One of the projects involves an assessment of the economic impacts of Lake Michigan water level on the recreation boating and charter fishing industries. The principal investigators are the Planning & Zoning Center, Inc., department of Park, Recreation and Tourism Resources of Michigan State University and EPIC-MRA. As part of the project marinas, dealerships, and charter boats were surveyed in five counties in Michigan and Wisconsin in 2000. The impacts of low water levels on marinas, dealerships, charter boats, and recreational boaters in four Lake Michigan states were estimated and identified in the 2001 study.

Impacts on marinas

Both studies indicates that marinas suffer measurable losses such as unusable slips, dredging cost and/or reduced revenues because of low water levels. In the 2000 studies conducted in five Lake Michigan counties in Michigan and Wisconsin, Mahoney et al. (2001) indicated that low water levels had a negative impact on recreational boating especially a financial effect on Michigan marinas such as a financial loss to marinas in the five study areas of between \$2 to \$4 million, which included the total lost slip revenue, increased dredging costs, and damage to dock and other structures (Planning & Zoning, Inc. et al., 2001). It was estimated that an additional 12” decrease (below 2000 water levels) in water levels would have a catastrophic impact on many of the marinas serving Lake Michigan boaters and this in turn would reduce boat sales and negatively impact local business that sell products and services to boaters including the local tourism industry (Planning & Zoning, Inc. et al., 2002, p.59).

The LMPDS (2002) estimates direct and indirect losses at marinas² located in 34 Lake Michigan coastal counties were around \$12 million in 2001. If Lake Michigan water level were to drop an additional 12” below 2001 water level, the financial impact to those marinas is estimated to be around \$21 million. If Lake Michigan water level were to drop an additional 18” below 2001 water level, the estimated financial impact would be approximately \$28 million. Low water level related damage to boats is substantial, estimated at about \$26 million in 2001.

² The estimate of the direct and indirect losses is based on the 297 marinas identified by that study.

Impacts on public boat launch ramps

As part of the 2002 LMPDS, the Planning & Zoning Center (PZC) visited and assessed all known public boat launch sites located on Lake Michigan in four states. The assessment included 97 boat launch ramps. The assessment determined that fluctuations in water levels significantly impacted on the accessibility of these facilities. In 2001, the 97 boat launch ramps with access to Lake Michigan remained open when water levels were at 577.6'. Based on measurements it was determined that if water levels were to reach a potential extreme low (574.4' IGLD 1998) only 33 ramps would be accessible to Lake Michigan. Conversely, if levels increased to the extreme high water level (583.4' IGLD 1998), only 17 of the 97 boat launch sites that access Lake Michigan would be open. At extreme high water levels, flooding could restrict access to some ramps and marina slips and there might be debris in the water that would represent a risk to boaters. On the other hand, with extreme low water levels, many boat launch ramps and marina slips would not have sufficient water depth to launch and navigate boats to gain access to deeper waters from protected harbors.

According to the report, communities on the west side of Lake Michigan are better to deal with low water level than the communities on the east side because of the better design of the boat ramps in Wisconsin. For example, there were plans for a new, modern ramp to be built in 2001 in Muskegon State Park. Besides ramps with the floating docks used in Wisconsin could be more usable with lower water level than the ramps with the permanent docks.

³ This number is calculated by dividing the total number of 370,000 possible trailer launched boats into the number of open boat launch ramps. The 370,000 trailer boats are the registered watercraft in the Lake Michigan coastal counties in four states and are smaller than 39' in length.

Thus extreme high and low Lake Michigan water levels would make some boat launches unusable and bring the pressure for boaters on boat launches. A decreased number of the available launch sites would require recreational boaters to travel greater distances (higher cost) to find another open launch site or private marinas to launch their boats. As a result, available boat launches and the waters they access will then become more crowded and the quality of recreational experiences may be diminished and pressure on resources may increase (Table 2.4). Overall, high and low water levels are expected to increase the cost of boating.

Table 2.4. Number of boats vying for each ramp in different water level*¹.

Water level	Estimated number for Lake Michigan Launch Ramp Open	Estimated number of boats vying for each ramp
2001 Water Level (577.6' IGLD 1985)	97* ²	3,824
Potential Extreme Low Water Level (574.3' IGLD 1998)	33	11,240
Potential Extreme High Water Level (583.4' IGLD 1998)	17	21,818

*1 The estimated number is based on the boat launch sites located in 34 Lake Michigan coastal counties and an estimate of 370,909 trailer launches boats owners reported using on Lake Michigan in the 34 shoreline counties and calculations based on inspections and measurements taken at boat launch ramps.

*2 This is the actual number according to the investigation result of Planning & Zoning Center.

Sources: Planning & Zoning Center, Inc. (2002)

In addition to making boat launches inaccessible, low and high lake levels will cause structural damage. It is estimated that there will be a loss of structure values for the seawalls/bulkheads in a 50-year period ranges from 10% to 75% for an extreme low lake level and from 75% to 90% for an extreme high lake level (Planning & Zoning, Inc. et

al., 2001). And the range of estimated construction costs for water level changes on Lake Michigan harbor structures will be from \$4,500 to \$1,900 per linear foot according to the design of the structure.

Impacts on recreational boaters

In the 2000 LMPDS, EPIC-MRA found that 29% of recreational boaters, who responded to their telephone survey, cited low water levels as the most important problem confronting boaters. More than 40% of respondents had used their boats less over the two or three years because of low water levels. Boaters were also asked how further drops in water levels would impact their boating. If Lake Michigan water levels were to drop about one, two or three feet, 33%, 86% or 90% of the respondents indicated that an additional drop of 12" would cause them to find alternative launch sites, which would have a major negative financial impact related to a decrease in boating.

The 2001 Lake Michigan Potential Damages Study telephone survey found that 9% of the boaters cited low water as the reason they were boating less in 2001 than during the previous few years ago. The study concluded that low water levels could substantially reduce boating activity because of low water and perceptions of low water related problems. They recommended that the boating industry should carefully consider the perception of recreation boaters about low or high water levels (Planning & Zoning, Inc. et al., 2002, p60). While two LMPDS indicated low water levels have a negative impact on boating, Mahoney (2002) suggested that we still need more information about what types of boater are influenced by low water and what are their potential boating behavioral changes because of low water. Mahoney (2002) went on to suggest that a

future effort to understand better Great Lakes boater behavior and the likely response changes in boating opportunities.

2.3 Previous Recreational Boating Studies

Michigan State University is a nationally recognized leader in the conduct of recreational boating studies. In addition to the low water studies, ten major statewide recreational boating studies have been conducted in 1965, 1968, 1971, 1974, 1977, 1980, 1986, 1994, 1998 and 2001. These studies are described in Table 2.5. In general these surveys collected and provided information on (1) the characteristics of the behaviors of boat owners, (2) boater behaviors and travel patterns, and (3) economic impacts of boating.

Spatial Patterns of Recreational Boating in Michigan

A number of these studies provide information relating to the spatial distribution of recreational boaters and their boating activity. In an earlier study by Chubb and Chubb (1975) and later studies by Talhelm et al. (1986) and Stynes et al. (1995), all provided a description of the spatial patterns of recreational boating. Those studies identified a predominate south-north movement of boaters with many of the boaters in southeast Michigan traveling to the northwest and northeast regions of the state. Also, more boats owned by boaters who live in the southern part of Michigan are stored in northern counties of Michigan.

Table 2.5. Previous Michigan Boating related studies and literature reviews.

Year of study	Conducted by	Major focus & findings
1965	Michigan Waterways Division	1. To provide a description of boating spatial patterns 2. The boats/boaters in the southeast counties of Michigan had highest level of boating use
1968	Department of Park and Recreation Resources of Michigan State University, by Chubb J.E. Oakwood (Thesis)	1. To make recommendations concerning the adequacy of the techniques and methods and to formulate a general planning process 2. More variables should be investigated in connection with determination and projection of demand for boating opportunities and the significance of out-of state as well as in-state boaters should be investigated
1971	Recreation Resource Consultants	1. To provide a description of boating use characteristics and patterns at the time of the studies
1974	Recreation Resources Consultants, By Chubb, M. & Chubb, H	1. To provide a description of boating spatial patterns 2. Boats registered in southern Michigan counties comprised the largest share of recreational boating use
	Warner (Thesis)	1. The analysis of recreational boating expenditures 2. An increase in income, family size, and age of the craft owner had a positive impact on recreational boating
1977	Michigan Waterways Division	1. To provide a description of boating use characteristics and patterns, the boating days and the total number of private and public slips for each county in Michigan
1980	Michigan Sea Grant, By Styne & Safronoff	1. A comprehensive summary of previous boating research and information collected prior to 1980 2. Fishing is the most popular boating activity 3. Southeastern Michigan continues generated the majority of boat days in Michigan

Table 2.5. Previous Michigan Boating related studies and literature reviews – cont'd.

Year of study	Conducted by	Major focus & findings
1986	Travel, Tourism and Recreation Center, Michigan State University, by Talhelm, Jordan, & Holecek	1. To provide a description of boating spatial patterns 2. More populated southern Michigan counties and counties with more boating opportunities located near population centers experienced the highest amount of recreational boating use
1994	Department of Park, Recreation and Tourism Resources, Michigan State University, by Stynes, Wu and Mahoney.	1. To measure patterns of boating activity as a basis for evaluating current and anticipated future needs 2. The northern LP and the straits areas are net importers of boats
	Wu (Dissertation)	1. A system model for estimating recreational boating use in Michigan counties 2. The system models produced estimates of the number of boats in different types of storage, the number of boats kept in Michigan counties, and the number of boat days in destination counties by boat storage segments
1998	Department of Park, Recreation and Tourism Resources, Michigan State University Lee (Dissertation)	1. To provide a description of boating use characteristics and trip expenditures by recreational boaters in Michigan Marinas 2. There were significant differences in both the levels and patterns of use and spending by storage pattern
2001	Planning & Zoning center, Department of Park, Recreation and Tourism Resources, Michigan State University & EPIC-MRA	1. To provide a description of boating use characteristics and the influence of low water on marinas, boat dealers, recreational boaters and boat launch facilities

A considerable variation in the rate of recreational boating participation existed among the registered watercraft owners in Michigan according to the result of the 1974 boating study (Fiske, 1974). A non-linear relationship was found existing between the family income of boaters and boating participation. Among boaters' socio-economic characteristics, income, family size, occupation, and age were significantly correlated with boating participation in one or more county regions in Michigan. In addition to variables relating to socio-economic characteristics, the storage location during the boating season was also found to be significantly correlated with boating participation in certain Michigan counties.

Fiske (1974) also found that boat length as an important factor in public policy concerning the construction of public boat marinas and other facilities because larger boats usually require more care and handling equipment than smaller boats. Moreover Fiske (1974) also concluded that boat type was another significant variable relating to the boating participation. The effect of transportation upon watercraft use was entered as a dummy variable and exhibited a significant influence on boating participation in Michigan. According to previous finding, the boating participation and behavior is influenced by boater's characteristics, watercraft characteristics, boat storage characteristics, and boat transportation (Fiske, 1974).

The variable about surface water acreage of county was identified having a positive correlation with boating participation in “bottom thirty”⁴ origin counties. The value for this variable consisted of the total surface water area contained in each county in selected water categories: (1) natural lakes and ponds, (2) natural lakes with a dam, (3) artificial lakes, (4) artificial ponds, (5) hydro-electric reservoirs, (6) small lakes, and (7) flood control reservoirs.

The 1994 Michigan boating study provided the most current information on statewide boating use at the county level (Stynes et al., 1995). The researchers used survey results including where boats were stored and used, boat registration data, information on seasonal homes and inventory of marina slips to estimate the number and type of boats stored in different counties during the boating season. This information is important because the registration data only includes the residence of the owner, but not where the boat is stored or used during the boating season. The information on boat storage locations was used to produce the estimates of boating days for individual counties by applying segment-specific parameters from the survey to the estimating numbers of watercraft of each type stored in a given county (Stynes et al., 1995, p. E3).

Wu (1995) used the data from the 1994 Michigan boating survey to develop a system of models to estimate the recreational boating use in Michigan counties. The models included a classification model, boat allocation model, a trip generation model, and trip distribution model.

⁴ The “bottom thirty” counties in Michigan include Kalkaska, Lake, Osceola, Oscoda, Missaukee, Arenac, Luce, Alcona, Ontonagon, Otsego, Montmorency, Baraga, Sanilac, Menominee, Gogebic, Ogemaw, Tuscola, Alger, Isabella, Lapeer, Clare, Crawford, Schoolcraft, Huron, Gladwin, Presque Isle, Oceana, Mecosta, Benzie, Iron counties.

Four segments were used as the basis for the system of models because boating use and spatial patterns of use different between boats in different type of storage (Wu, 1995). The four storage segments used in that study were marinas, second homes, waterfront homes and non-waterfront homes, which will be used in this study also. For the classification model, the independent variables used to classify the boat storage type included the characteristics of boats and boat owners: (1) length of boat, (2) type of boat, (3) residence location, (4) ownership of second home, (5) income and (6) age. The type of boat was grouped into inboards, outboards, pontoon boats, and canoes. The location of owners' residence was grouped into seven regions: south-coast region, central coast region, north-coast region, Upper Peninsula and out-of state.

The 1998 Michigan Boating Survey focused on spending patterns of recreational boaters. It was estimated that owners of registered boats spent an estimated \$635 million on trips within Michigan in 1998. A typical boater spent \$23 a day on day trips and \$60 a day on overnight trips, averaging about \$35 per day. Boaters keeping their boats at marinas spent \$76 on boating trips, while at the other extreme boaters storing their boats at waterfront primary homes spent \$20 a day (Lee, 1998, p.108). Wu (1995) found that boats kept at marinas during the boating season generated more in terms of local spending and economic impacts than boaters who kept their boats at permanent residences and trailered to boating locations due in part because bigger boats are generally kept at marinas and spent more money on marina slip rental fee, storage fee, maintenance or service fees.

2.4 The Binary LOGIT Model

This section provides a description of the binary LOGIT model and how to apply the binary LOGIT model to three different study objectives.

Many areas of social science research involve dependent variables with two possible values/outcomes (Wrigley, 1985; Agresti & Barbara, 1986; Cramer, 1991; Powers & Xie, 2000). A dependent variable with two alternatives is called a binary choice, usually represented as “Yes” or “No” or coded as “1” and “0”(Stynes & Peterson, 1984; Ben-Akiva & Lerman, 1985). Such choices are common in recreation research, e.g., whether to participate in a recreation activity, whether to go fishing, and whether to visit a state park. In the case of this study recreational boaters can react to low water problems by continuing to boat or not boat.

In situations with dependent variables having two possible values or outcomes, some problems arise in using a standard regression model (linear model) (Cramer, 1991; Powers & Xie, 2000). The predictions in a linear regression model are unbounded and are not necessarily restricted to (0,1). Thus the error structure will be heteroscedastic and non-normal, which will cause inefficient estimates (Smith & Munley, 1978; Stynes & Peterson, 1984; Cramer, 1991; Gujarati, 1995).

The most widely used binary response models are those using a logit transformation approach (the logistic function) to resolve those problems caused by using a linear regression model (Hosmer & Lemeshow, 2000). With binary dependent variables, the goal is to estimate or predict the probability of success or failure (yes or no), conditional on a set of independent variables (Powers & Xie, 2000). For those

models using logit transformation approach, the larger the value of the index is; the greater the probability that the event (Yes) in question will occur (Cramer, 1991; Powers & Xie, 2000). In this study, events include different awareness (or perceptions) toward water level changes and various reactions (related to three study objectives) to low water level issues. For example, one event would be that boaters reduced the amount of their boating days in response to the low water levels, or they changed locations of boating. A monotonic relationship between the value of the index and the probability of the event occurring can be assumed. Under these assumptions, the “true” probability function has the characteristic shape of a cumulative distribution function (CDF).

The two most commonly used CDFs are the normal (PROBIT model) and logistic (LOGIT model) (Stynes et al., 1984; Cramer, 1991). Since the logistics cumulative density function can closely approximate that of a normal random variable, there is usually little difference in the empirical results produced by the two models. Unless there is theoretical justification for preferring the normal to the logistic cumulative distribution function, the LOGIT model is preferred to the PROBIT model when repeated observations are available (Judge et al., 1980).

Assumptions about the logistic regression

Logistic regression is an often used method in part because it enables the researchers to overcome many of the restrictive assumptions and requirements of OLS regression. First, instead of assuming a linear relationship between the dependents and independents variables, logistics regression is capable of handling nonlinear effects. Second, the dependent variable need not be normally distributed. Third, the dependent

variables do not to be homoscedastic for each level of the independent variables and normally distributed error terms are not assumed. Fourth, logistic regression does not require interval independent variables. Fifth, logistic regression does not require that the independents be unbounded. However there are still some other constraints for logistic regression. For example, the coding for dependent variable should be meaningful such as 1 and 0. Also, the error terms are assumed to be independent (independent sampling).

Another important consideration that must be recognized is that of multicollinearity. To the extent that one independent is a linear function of another independent, multicollinearity will occur in logistic regression. The greater the correlation between independent variables, the more the standard errors of the logit (effect) coefficients will be inflated. High standard errors flag possible multicollinearity. In LOGIT modeling, convergence is usually achieved in 4 or 5 iterations. A general warning is that if the number of iterations exceeds 10 or 15 this may be a signal of multicollinearity in the data set. A result may be relatively high estimated standard errors on the estimation output (Wooldridge, 2000).

The Logistic Function and Logistic Transformation

LOGIT model is based on the logistic function (Equation 2.1) and the logistic curve is shown in Figure 2.2.

$$y = \frac{1}{1 + e^{-(a+bx)}} = \frac{e^{a+bx}}{1 + e^{a+bx}} \quad (2.1)$$

Where y = A dependent variable

x = An independent variable

a, b = The estimated coefficients

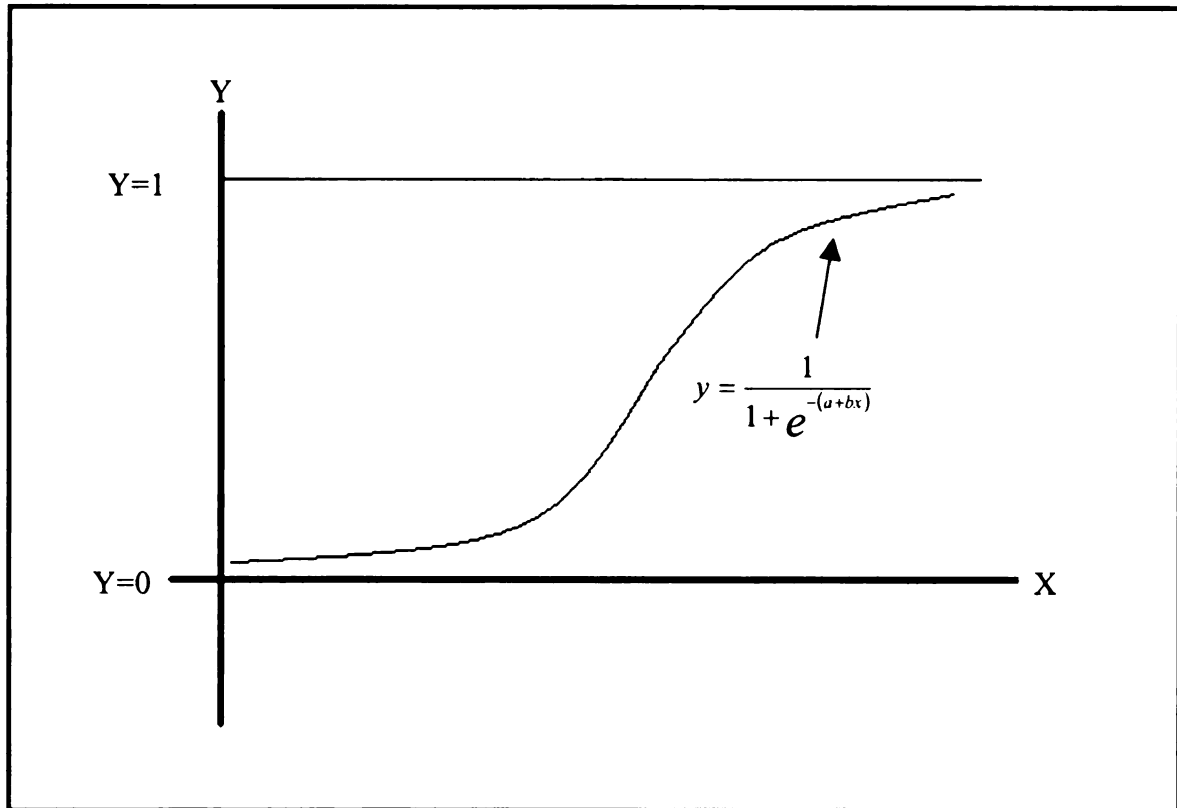


Figure 2.2. The logistic function curve.

The graph shows that the value of “ y ” is bounded asymptotic by approaching 1 and 0 when “ x ” approaches positive and negative infinity, respectively. In the function form, “ y ” is considered as dependent variable and “ x ” is independent variable. The slope of the logistic function (equation 2.2) is directly proportional to the product of the distances to the two asymptotes with b the constant of proportionality and can be used to measure how far about the two distributions are. The slope of the logistic curve is governed by “ b ”, and at the point of inflexion it equals “ $b/4$ ”.

$$dx/dy = by(1 - y) \quad (2.2)$$

Equation 2.1 represents the simple logistic function with one independent variable and two parameters. Frequently often more than one independent variable associated with the dependent variable is present. The multivariate logistic function is written as Equation 2.3.

$$y = \frac{1}{1 + e^{-(a + b_1x_1 + b_2x_2 + \dots + b_nx_n)}} \text{ or } y = \frac{e^{a + b_1x_1 + b_2x_2 + \dots + b_nx_n}}{1 + e^{a + b_1x_1 + b_2x_2 + \dots + b_nx_n}} \quad (2.3)$$

Where y = A dependent variable

$x_1, x_2, x_3, \dots, x_n$ = Independent variables

$a, b_1, b_2, b_3, \dots, b_n$, = The estimated coefficients

LOGIT Models

The logistic function is restricted to the (0,1) interval, which allows it to be used as a probability function and the logistic regression model with using the logit transformation can be converted to a convenient linear form. If we assume the probability (P) of success (yes, $Y=1$) is a logistic function of the set of independent variables (Equation 2.4), the probability of failure (no, $Y=0$) will be “1-P (Equation 2.5).”

$$P = \frac{1}{1 + e^{-(a+b_1x_1+b_2x_2+\dots+b_nx_n)}} = \frac{e^{a+b_1x_1+b_2x_2+\dots+b_nx_n}}{1 + e^{a+b_1x_1+b_2x_2+\dots+b_nx_n}} \quad (2.4)$$

$$1 - P = \frac{1}{1 + e^{a+b_1x_1+b_2x_2+\dots+b_nx_n}} \quad (2.5)$$

Instead of fitting a model for P , we could use the odds of a “success (Yes)” outcome. The odds are defined as the probability of “success (Yes=1)” divided by the probability of “failure (No=0)”. The odds can be a value between 0 to ∞ . The odds are shown in Equation 2.6.

$$odds = \frac{\Pr(Yes)}{\Pr(No)} = \frac{p}{1 - p} = e^{a+b_1x_1+b_2x_2+\dots+b_nx_n} \quad (2.6)$$

Taking natural logarithms of both side of Equation 2.5 yields a linear equation (Equation 2.7). These LOGITs are the log odds of success (yes) vs. failure (no). In addition, they are unbounded and linearly related to the independent variables. Thus by using a logistic function, the probabilities of “Y” can be restricted to (0,1) and also related to the independent variables: $X_1, \dots, X_n$.

$$\log\left(\frac{P}{1 - P}\right) = \log\left(e^{a+b_1x_1+b_2x_2+\dots+b_nx_n}\right) = a + \sum_{i=1}^n b_i x_i \quad (2.7)$$

Estimation from Individual Data: Maximum Likelihood Method

Two basic methods can be used to estimate the LOGIT model. The maximum likelihood method can be used with either individual observation or group frequencies. The weighted least square method uses group frequencies (Stynes et al., 1984). The maximum likelihood method is preferable when, in situations like this study, probability models are estimated from survey data, which provide large samples of independent observations with a wide range of variation of the regressor variables (Berkson, 1953). One advantage of maximum likelihood method is that the parameter estimates can be almost any analytical specification of the probability function, and the result of estimations are consistent and asymptotically efficient, together with ready estimates of their asymptotic covariance matrix (Cramer, 1990). Because the likelihood of the parameters given, the data are defined to be equal to the probability of the data given the parameters, the maximum likelihood estimation can find the parameter value(s) that make(s) the observed data most likely (Berkson, 1953).

Summary

This section reviewed the theory and application of the LOGIT model, which will be used a statistical tool to develop different models for three study objectives. Then the modeling specifications and model evaluation tools for five binary LOGIT models of three objectives will be discussed in the last section of chapter three.

CHAPTER 3

METHODS

Two types of data are used to develop five LOGIT models for three study objectives. For study objective 1, the data from the Lake Michigan Potential Damages Study telephone survey is used to develop two LOGIT models: (1) “Awareness of Lake Michigan Water Level Model” and (2) “Perceptions of the Drop in Water Levels Model”. For study objective 2 and 3, the data from the Lake Michigan Potential Damages Study mail survey is used to develop another three models: (1) “Concerns about Low Water Level Influences Boaters Model”, (2) “Low Water Levels Change Boating Locations” model, and (3) “Low Water Levels Reduce Boating Amount” model. Both surveys are originally designed for the Lake Michigan Potential Damages Study.

This chapter provides a description of (1) the survey methods employed to collect the data that is used to both test and formulate the binary LOGIT models, (2) the formation of the variables that comprise the model, and (3) the specification process for five LOGIT models. The description of the survey methods includes the study population, sampling procedures, data collection, survey instruments and response rate. The model specification section will have descriptions about the definition of dependent variables, the selection of independent variables and model function forms and evaluation tools for model performance.

3.1 Study Population

The study population consisted of recreational boaters, who owned recreational/pleasure watercraft longer than 17 feet that were registered to operate in 2001 in Michigan, Wisconsin, Indiana and Illinois. However, the sampling was weighted to obtain a greater percentage of recreational boaters, who reside or registered their watercraft in 34 Lake Michigan coastal counties (Figure 3.1). Some states like Michigan register boats where their owners permanently reside, others where their boats are stored during the boating season. The 34 Lake Michigan coastal counties are Michigan counties: Menominee, Delta, Schoolcraft, Mackinac, Cheboygan, Emmet, Charlevoix, Antrim, Grand Traverse, Leelanau, Benzie, Manistee, Mason, Oceana, Muskegon, Ottawa, Allegan, Van Buren, and Berrien; Wisconsin counties: Marinette, Oconto, Brown, Door, Manitowoc, Kewaunee, Sheboygan, Ozaukee, Milwaukee, Racine, and Kenosha; Indiana counties: La Porte, Porter and Lake, and Illinois counties: Lake and Cook.

The 2001 registration lists for the four states were obtained with the cooperation of the U.S. Army Corps of Engineers. Information obtained in the four registration lists differed (Table 3.1). All four states provided information about boat length, type of watercraft¹, mode of power², boat use³ and the location of the boat owners' residences. Wisconsin and Indiana also provide information on where the watercraft is kept during the boating season. Recreational watercraft registrations are renewed every three years.

¹ "Type of watercraft" could be open boat, cabin boat, sail boat, houseboat, pontoon or canoe.

² "Mode of power" could be inboard, outboard, in/outboard motorboat, or non-motorized boat.

³ "Boat use" could be for recreational use, commercial use, livery use, fishing use or government use.

Copies of the watercraft certificate application/title form for four states are included in Appendix A, B, C, and D.



Figure 3.1. Lake Michigan counties in the four states.

Table 3.1. Information contained in the watercraft registration lists in the four Lake Michigan states.

<u>Michigan</u>	<u>Wisconsin</u>	<u>Indiana</u>	<u>Illinois</u>
Owner's name	Registration ID	Registration #	Name
Address	Registration status	HULL ID	Address
City	Registration type	HIN verification	City
State	Expiry year	Owners name	State
Zip	Length (feet)	Owner type	Zip code
County code	Length (inches)	Commercial status	County code
Make	County kept	Primary owners name	Boat type
Length (feet)	Hull ID	Primary owners	Propulsion code
Length (inches)	Hull ID verification	Address	Boat length
Hull ID #	Hull make	Primary owners	Manufacturer
Hull code	Make name	Address2	Hull ID number
Propulsion code	Model name	Primary owner city	Registration #
Use code	Model year	Primary owner state	
Type code	Boat type	Primary zip	
Fuel code	Engine type	Primary extended zip	
Filler	Fuel type	Additional owner	
	Propulsion type	Owner county	
	Use type	Storage county	
	Purchase date	Storage address	
	Information disclosure	Storage city	
	Last name	Storage state	
	First name	Storage Zip	
	Initial	Storage extended zip	
	Address	Storage township	
	City	Class	
	State	Purchase date	
	County	Make	
	Zip	Make2	
		Model	
		Model year	
		Length	
		Propulsion	
		Fuel type	
		Hull type	
		Use	
		Type	

3.2 Sampling Procedure

The primary objective of the sampling method for both 2001 Lake Michigan Potential Damages Study mail and telephone surveys that gathered data for this study was to identify a high proportion of boats that could potentially be operated on Lake Michigan. No information on where boats are used is contained in the registration databases and a range of different types and sizes of boats that can be operated on the Great Lakes. Another problem is that not all watercraft contained on the registration lists are currently registered. For example, Michigan's list contains boats whose registrations have been expired for up to three years. These boats cannot legally be operated and therefore were not included in the sampling procedure. Three sampling criteria were established to sample a higher proportion of currently registered recreational watercraft that were likely to be operated on Lake Michigan. First, they must be registered currently and able to operate legally during the 2001 boating season. Secondly, they must be recreational or pleasure watercraft, not commercial or government owned watercraft. Thirdly, the size of a watercraft should be longer than 17 feet, capable of being operated on Lake Michigan, stored or registered in counties near Lake Michigan.

Step 1 of the Sampling Procedure for the 2001 Lake Michigan Potential Damages Study Mail Survey

Registration procedures and databases differ across states. States like Michigan maintain boats with expired registrations in their databases for more than two years in some cases. These boats cannot be legally operated, but the procedure saves the state's

money if the boat owner decides to renew the registration. So, the first step in sampling was to identify watercraft with valid 2001 registrations (Table 3.2). Michigan has a three-year registration so watercraft whose registrations would expire in 2002, 2003 and 2004 were included in the sample. Since the expiration month in Michigan is April, watercraft whose registrations expired in 2001 (April) were not included in the sample since they were not eligible to be operated at the time (June, 2001) the sample was drawn.

The Wisconsin registration database included watercraft with valid registration in 2002, 2003 and 2004. Indiana registration database only included the watercraft that could legally be operated in 2001. Since the expiration month of the watercraft registration in Illinois is August, all watercraft with 2001 registration list were included in the sample because they could be operated for most of the boating season even if their registrations were not renewed.

Table 3.2. Number of the watercraft with the valid 2001 registrations including their expiration year.

	<u>Michigan</u>		<u>Wisconsin</u>		<u>Indiana</u>		<u>Illinois</u>	
	N	%	N	%	N	%	N	%
2001	-	-	-	-	-	-	39,336	9%
2002	286,628	35%	44,712	7%	-	-	130,921	30%
2003	266,305	32%	277,734	46%	-	-	133,820	31%
2004	<u>272,327</u>	<u>33%</u>	<u>281,264</u>	<u>47%</u>	-	-	<u>129,679</u>	<u>30%</u>
Total	825,260	100%	603,710	100%	245,371	100%	433,756	100%

Step 2 of the Sampling Procedure for the 2001 Lake Michigan Potential Damages

Study Mail Survey

The second sampling requirement was that the watercraft had to be recreational and pleasure watercraft but not commercial, livery, dealership or government watercraft. Ninety-five percent of the watercraft on the registration databases for the four states was registered as recreational/pleasure watercraft. Of 825,620 watercraft with valid 2001 registration in Michigan database, 97% were used for recreational or pleasure purpose. Table 3.3 shows the “use type” for the 2001 registered watercraft.

Table 3.3. Type of use of the valid 2001 registered watercraft.

	<u>Michigan</u>		<u>Wisconsin</u>		<u>Indiana</u>		<u>Illinois</u>	
	N	%	N	%	N	%	N	%
Pleasure	801,681	97.1%	587,713	97.5%	243,925	99.0%	424,851	97.9%
Commercial	4,392	0.5%	-	-	-	-	-	-
Boat dealer	3,080	0.4%	900	0.1%	-	-	862	0.2%
Livery	14,790	1.8%	-	-	-	-	-	-
Passenger	696	0.1%	-	-	-	-	-	-
Rental	-	-	14,280	2.4%	-	-	2,488	0.7%
Other	<u>621</u>	<u>0.1%</u>	<u>0</u>	<u>0</u>	<u>1,446</u>	<u>1.0%</u>	<u>5,555</u>	<u>1.2%</u>
Total	825,260	100%	602,893*	100%	245,371	100%	433,756	100%

* In Wisconsin registration list, there were 817 watercraft without 'use type' information.

The sampling procedure resulted in the identification of the 2,058,170 2001 registered recreational/pleasure watercraft (Table 3.4). Michigan watercraft comprised 39% of these watercraft followed by Wisconsin (29%), Illinois (21%), and Indiana (12%).

Table 3.4. Number of the 2001 registered watercraft and recreational/pleasure watercraft.

	Michigan	Wisconsin	Indiana	Illinois	Total
Number of watercraft listed in registration database	1,170,517	603,710	533,924	416,422	2,724,573
Number of the valid 2001 registered watercraft	825,260	603,710	245,371	433,756	2,108,097
Number of the valid 2001 registered recreational (pleasure) watercraft	801,681	587,713	243,925	424,851	2,058,170

Table 3.5 shows how the sample (size) was allocated across states. A total of 2,058,170 recreational/pleasure watercraft in the four states was eligible for sampling. Of these, 3,200 were selected to comprise the sample for the 2001 Recreational Boating Mail Survey. Another sample of 1,870 recreational watercraft owners was interviewed for the telephone survey.

Table 3.5. Number of the valid 2001 registered recreational/pleasure watercraft to be sampled in each of the four states.

	2001 registered recreational watercraft	Percentage of 2001 registered recreational watercraft	Sample size for each state
Michigan	801,681	39%	1,249
Wisconsin	587,713	29%	896
Indiana	243,925	12%	396
Illinois	<u>424,851</u>	<u>21%</u>	<u>659</u>
Total	2,058,170	100%	3,200

Step 3 of the Sampling Procedure for the 2001 Lake Michigan Potential Damages Study Mail Survey

Since the purpose of the study was to determine the impacts of low Lake Michigan water levels on boating, the sampling procedure was designed to select Lake Michigan boaters. The third step was the identification of the valid 2001 registered recreational/pleasure watercraft, which were most likely to be operated in Lake Michigan. The assumption was that boats registered or stored closer to Lake Michigan are more likely to be operated on Lake Michigan than boats registered further away. The complication is that many boat owners trailer their boats to Lake Michigan from inland counties and many owners, who live in inland counties, store their boats on Lake Michigan during the boating seasons. Watercraft less than 40' in length are frequently trailered and launched on Lake Michigan.

To maximize the number of registered recreational/pleasure watercraft that were operated on Lake Michigan, the sampling proportion was stratified to allow for the selection of the higher proportion of watercraft registered or stored in Lake Michigan counties or Lake Michigan adjacent counties and nearby counties. Again, in Michigan and Illinois, the registration data only included the address of the owner. Wisconsin and Indiana registration data included the "during the boating season storage county" address.

Three different sampling zones were established for each state. Zone 1 included all counties that bordered Lake Michigan. Zone 2 consisted of all counties immediately adjacent to Lake Michigan counties. The remaining counties in each of the states comprised Zone 3 (Figures 3.2, 3.3, 3.4, and 3.5).

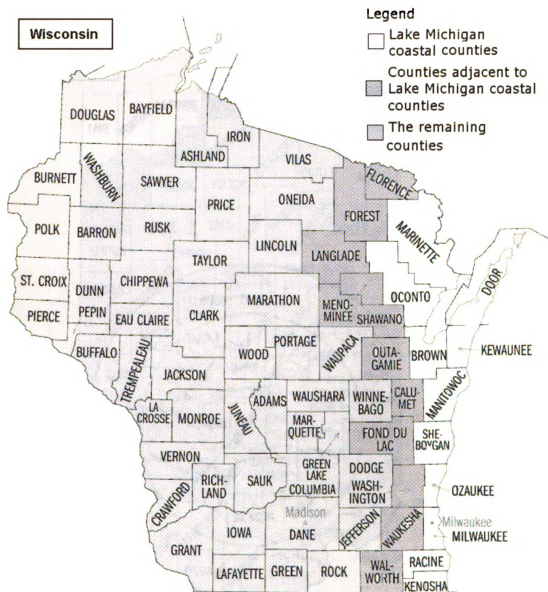


Figure 3.3. Sampling proportions for the three sampling zones in Wisconsin.



Figure 3.4. Sampling proportions for the three sampling zones in Indiana.



Figure 3.5. Sampling proportions for the three sampling zones in Illinois.

In Michigan, half of the valid 2001 registered recreational/pleasure watercraft were registered to persons living in 34 Lake Michigan counties (Zone 1); 25% were registered in Zone 2; and 25% were owned by persons living in Zone 3. The number of the valid 2001 registered recreational/pleasure watercraft sampled in each zone for each state is reported in Table 3.6.

Table 3.6. Number of the valid 2001 registered recreational/pleasure watercraft sampled by county zone and state for the 2001 Lake Michigan Potential Damages Study mail survey.

	Zone 1 ¹	Zone 2 ²	Zone 3 ³	Total	Percentage
Michigan	665	292	292	1,249	39%
Wisconsin	468	214	214	896	28%
Indiana	218	89	89	396	12%
Illinois	349	155	155	659	<u>21%</u>
Total	<u>1,700</u>	<u>750</u>	<u>750</u>	<u>3,200</u>	100%
Percentage	53%	23%	23%	100%	-

1 Zone 1: Lake Michigan coastal counties.

2 Zone 2: All counties adjacent to Lake Michigan coastal counties.

3 Zone 3: The remaining counties.

Step 4 of the Sampling Procedure for the 2001 Lake Michigan Potential Damages Study Mail Survey

The fourth step of the sampling procedure was to stratify the valid 2001 registered recreational/pleasure watercraft in Zone 1, 2, and 3 by boat size. Watercraft under 17' in length were not sampled because they are much less likely to be operated on the Great Lakes. The three (boat) size strata are: 17' to 25', 26' to 39' and over 40'. Table 3.7 shows the results of the stratification sampling including the number of different size

boats in different zones in each of the four states that comprised the final sample.

Watercraft 17' to 25' in length are often trailered to launch sites compared to watercraft bigger than 40', which are normally kept at Great Lakes marinas or waterfront homes.

Watercraft bigger than 40' were sampled at a higher proportion to identify a greater number of watercraft that were operated on Lake Michigan.

Table 3.7. Number of the valid 2001 registered recreational/pleasure watercraft of different sizes in different zones in each of the four states for the 2001 Lake Michigan Potential Damages Study mail survey.

State	Boat Size	Number of recreational watercraft sampled			Total
		Zone 1	Zone 2	Zone 3	
Michigan	17' to 25'	511	266	256	
	26' to 39'	67	23	32	
	40' +	<u>87</u>	<u>3</u>	<u>4</u>	
	Total	665	292	292	1,249
Wisconsin	17' to 25'	378	204	204	
	26' to 39'	45	9	8	
	40' +	<u>45</u>	<u>1</u>	<u>2</u>	
	Total	468	214	214	896
Indiana	17' to 25'	150	83	79	
	26' to 39'	19	2	3	
	40' +	<u>49</u>	<u>4</u>	<u>7</u>	
	Total	218	89	89	396
Illinois	17' to 25'	247	139	145	
	26' to 39'	45	13	8	
	40' +	<u>47</u>	<u>3</u>	<u>2</u>	
	Total	349	155	155	659

Sampling Procedure for the 2001 Lake Michigan Potential Damages Study

Telephone Survey

A similar sampling procedure was used for the 2001 Lake Michigan Potential Damages Study telephone survey conducted by EPIC MRA⁴. The only difference was that larger sized (over 40') watercraft were not over-sampled. The total number of the valid 2001 registered recreational/pleasure watercraft owners was 1,870 boat owners who were interviewed through the telephone by EPIC from December 2001 to January 2002. For the telephone survey, the results of interviewed registered watercraft owners located in each zone in each state are reported in Tables 3.8 and Table 3.9.

Table 3.8. Number of the valid 2001 registered recreational/pleasure watercraft interviewed by the 2001 Lake Michigan Potential Damages Study telephone survey by county zone and state.

	Zone 1 ¹	Zone 2 ²	Zone 3 ³	Total	Percentage
Michigan	298	134	174	606	32%
Wisconsin	230	105	111	446	24%
Indiana	68	69	142	279	15%
Illinois	155	117	267	539	<u>29%</u>
Total	<u>751</u>	<u>425</u>	<u>694</u>	<u>1,870</u>	100%
Percentage	40%	23%	37%	100%	-

1 Zone 1: Lake Michigan coastal counties.

2 Zone 2: All counties adjacent to Lake Michigan coastal counties.

3 Zone 3: The remaining counties.

⁴ Telephone survey was designed and supervised by EPIC MRA, a Lansing-based survey research firm.

Table 3.9. Number of the valid 2001 registered recreational/pleasure watercraft of different sizes in different zones in each of the four states for the 2001 Lake Michigan Potential Damages Study telephone survey.

State	Boat Size	<u>Number of recreational watercraft surveyed</u>			Total
		Zone 1	Zone 2	Zone 3	
Michigan	17' to 25'	266	119	154	606
	26' to 39'	30	13	18	
	40' +	<u>2</u>	<u>2</u>	<u>2</u>	
	Total	298	134	174	
Wisconsin	17' to 25'	203	92	97	446
	26' to 39'	25	13	12	
	40' +	<u>2</u>		<u>2</u>	
	Total	230	105	111	
Indiana	17' to 25'	60	66	141	279
	26' to 39'	6	1	1	
	40' +	<u>2</u>	<u>2</u>	<u>0</u>	
	Total	68	69	142	
Illinois	17' to 25'	141	109	252	539
	26' to 39'	12	7	15	
	40' +	<u>2</u>	<u>1</u>	<u>0</u>	
	Total	155	117	267	

3.3 Data Collection

On October 23, 2001 a six-page questionnaire was mailed to the owners of stratified 3,200 2001 registered recreational/pleasure watercraft that were sampled. A follow-up questionnaire was sent to 3,200 boaters on November 12, 2001 because no identification mark on the returned questionnaires to identify respondents and non-respondents was evident.

Since some of the boat owners owned more than one watercraft, the registration number and size of the sampled watercraft were included on the mailing label to better insure that the owners answered for the sampled watercraft. A postage paid business reply envelope was also included as part of the mailing. The 2001 Lake Michigan Potential Damages Study telephone survey interviewed the owners of 1,870 2001 registered recreational/pleasure watercraft between December 2001 to January 2002.

3.4 Survey Instruments

Many of the questions contained on the 2001 Lake Michigan Potential Damages Study mail and telephone surveys were similar.

The 2001 Lake Michigan Potential Damages Study Mail Survey Instrument

The 2001 Lake Michigan Potential Damages Study mail survey was six pages in length (Appendix E). The first section/page collected information relating to the ownership of the sampled watercraft and boating done during the 2001 boating season. The questions included: (1) whether they still owned the watercraft that was sampled, type and size of the watercraft (confirmation information) and the year they acquired the watercraft and (2) “when and where they operated the boat during the 2001 boating season and if they did not put it in the water, why not? ”

The second section/page focused on the number of days the boaters boated during the 2001 boating season, the location of their boating (states and counties) and the distribution of those days between the Great Lakes including Lake Michigan and inland

lakes and streams. The third section/page of the questionnaire collected information about the location where the owners stored their boats during the boating season (i.e., permanent residence, cottage/second home, marina, or yacht club), type of storage (i.e., on-land, in a dry stack facility, or in the water), what type of water bodies that can be accessed from the storage location (i.e., waterfront site with access to Lake Michigan, waterfront site with access to other Great Lakes, access to an inland lake waterfront site, a river or stream waterfront site), the distance from the storage location to their permanent residence, whether they changed their storage 2000 location and whether low water was a reason for the change of storage location.

The next part/section of the questionnaire emphasized the impacts of low water on boating volume, behaviors and locations. These questions included: (1) trailering and launching the boat (number of launches and locations of launches) and whether they encountered any low water related launching problems, (2) the influence of low water related problems on the volume of boating days and boating locations including if they stopped boating or do more or less boating in certain counties, and (3) whether and how the boaters requested/received any information concerning water levels. The final section/page collected information on the socio-economic characteristics of the registered boat owners such as the location of their permanent residence, their ages, number of adults and children in their families, gross annual income, and number of watercraft they own.

The 2001 Lake Michigan Potential Damages Study Telephone Survey Instrument

The questionnaire for the 2001 Lake Michigan Potential Damages Study telephone survey consisted of 70 questions (Appendix F), which paralleled the questions comprising the 2001 Lake Michigan Potential Damages Study mail survey. In addition, the telephone survey asked more questions relating to boat launch sites including the perceived quality of public launch sites. About half of questions inquired concerning boaters' knowledge and perceptions about water level changes in Great Lakes. Boaters were also asked about their willingness to pay to alternative water level problems, which government agencies should be responsible for addressing the water level problems, agency performance dealing with water level issues and their possible behaviors if water levels fluctuated by certain amounts.

3.5 Response Rate and Data Preparation

The response rate for the mail survey was approximately 50%. The first mailing resulted in 951 returned surveys, which is a response rate of 30%. After the second mailing a total of 1,481 completed surveys had been returned for a response rate of almost 50% (Table 3.10). In Michigan response rate was 57% (the highest of four states) followed by Wisconsin (47%). The lowest response rate (39%) was from Illinois registered boat owners.

There were a host of problems associated with the timing of the survey that lowered the response rate. First, the initial surveys were mailed on October 23, only 45 days after the September 11 (2001) terrorism attacks. This timing not only slowed the

mail but persons were obviously pre-occupied with international issues. As a result, the data collection process took approximately two months compared to the projected one month.

Table 3.10. Response rate to the 2001 Lake Michigan Potential Damages Study mail survey.

	Completed survey	Original sample	Undelivered mail	Delivered sample size ¹	Response rate ²
Michigan	683	1249	52	1197	57%
Wisconsin	405	896	35	861	47%
Indiana	157	396	10	386	41%
Illinois	<u>236</u>	<u>659</u>	<u>58</u>	<u>601</u>	<u>39%</u>
Total	1,481	3,200	155	3,045	49%

1 Delivered sample size = original sample – undelivered mail

2 Response rate = completed survey / delivered sample size

The returned mail questionnaires were coded as they were received using a Microsoft EXCEL program. Response ranges were used to establish valid responses and to identify possible coding errors and outliers. EPIC administered the 2001 Lake Michigan Potential Damages Study telephone survey. They provided an electronic file of their database to this study.

3.6 Definition and Formation of Variables

This section discusses the definitions of boating days and the formation of boater awareness and assessment about the Lake Michigan water level changes and boat storage segments.

Definition of Boating Days

For the purposes of this study, a boating day is any day, which a boat is taken out under power or sail. If the boat is visited (e.g., entertaining, lodging, maintenance) but it is not taken out under power or sail, this does not count as a boating day. On the 2001 Lake Michigan Potential Damages Study mail survey registered boat owners were asked about (1) the number of days the boat had been operated up until the time of the survey and (2) the number of days the boat was likely to be operated in 2001 after they had completed the survey (Question 4, mail survey in Appendix E). Because of the late date of the survey, most owners had completed their 2001 boating seasons and had already stored their boats for the winter. For the small percentage of boaters who planned to continue boating after they had completed the survey, their 2001 boating days were calculated as the sum of the “before and after the survey” boating days.

Formation of Boat Storage Segments

Boaters, who responded to the study provided information on the location where their boats were stored during the 2001 boating season including type of storage (permanent residence, cottage/second home, public marina, commercial marina, condominium slip, and yacht/boat club) and water access from the storage location (Lake Michigan, other Great Lakes, inland lakes, and rivers or streams) (Question 6, mail survey in Appendix E). Storage information is shown in Table 3.11 and Table 3.12

Table 3.11. Types of 2001 boating seasons storage facilities.

	Percent
Permanent residence	52%
Cottage/second home	17%
Public marina	12%
Commercial marina	7%
Owned space in marina/dockominium	3%
Yacht/boat club	3%
Other	<u>6%</u>
Total	100%

Table 3.12. Types of 2001 boating seasons storage access to different waters.

	Percent
A waterfront site with access to Lake Michigan	33%
A waterfront site with access to other Great Lakes	6%
A waterfront site with access to inland lakes	38%
A waterfront site with access to a river or stream	5%
A non-waterfront site	<u>18%</u>
Total	100%

Based on this information, boats were classified into one of four storage segments: (1) marinas, (2) second homes, (3) permanent waterfront home, and (4) permanent non-waterfront home. The same segments were utilized by Wu (1995) to develop recreational boating models. Boats kept at “other” type of storage facilities, and boats with missing storage information were excluded from the analysis. The four segments are (Table 3.13):

1. Marina segment: boats stored at rented space in public marinas and commercial marinas, boats kept at owned slips in commercial marinas, and boats kept in yacht clubs during the boating season.
2. Second home segment: boats kept at cottages or second homes during the boating season.
3. Permanent waterfront home segment: boats kept at permanent waterfront residences during the boating season.
4. Permanent non-waterfront home segment: boats kept at non-waterfront permanent residences during the boating season.

Table 3.13. Boat storage segments from the 2001 Lake Michigan Potential Damages Study mail survey.

	Number	Percent
Marina	328	26%
Second home	225	18%
Permanent waterfront home	525	42%
Permanent non-waterfront home	<u>181</u>	<u>14%</u>
Total	1,259	100%

The telephone survey did not gather information about water access from the storage location (Lake Michigan, other Great Lakes, inland lakes, and rivers or streams). As a result three, not four, storage segments were formed. The three storage segments are shown in Table 3.14.

Table 3.14. Boat storage segments from the 2001 Lake Michigan Potential Damages Study telephone survey.

	Number	Percent
Marina	184	32%
Cottage/second home	52	8%
Permanent home	<u>379</u>	<u>60%</u>
Total	615	100%

Recreational Boater Awareness and Assessment of Changes in Lake Michigan

Water Levels

Objective 1 of this study is to identify how recreational boaters perceive the extent of changes in Lake Michigan water levels. The telephone survey included a question that asked boaters first whether they were aware of Lake Michigan water levels, and if so, they were asked about their perceptions regarding the degree of Lake Michigan water level changes during the previous three years (Question 11 and 57, telephone survey in Appendix F). They were asked to choose from five possible responses about the Lake Michigan water level changes: (1) water levels had dropped a lot, (2) water levels had dropped just a little, (3) water levels had remained the same, (4) water levels had increased a little or (5) did not know (Table 3.15). Thirteen boaters, who believed that the Lake Michigan had increased a little, were excluded from the analysis.

Table 3.15. Recreational boaters' responses about Lake Michigan water level changes.

	Number	Percent
Lake Michigan water levels had dropped a lot	870	52%
Lake Michigan water levels had dropped just a little	182	11%
Lake Michigan water levels had remained about the same	125	8%
Lake Michigan Water levels had increased a little	13	1%
Did not know about the Lake Michigan water level changes	<u>469</u>	<u>28%</u>
Total	1,659	100%

The four responses were grouped into two categories according to their awareness about the Lake Michigan water level changes: (1) The recreational boaters were aware of the water level changes (e.g., water level had dropped a lot, a little, or remained the same) and (2) The recreational boaters did not know about the Lake Michigan water level changes (Table 3.16).

Table 3.16. Recreational boaters' awareness about Lake Michigan water level changes.

	Number	Percent
Recreational boaters were aware of the Lake Michigan water level changes	1,177	72%
Recreational boaters were not aware of the Lake Michigan water level changes	<u>469</u>	<u>28%</u>
Total	1,646	100%

Furthermore, for the boaters who were aware of the water level changes, they were regrouped to two other categories according to their different perceptions about the degree of the Lake Michigan water level changes: (1) Lake Michigan water levels had dropped "a lot", and (2) Lake Michigan water levels had remained the same or dropped

just “a little” (Table 3.17). Awareness of Lake Michigan water level changes and perceptions of the extent of water levels changes were two dependent variables in two binary LOGIT models of objective 1.

Table 3.17. Recreational boaters’ perceptions about the degree of the Lake Michigan water level changes.

	Number	Percent
The Lake Michigan water levels had dropped a lot	870	74%
The Lake Michigan water level had remained the same or just dropped a little	<u>307</u>	<u>26%</u>
Total	1,177	100%

3.7 Statistical Analyses and Specification of the Binary LOGIT Models

Figure 3.6 shows the relationship between each of the objectives and the five binary LOGIT models and also describes the statistical analyses performed and the binary LOGIT models formulated to achieve each of the three study objectives. It also identifies the primary research question relating to each of the objectives and the source of the data used to formulate the binary LOGIT models and on which various statistical analyses are performed. Frequencies and t-tests/chi-square tests are performed as a precursor to the binary LOGIT models.

The sequence of steps employed to formulate and test the binary LOGIT models are graphically presented in Figure 3.6. The binary LOGIT model results in Chapter four will be presented in the same sequence.

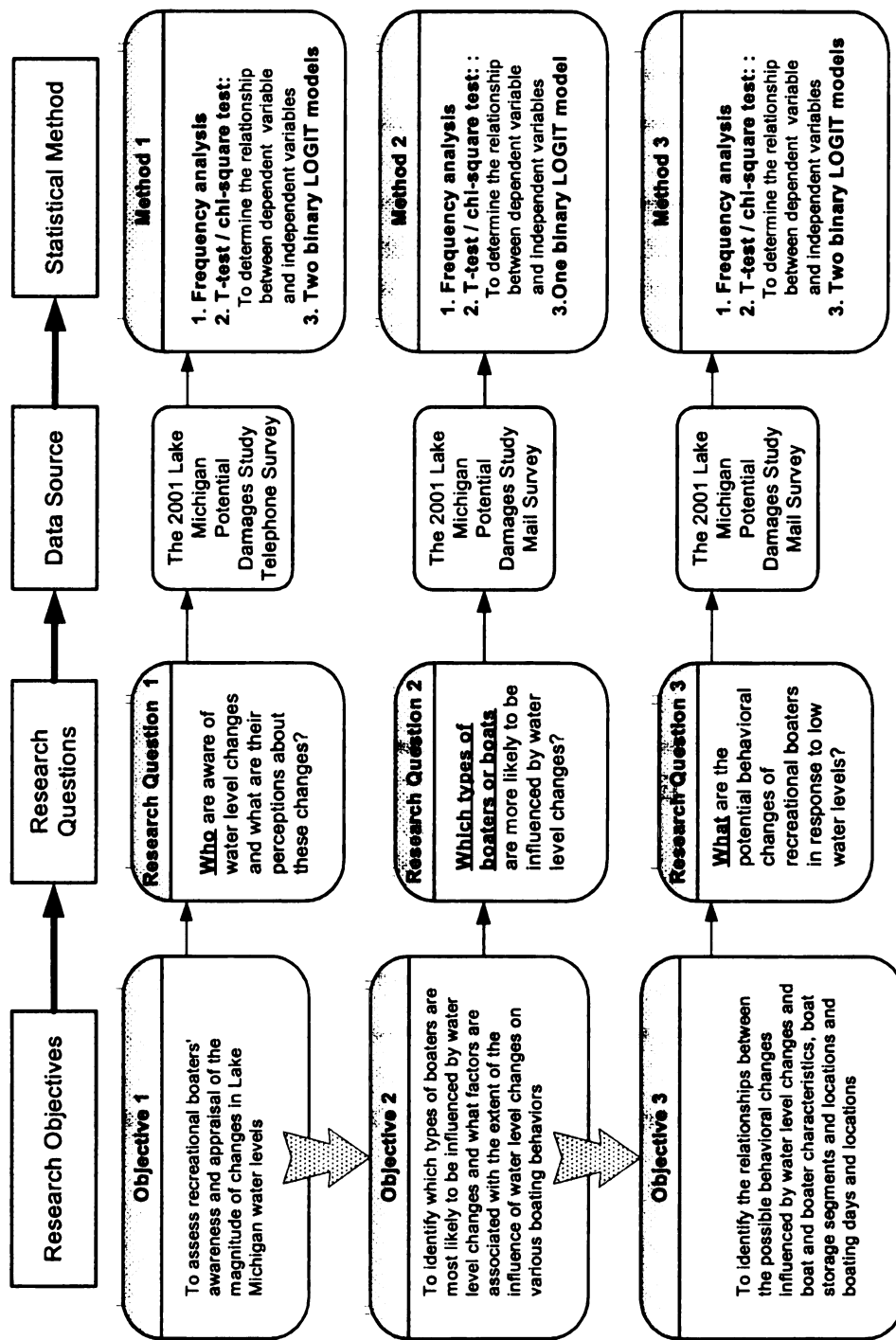


Figure 3.6. The framework of the study.

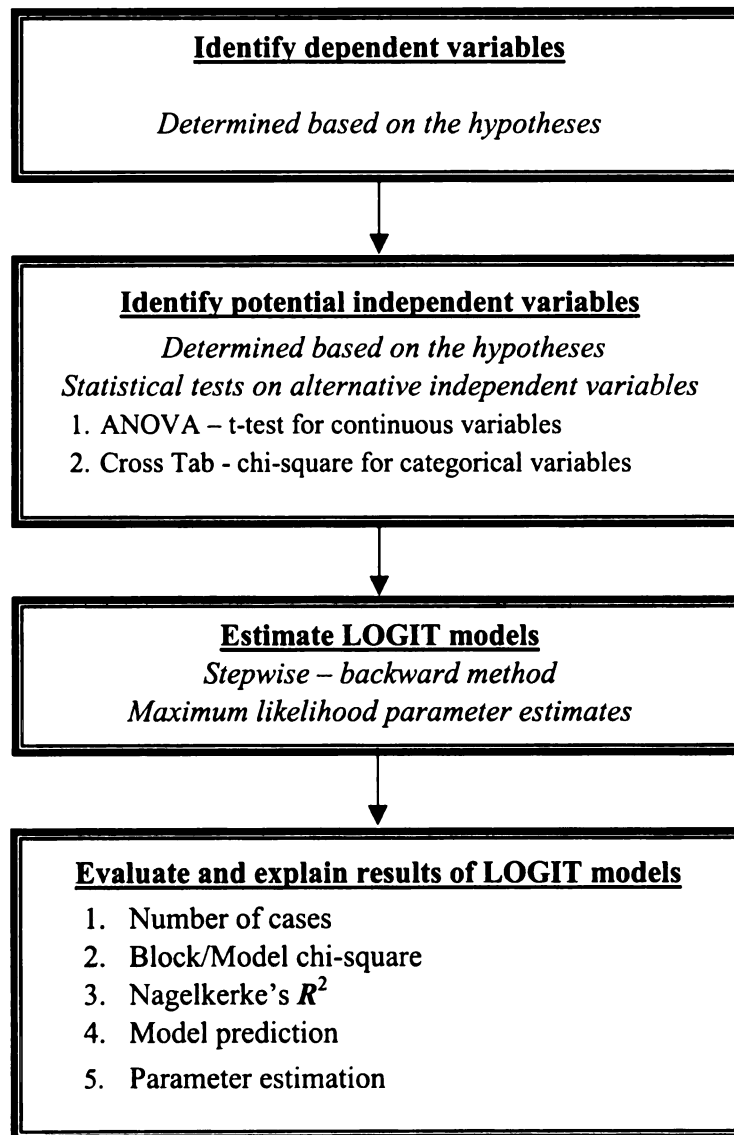


Figure 3.7. The sequence of steps for developing and evaluating LOGIT models.

Identify Dependent Variables

Each binary LOGIT model has a different dependent (dummy) variable. The following five (dependent) variables were recoded as dummy variables shown in Table 3.18.

Table 3.18. The dependent variables for five binary LOGIT models.

	Yes = 1	No = 0	Question Number
<u>Objective 1</u>			
Dependent variable 1	Boaters aware of Lake Michigan water level changes	Boaters not aware of the Lake Michigan water level changes	Telephone survey: Q 11 and Q57: “Based on your experience or what you have heard from others, would you say that Lake Michigan water levels had dropped a lot or remained about the same over the past few years in your usual boating waters?”
Dependent variable 2	Boaters perceived or assessed that Lake Michigan water levels had dropped a lot	Boaters perceived or assessed that Lake Michigan water levels had remained the same/dropped a little	
<u>Objective 2</u>			
Dependent variable 3	Boaters are influenced by concerns relating to low Lake Michigan water levels	Boaters are not influenced by concerns relating to low Lake Michigan water levels	Mail survey: Q 10: “Did low water concerns influence your boating during the 2001 boating season?”
<u>Objective 3</u>			
Dependent variable 4	Boaters changed boating locations in response to low Lake Michigan water levels	Boaters did not change boating locations in response to low Lake Michigan water levels	Mail survey: Q 10b: “Did low water influence the locations where you boated?”
Dependent variable 5	Boaters reduced their boating (days) in response to low Lake Michigan water levels	Boaters did not reduce their boating (days) in response to low Lake Michigan water levels	Mail survey: Q 10a: “Did you do less boating in 2001 because of low water?”

Identify Independent Variables

According to previous boating studies, the boating participation and boaters' boating behavior are significantly related to boater socio-economic characteristic, watercraft characteristics, boat storage characteristics and boat days and locations. Those variables are potential independent variables to develop five LOGIT models and will be determined to enter in different LOGIT models according to the results of the hypotheses testing. Besides the independent variables with category characteristics are recoded as dummy variables to develop the LOGIT models. The description of those independent variables was shown in Table 3.19.

Table 3.19. The potential independent variables for five binary LOGIT models.

Variable name (Category)	Type of data	Question # in mail survey	Question # in telephone survey
<i>Boaters Socio-economic characteristics</i>			
Age	Continuous data	Q16	Q67
Education			
Under college	Category data	NA ^{*2}	Q68
College			
Graduate (Default) ^{*1}			
Income			
Under \$45K (T) / Under \$60K (M) ^{*3}	Category data	Q18	Q69
\$45K to \$60K (T)/ \$60K to \$99K (M)			
Over \$60K(T)/ Over \$100K (M) (Default)			
Gender			
Male (Coded as 1)	Dummy variable	NA	Q70
Female (Coded as 0)			

*1 For the category data, the last category of variable is considered as the reference (default) category.

*2 "NA" means the information is not collected in this survey.

*3 The category for income variable is different in telephone and mail survey. The "T" is referred to the telephone survey. The "M" is referred to the mail survey.

Table 3.19. The potential independent variables for five binary LOGIT models – cont'd.

Variable name (Category)	Type of data	Question # in mail survey	Question # in telephone survey
Permanent state of residence			
Michigan	Dummy variable* ⁴	Q14	Recorded by interviewer
Wisconsin	Dummy variable		
Indiana	Dummy variable		
Illinois	Dummy variable		
Location of permanent residence			
Lake Michigan coastal counties	Dummy variable	Q14	Recorded by interviewer
Next to Lake Michigan coastal counties	Dummy variable		
Other Counties	Dummy variable		
<i>Boat characteristics</i>			
Boat type			
Outboard motor boat	Dummy variable	Q2a	Q5
Inboard-outboards	Dummy variable		
Inboard motor boat	Dummy variable		
Powered sailboat	Dummy variable		
Pontoon	Dummy variable		
Boat length	Continuous data	Q2b	Q3
Number of years the boat has been owned	Continuous data	Q2c	Q4
<i>Boat storage characteristics</i>			
Boat storage type			
Marina	Dummy variable	Q6	Q20
Cottage and Second home	Dummy variable		
Permanent waterfront home* ⁵	Dummy variable		
Permanent non-waterfront home* ⁵	Dummy variable		
Boat storage state location			
Michigan	Dummy variable	Q6	Q18
Wisconsin	Dummy variable		
Indiana	Dummy variable		
Illinois	Dummy variable		

Table 3.19. The potential independent variables for five binary LOGIT models – cont'd.

Variable name (Category)	Type of data	Question # in mail survey	Question # in telephone survey
Boat storage county location			
Lake Michigan coastal counties	Dummy variable	Q6	Q18
Next to Lake Michigan coastal counties	Dummy variable		
Other Counties	Dummy variable		
<i>Boating days and locations</i>			
Number of boating days			
Total number of boating days	Continuous data	Q4	NA
Lake Michigan boating days	Continuous data	Q4d	Q13
Other Great Lakes boating days	Continuous data	Q4f	NA
Boating experiences during the past 3 years			
Operated the boat during the past 3 years	Dummy variable	Q3	Q6
Operated on inland lakes	Dummy variable	Q4d, Q4f	Q7
Operated on other Great Lakes	Dummy variable	Q4f	Q8
Operated on Lake Michigan	Dummy variable	Q4d	Q9
Number of different boating counties	Continuous data	Q4a	NA
<i>Other information</i>			
Requested any information concerning water levels (Yes=1)	Dummy variable	Q12	NA
The boat was trailered to launch (Yes=1)	Dummy variable	Q9	NA
The boater own a waterfront home (Yes=1)	Dummy variable	Q15	NA

*4 The category data is recorded as dummy variable. For example, if the respondent lives in Michigan, the answer is recorded as "Yes=1". If not, the answer is recorded as "0" for No.

*5 The storage types of permanent waterfront home and permanent non-waterfront home are combined in one variable for telephone survey.

Estimate LOGIT Models

Potential independent variables for the binary LOGIT models included: (1) registered boat owner socio-economic characteristics (e.g., income, gender, permanent state and location of residence) (X_1), (2) boat's characteristics (e.g., boat length, type, number of years, the boat has been owned) (X_2), (3) boat storage segments and locations (X_3), (4) volume of boating days and boating locations (X_4) and (5) other information (e.g., requested/received any information concerning water levels, trailing boats) (X_5). A set of hypotheses was tested to determine the significance of the relationship between the different dependent variables and hypothesized independent variables. T- tests were used to test relationships between the dependent variables and the continuous independent variables and chi-square tests were employed to test relationships between the dependent variables and the categorical and dummy independent variables.

Suppose Y is a dummy variable, coded as 1 for the outcome, which the respondents checked "Yes" ($Y=1$) and " $Y=0$ " for the other possible outcome. The probability of a "Yes" answer is equal to p . The probability of a "No" outcome is then equal to $1 - p$. Some explanatory variables (such as $X_1, X_2, \dots, X_5$) are used to explain the probability of the dummy variable (Y). If we assume the probability of an event (such as five dependent variables shown in Table 3.18) occurring ($Y = \text{"Yes"} = 1$) is a logistic function of the independent variable as Equation 3.1. Then the probability of an event not occurring ($Y = \text{"No"} = 0$) is as Equation 3.2.

$$\Pr(Y = 1) = p = \frac{e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_5 X_5)}}{1 + e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_5 X_5)}} \quad (3.1)$$

$$\Pr(Y = 0) = 1 - p = \frac{1}{1 + e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_5 X_5)}} \quad (3.2)$$

Where p = The probability of an event occurring (Y ="Yes"=1)

$1 - p$ = The probability of an event not occurring (Y ="No"=0)

X_1 = The independent variables - socioeconomic characteristics

X_2 = The independent variables - boat characteristics

X_3 = The independent variables - boat storage segments and locations

X_4 = The independent variables - volume of boating days and boating locations

X_5 = The independent variables - other information

β_0 , = Constant

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Model parameters

The odds are defined as the probability of an “event occurring” divided by the probability of an “event not occurring” (Equation 3.3).

$$odds = \frac{\Pr(Yes)}{\Pr(No)} = \frac{p}{1 - p} = e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_5 X_5)} \quad (3.3)$$

Taking natural logarithms of both sides yields a linear equation for the “logits” L.

$$L = \log\left(\frac{p}{1-p}\right) = \log it(p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_5 X_5 \quad (3.4)$$

So these logits are the log odds. The logits L are unbound and can have a linear relationship with those independent variables. Then software - SPSS 11.0 will be used to estimate those logits and odds as the Equation 3.5

$$\log it\left(\hat{p}\right) = \beta_0 + \sum_{i=1}^5 \beta_i x_i \quad (3.5)$$

Where i = An individual recreational boater

$\beta_0, \beta_1, \beta_2, \dots, \beta_5$ = The estimated coefficients from SPSS

Evaluation and Explanation of LOGIT Models

The t-tests and chi-square tests identified a set of independent variables that have statistically significant relationships with five different dependent variables. These served as the independent variables to formulate those five binary LOGIT models. A stepwise- backward method was used to develop the models for two principal reasons. First, a stepwise method is commonly used in situations where little or no previous research exists to base the formation and specification of LOGIT models (e.g., identification of statistically significant independent variables). A stepwise method is also frequently employed in situations where the primary purpose is to determine a model

that fits the data, rather than determining causality (Agresti & Barbara, 1986; Huberty, 1989).

Then it was necessary to decide between either a backward or forward stepwise method. The backward method is preferable to the forward method because of suppressor effects which occur when a predictor has significant effect, but only when another variable is held constant (Field, 2000).

The backward method begins with a model that includes all the independent/predictor variables, which are determined to be statistically related to five different dependent variables. Next, independent/predictor variables that can be removed from the model without substantially reducing how well the model fits the observed data are identified. These variables are deleted from the model sequentially with the first variable removed being the one that least impacts how the model fits the data.

The efficiency and reliability of each of the binary LOGIT models are evaluated by three statistical results: (1) classification table, (2) measures of the proportion of variation explained, and (3) the coefficient estimates of the independent variables (Field, 2000; Long & Freese, 2000). Those four numbers are considered as the “Goodness-of-fit Measure”, which is used to compare alternative models forming in terms of the composite contributions of the independent variables.

The classification table is a simple tool for assessing how well the model fits the data by counting up how many observations the model can predict correctly. The higher the overall percentage of correct predictions the better the model. Besides the value of the percentage of correct predictions provided by the LOGIT model, two other criteria: maximum chance criterion and proportional chance criterion are also suggested to use to

evaluate the performance of model's predictive accuracy (Hair, Anderson and Tatham, 1987). The first one is the "maximum chance criterion", which indicated that the percent of correct classification from the LOGIT model should be higher than the percent of observed group member in the largest group. Another criterion is the "proportional chance criterion", which needs to take into account of the ability of the LOGIT model to classify correctly subjects/objects into smaller group as well as the largest group. Again, the percentage of correct predictions provided by the LOGIT model should be higher than the proportional chance criterion.

For the measures of the proportion of variation explained, SPSS 11.0 produces two numbers: Cox and Snell's R^2 and Nagelkerke's R^2 . Nagelkerke's R^2 is an improvement over Cox and Snell's R^2 that can attain a value of one when the model predicts the data perfectly (Cox & Snell, 1989; Nagelkerke, 1991). For binary choice model with an alternative specific constant, those two R^2 should be between 1 and 0 (Ben-Akiva and Lerman, 1985). Besides R^2 may not achieve value of "1" even when the models predicts all the outcomes perfectly (Field, 2000). The higher the " R^2 " the more the model can explain for the variations in the data.

For the independent variables, the estimated coefficients in the LOGIT models should have a value different from "0" (positive or negative value) for the function to be evaluated to be reliable and efficient. A " β " parameter is derived for each of the binary LOGIT models. An "Odds Ratio" ($\text{Exp}(\beta)$) is calculated by computing the natural logarithm of the " β " parameter. The "Odds Ratio" is an indicator of the changes in odds of an event occurring (e.g., reducing boating days due to low water levels) resulting from a unit change in the independent variable (e.g., boat length, type of boat, boat storage

segment). An “Odds Ratio > 1 ” indicates that the value of the independent variable increases the probability of an event occurring also increases. For example, as boat size increases the probability that low water concerns will influence their boating will increase too. On the other hand, an “Odds Ratio < 1 ” indicates that the value of the independent variable decreases the probability of an event occurring also decreases.

CHAPTER 4

RESULTS

This chapter provides the results of five LOGIT models related to the three study objectives. This chapter begins with a description of the types of data produced from two 2001 Lake Michigan Potential Damages Study surveys described in chapter 3. This includes descriptive analyses conducted on these data. The second section describes the results for “Awareness of Lake Michigan Water Level Model” and “Perceptions of the Drop in Water Levels Model” for objective 1. The third section describes the results for “Concerns about Low Water Level Influences Boaters Model” for objective 2. The fourth section describes the results for “Low Water Levels Change Boating Locations” and “Low Water Levels Reduce Boating Amount” models for objectives 3. The results for five LOGIT models are presented in four stages: (1) hypothesis testing, (2) model specification, (3) LOGIT model parameter estimations, and (4) LOGIT model evaluation and correct prediction.

4.1 Description of Data Obtained from the 2001 Lake Michigan

Potential Damages Study Mail and Telephone Surveys

The 2001 Lake Michigan Potential Damages Study mail and telephone surveys conducted for this study produced the most current information on boating activities and patterns in Michigan, Wisconsin, Indiana and Illinois. The two surveys also produced

information on the characteristics of boaters (Tables 4.1 and 4.2) and registered watercraft (Tables 4.3 and 4.4).

The average age of respondents from the mail survey was around 53 years old. Sixty four percent of registered boat owners, who responded to the mail survey, have at least one child in their households, with an average of two children per household. Two thirds (66%) of registered boat owners who responded to the mail survey and almost 40% of registered boat owners who answered the telephone survey had annual household incomes of over \$60K. A quarter of the mail survey respondents (Table 4.1) owned a permanent waterfront home and almost 20% had a waterfront seasonal home in the state where they register their boats. Sixty percent of telephone survey respondents (Table 4.2) had a college degree. Ninety-one percent of telephone survey respondents are males. The average age of respondents from the telephone survey was around 52 years old. A third (33%) are retired.

Tables 4.3 and 4.4 provide a summary of the characteristics of the registered watercraft owned by respondents to the 2001 Lake Michigan Potential Damages Study mail and telephone surveys. Just 3% of the mail survey respondents own a watercraft less than 16 feet in length and is regrouped in the category of 17' to 20'. This low percentage of small watercraft is a result of the sampling method that deliberately over-sampled larger watercraft. Seven percent of the boats from the mail survey were over 40 feet and one percent of the telephone respondents own a boat over 40 feet. The majority of mail survey respondents owned inboard-outboards. A higher proportion of the telephone survey respondents owned outboard motor boats and this was due in part to the sampling method. Respondents to both surveys owned their boats an average of 7 years.

Table 4.1. Registered boaters who completed the 2001 Lake Michigan Potential Damages Study mail survey.

Variables	Percentage/Mean
Age of registered boat owners	53 years
Number of adults in the household	
1 adults	13%
2 adults	73%
3 or more than 3 adults	<u>14%</u>
	100%
Household with children	
No children	36%
1 child	25%
2 children	25%
3 children or more than 3 children	<u>14%</u>
	100%
Household income	
Under \$60K	34%
\$60K-\$99K	32%
Over \$100K	<u>34%</u>
	100%
State where boat owners' permanent residence is	
Michigan	44%
Wisconsin	24%
Indiana	11%
Illinois	19%
Other states	<u>2%</u>
	100%
Waterfront home	
Own a waterfront permanent home	25%
Own a waterfront cottage or seasonal home	19%
Number of owned watercraft*	
1 watercraft	44%
2 watercraft	30%
3 watercraft	16%
4 or more than 4 watercraft	<u>10%</u>
	100%

* Number of owned watercraft included the watercraft sampled in the mail survey

Table 4.2. Registered boaters who answered the 2001 Lake Michigan Potential Damages Study telephone survey.

Variables*	Percentage/Mean
Age of boat owner	52 years
Educational level	
Under college	40%
College	22%
Higher than college	<u>38%</u>
	100%
Income	
Under \$45K	21%
\$45K to \$60K	40%
Over \$60K	<u>39%</u>
	100%
Employment	
Employed	62%
Unemployed	3%
Retired	33%
Homemaker	<u>2%</u>
	100%
Gender	
Male	91%
Female	<u>9%</u>
	100%

*The response - refused is treated as a missing value in the analysis.

Table 4.3. Characteristics of registered watercraft owned by mail survey respondents.

Variables	Percentage
Boat length*	
17' to 20'	59%
21' to 25'	21%
26' to 39'	13%
More than 40'	<u>7%</u>
	100%
Boat type	
Inboard motor boat	19%
Inboard-outboards	30%
Outboard motor boat	27%
Powered sailboat	8%
Pontoon boat	<u>16%</u>
	100%
Year the watercraft was purchased**	
Earlier than 1985	11%
1986 to 1990	12%
1991 to 1995	18%
1996 to 1998	25%
1999	13%
2000	13%
2001	<u>8%</u>
	100%
Average number of years the boat has been owned	7.41 years
New or pre-owned	
New boat	45%
Pre-owned boat	<u>55%</u>
	100%
State where the watercraft was registered	
Michigan	46%
Wisconsin	27%
Indiana	11%
Illinois	<u>16%</u>
	100%

* The percentage of boat length is not the same as the percentage in the original sample because 10% of the mail survey respondents did not own the sampled watercraft and owned another registered watercraft, which was used to answer the survey.

** This variable referred to the year the watercraft was purchased. It could be either new or pre-owned watercraft.

Table 4.4. Characteristics of registered watercraft owned by telephone survey respondents.

Variables	Percentage
Boat length*	
17' to 20'	63%
21' to 25'	26%
26' to 39'	10%
More than 40'	<u>1%</u>
	100%
Boat type	
Inboard motor boat	13%
Inboard-outboards	34%
Outboard motor boat	37%
Powered sailboat	4%
Pontoon boat	<u>12%</u>
	100%
Year the watercraft was purchased	
Earlier than 1985	19%
1986 to 1990	14%
1991 to 1995	28%
1996 to 1998	21%
1999	10%
2000	4%
2001	<u>4%</u>
	100%
Average number of years the boat has been owned	7.29 years
State where the watercraft was registered	
Michigan	32%
Wisconsin	24%
Indiana	15%
Illinois	<u>29%</u>
	100%

* The telephone survey did not sample the boat smaller than 16 feet. Of all respondents, only 1% did not own the sampled watercraft but owned another registered watercraft. Of 1%, only 1 respondent owned another registered watercraft smaller than 16 feet and was excluded from the analysis.

Although two 2001 Lake Michigan Potential Damages Study surveys were conducted during the same period and had the same sampling frame (owners of currently registered recreational watercraft in the four states), the samples were still different. Statistical tests were first performed to determine any statistically significant differences in the characteristics of telephone and mail survey respondents including their ages, incomes, state of registry, boat length, boat type and number of years the boat has been owned. The results of the statistical tests are presented in Table 4.5.

Chi-square analyses showed that there is no significant difference on the average age of boat owners between mail and telephone survey respondents. Statistically significant differences existed in the income, state of registry, boat length, boat type and number of years the boat has been owned between mail and telephone surveys.

Table 4.5. The comparison between the 2001 Lake Michigan Potential Damages Study mail and telephone surveys.

	Mail	Telephone	χ^2 (df)	<i>P-value</i>
By age				
<29	33%	67%	7.962(6)	0.241
30-39	40%	60%		
40-49	43%	57%		
50-59	43%	57%		
60-65	45%	55%		
>66	<u>43%</u>	<u>57%</u>		
	42%	58%		

Table 4.5. The comparison between the 2001 Lake Michigan Potential Damages Study mail and telephone surveys - cont'd.

	Mail	Telephone	χ^2 (df)	<i>P-value</i>
By income				
Under \$20K	24%	76%	91.906(4)	0.000
\$20 to \$40K	47%	53%		
\$40 to \$60K	45%	55%		
\$60 to \$100K	43%	57%		
Over \$100K	<u>60%</u> 42%	<u>40%</u> 58%		
By state of registry				
Michigan	53%	47%	115.835(3)	0.000
Wisconsin	47%	53%		
Indiana	36%	64%		
Illinois	<u>30%</u> 42%	<u>70%</u> 58%		
By boat length				
17' to 20'	39%	61%	136.774(4)	0.000
21' to 25'	37%	63%		
26' to 39'	49%	51%		
Over 40'	<u>77%</u> 42%	<u>23%</u> 58%		
By boat type				
Outboard motor boat	28%	72%	196.988(4)	0.000
Inboard-outboards	39%	61%		
Inboard motor boat	61%	39%		
Powered sailboat	57%	43%		
Pontoon boat	<u>45%</u> 42%	<u>55%</u> 58%		
By year the watercraft was purchased				
< 1980	32%	68%	189.449(7)	0.000
1981 to 1985	25%	75%		
1986 to 1990	39%	61%		
1991 to 1995	32%	68%		
1996 to 1998	47%	53%		
1999	49%	51%		
2000	68%	32%		
2001	<u>62%</u> 42%	<u>38%</u> 58%		

4.2 Recreational Boater Awareness and Perceptions of Lake Michigan Water Level Changes (Study Objective #1)

This section reports on the analyses employed in the development of two binary LOGIT models developed to explain recreational boaters' awareness and appraisal of the magnitude of changes in Lake Michigan water levels. The models utilized data generated by the 2001 Lake Michigan Potential Damages Study telephone survey. Boaters (1,646) were first organized into two groups based on their awareness of Lake Michigan water level changes. Then the 1,177 boaters, who indicated an awareness of Lake Michigan water level changes, were further divided into two groups according to their assessments about how much Lake Michigan water levels had changed. Potential independent variables included boater and boat characteristics, boat storage characteristics, boating locations and amount/volume of boating days.

4.2.1 Awareness of Lake Michigan Water Level Changes

Of the 1,646 boaters who responded to the 2001 Lake Michigan Potential Damages Study telephone survey, almost three quarters (72%) of boaters were aware of Lake Michigan water level changes.

Hypothesis Testing

The hypothesis is that recreational boaters' awareness of Lake Michigan water level changes is significantly influenced by their socioeconomic characteristics, boat characteristics, boat storage types and locations, their boating activity level (days) or

boating locations during the past three years. Table 4.6 reports the results of hypothesis testing of the relationship between possible independent variables (for the binary LOGIT model) and boaters' awareness of Lake Michigan water level changes.

Statistically significant relationships were found between recreational boaters' awareness of Lake Michigan water level changes and their socioeconomic characteristics including education, income, gender, where their permanent residence is located and their boat's characteristics including type and size.

Owners who have inboards and inboard-outboards are much more aware of changes in Lake Michigan water levels. Large powered sailboats are even more aware of water level changes given that the draft of these boats makes them more susceptible to water level impacts. No statistically significant relationship between lake level awareness and the type of 'during the boating season storage' and location where they stored their boats is present. Their Great Lake boating experiences during three previous years are statistically related to their awareness of Lake Michigan water level changes. As expected, active boaters are more likely to be aware of fluctuations in Lake Michigan water levels.

Table 4.6. Relationships between boater and boat characteristics and boater awareness of Lake Michigan water level changes.

	Aware of LM water level fluctuations	Not aware of LM water level fluctuations	χ^2 / F-value (df)	<i>P-value</i>
Boater characteristics				
Age (Mean)	53	51	2.269(1)	0.132
Education				
Under college	67%	33%	16.62(2)	0.000
College	69%	31%		
Graduate	<u>77%</u>	<u>23%</u>		
	72%	28%		
Income				
Under \$45K	63%	37%	13.81(2)	0.001
\$45K to \$60K	70%	30%		
Over \$60K	<u>76%</u>	<u>24%</u>		
	72%	28%		
Gender				
Female	65%	35%	3.30(1)	0.040
Male	<u>72%</u>	<u>28%</u>		
	72%	28%		
Permanent state of residence				
Michigan	89%	11%	168.4(3)	0.000
Wisconsin	77%	23%		
Indiana	60%	40%		
Illinois	<u>54%</u>	<u>46%</u>		
	72%	28%		
Location of permanent residence				
LM coastal counties	89%	11%	255.5(2)	0.000
Next to LM coastal counties	81%	19%		
Other counties	<u>50%</u>	<u>50%</u>		
	72%	28%		
Boat characteristics				
Boat type				
Outboard motor boat	68%	32%	21.1(4)	0.000
Inboard-outboard	75%	25%		
Inboard motor boat	73%	27%		
Powered sailboat	90%	10%		
Pontoon	<u>66%</u>	<u>34%</u>		
	72%	28%		

Table 4.6. Relationships between boater and boat characteristics and boater awareness of Lake Michigan water level changes – cont'd.

	Aware of LM water level fluctuations	Not aware of LM water level fluctuations	χ^2 / F-value (df)	<i>P-value</i>
Boat length	22	20	6.43(1)	0.010
Number of years, the boat has been owned	7.4	7.0	1.48(1)	0.255
Boat storage characteristics				
Boat storage type				
Permanent home	61%	79%	2.269(2)	0.433
Cottage and second home	9%	0%		
Marina	<u>30%</u> 72%	<u>21%</u> 28%		
Boating behavior				
Boating days (Mean)	24	13	1.513(1)	0.219
Operated the boat during the past three years				
Yes	72%	28%	15.92(1)	0.000
No	<u>47%</u> 72%	<u>53%</u> 28%		
Operated the boat on inland lakes during the past three years				
Yes	71%	29%	5.61(1)	0.010
No	<u>79%</u> 72%	<u>21%</u> 28%		
Operated the boat on other Great Lakes during the past 3 years				
Yes	92%	8%	220.0(1)	0.000
No	<u>59%</u> 72%	<u>41%</u> 28%		
Operated the boat on Lake Michigan during the past 3 years				
Yes	98%	2%	332.3(1)	0.000
No	<u>56%</u> 72%	<u>44%</u> 28%		

Model Specification

Variables having statistically significant relationships with the awareness of Lake Michigan water level fluctuations for use in the binary LOGIT model are (1) Income, (2) Education, (3) Gender, (4) Permanent state of residence, (5) Location of permanent residence, (6) Boat length, (7) Boat type, and (8) Where boats were operated (e.g. on Lake Michigan & on other Great Lakes). The default category for income variable is over \$60K. For education variable, the default category is having a graduate degree. Each category (Michigan, Wisconsin, Indiana, & Illinois) of the “location of permanent residence” variable is recorded to four dummy variables.

Of the 1,646 survey respondents, only 1,142 cases were available to develop the binary LOGIT model. Approximately 500 cases were excluded because they had a missing value for one or more of the independent variables. The stepwise- backward method begins with all 11 independent variables. Statistical tests are then performed to assess whether removing any of these predictors can be done without appreciably affecting how well the model fits the observed data. This backward-stepwise method produced eight separate binary LOGIT models. The following variables were sequentially removed: “boater education,” “boat length,” “operating experience on inland lakes,” “boat type: inboard-outboards, outboards and pontoon,” and “operating experience on other Great Lakes.” Eight significant independent variables remaining in final LOGIT model are permanent state of residence-Michigan, Wisconsin and Indiana, location of their permanent residence- Lake Michigan coastal counties, counties adjacent to Lake Michigan coastal counties, Lake Michigan boating experience, annual income (45K to 60K) and gender.

LOGIT Model Parameter Estimations

The estimate of LOGIT model is (Table 4.7):

$$\log it(p) = -1.409 + 1.885MI + 0.380WI + 0.624IN + 1.627LMC + 1.419NLMC \\ + 2.778OLM - 0.456INCOME + 0.651MALE$$

P = The probability that a boater was aware of Lake Michigan water level changes

MI, WI, IN = Permanent state of residence-Michigan, Wisconsin and Indiana

LMC = Location of permanent residence for Lake Michigan coastal counties

NLMC = Location of permanent residence for counties adjacent to Lake Michigan coastal counties

OLM = Operated the boats on Lake Michigan

INCOME = Income - \$45K to 60K

MALE = Male boater

The equation can be used to predict the odds and the probability of a recreational boater who was aware of Lake Michigan water level changes for given values of those independent variables. A positive “ β ” indicates that as the value of the independent variable increases the probability of being aware of water level changes also increases. A negative “ β ” indicates that as the value of the independent variable increases the probability will decrease. The larger the value of “ β ”, the greater the relative importance of this variable in predicting awareness. The Wald tests whether the coefficient is significantly different from zero.

Using the first significant variable to illustrate – permanent state of residence “Michigan” as the example, the estimate of “ β ” is 1.885 with a standard error of 0.268 and is significant according to the Wald’s test. The interpretation of the coefficient β_1 (e.g., 1.885) is the change in the log odds of awareness for a resident of Michigan relative to a non-Michigan resident. The “Odds Ratio” ($\text{Exp}(\beta_1)$) is calculated by computing the natural logarithm of the “ β ” parameter and is an indicator of the awareness of Lake Michigan water level changes resulting from a unit change in the independent variable (in this case, living in Michigan, rather than Illinois).

For a recreation boater who did not live in Michigan, the calculation would be:

$$\log(\text{odds}) = -1.409$$

Therefore, the odds of the awareness of Lake Michigan water level changes is:

$$\text{odds}(\text{awareness}) = \exp(-1.409) = 0.244$$

And the probability of awareness is:

$$p(\text{awareness}) = \frac{0.244}{1 + 0.244} = 0.196$$

For a recreation boater who lived in Michigan, the odds and probability of his awareness of Lake Michigan water level changes is:

$$\begin{aligned}\log(\text{odds}) &= -1.409 + 1.885 * 1 = 0.476, \\ \text{Odds}(\text{awareness}) &= \exp(0.476) = 1.6096, \\ p(\text{awareness}) &= \frac{1.6096}{1 + 1.6096} = 0.6168\end{aligned}$$

For a recreation boater who lived in Michigan, the probability of being aware of Lake Michigan water level changes is around 62%, compared to only 20% for non-Michigan residents.

Examining the coefficient of county location variable, the probability of being aware of Lake Michigan water level changes for a boater who lives in Lake Michigan coastal counties is around 55%. Moreover, boaters who live in Lake Michigan coastal counties are almost 5 times higher to be aware of Lake Michigan water level changes than boaters who do not live in the Lake Michigan coastal counties.

The most important factor to influence the boaters' awareness of Lake Michigan water level changes is whether they operated their boats on Lake Michigan. If the boater who lived in Michigan and also operated the boat on Lake Michigan, the probability of being aware of the water level changes will be around 96% with the default values (0) of all other variables. In this case, the probability of being aware of Lake Michigan water level changes increases from 62% to 96%. Male boaters are more likely to be aware of the Lake Michigan water level changes than female boaters.

Table 4.8 illustrates the calculation of probabilities of being aware of Lake Michigan water level changes using the LOGIT model. The examples from one to four are the probability of being aware of Lake Michigan water level changes for boaters who lives in Michigan but have different characteristics. The examples from five to eight are the probability for boaters who live in Wisconsin but have different characteristics. Probabilities of being aware of Lake Michigan water level changes increase from 62% for Michigan residents with the default values of all other variables (did not live in Lake Michigan county, did not operate on Lake Michigan, income less than \$45K or more than 60K, female) to 89% if living in a coastal county or 96% if operated a boat on Lake Michigan, and finally 98% if all of the earlier characteristics and male. For the Wisconsin residents, probabilities of being aware of Lake Michigan water level changes

increase from 26% with the default values of all other variables (the same as the setting for Michigan residents) to 65% if living in a coastal county or 85% if operated a boat on Lake Michigan, and finally 92% if all of the earlier characteristics and male.

Table 4.7. The result of the final binary LOGIT model for boaters' awareness of Lake Michigan water level changes.

	β	S.E	Wald	df	Sig.	Exp(β)
Permanent state of residence						
Michigan	1.885	0.268	49.552	1	0.000	6.586
Wisconsin	0.380	0.225	2.836	1	0.092	1.462
Indiana	0.624	0.215	8.396	1	0.004	1.867
Location of permanent residence						
LM coastal counties	1.627	0.224	52.736	1	0.000	5.091
Next to LM coastal counties	1.419	0.213	44.569	1	0.000	4.132
Operated the boat on Lake Michigan						
	2.778	0.304	83.650	1	0.000	16.090
Income						
Over \$60K	-	-	4.167	2	0.124	-
\$45K to \$60K	-0.456	0.229	3.982	1	0.046	0.634
Under \$45K	-0.092	0.187	0.244	1	0.621	0.912
Male						
	0.651	0.281	5.376	1	0.020	1.918
Constant						
	-1.409	0.329	18.398	1	0.000	0.244
Summary Statistics						
Model chi-square [df]=459.5[9]*						
Nagelkerke R^2 =0.48						
% Correct predictions=82%						

* P -value < 0.05

Table 4.8. The probability of awareness of Lake Michigan water level changes by selected boater characteristics.

	<u>Example 1</u>		<u>Example 2</u>		<u>Example 3</u>		<u>Example 4</u>	
	A boater who lives in Michigan	A boater who lives in Lake Michigan coastal counties in Michigan	A boater who lives in Lake Michigan coastal counties in Michigan and operated the boat on Lake Michigan	A male boater who lives in Lake Michigan coastal counties in Michigan and operated the boat on Lake Michigan				
	β	Exp(β)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)
Michigan	1.885	6.586	1	1.885	1	1.885	1	1.885
Wisconsin	0.38	1.462	0	0	0	0	0	0
Indiana	0.624	1.866	0	0	0	0	0	0
LM coastal counties	1.627	5.089	0	0	1	1.627	0	0
Next to LM coastal counties	1.419	4.133	0	0	0	0	0	0
Operated the boat on LM	2.778	16.087	0	0	0	0	1	2.778
Income (45K-60K)	-0.460	0.631	0	0	0	0	0	0
Male	0.651	1.917	0	0	0	0	0	0.651
Constant	-1.409	0.244	1	-1.409	1	-1.409	1	-1.409
In odds		0.476		2.103		3.254		3.905
y/(1-y)		1.610		8.191		25.894		49.650
y (P)		62%		89%		96%		98%

Table 4.8. The probability for the boaters who are aware of Lake Michigan water level changes with different characteristics – cont'd.

	<u>Example 5</u>			<u>Example 6</u>			<u>Example 7</u>			<u>Example 8</u>		
	β	Exp(β)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)
Michigan	1.885	6.586	0	0	0	0	0	0	0	0	0	0
Wisconsin	0.38	1.462	1	0.38	1	0.38	1	0.38	1	0.38	1	0.38
Indiana	0.624	1.866	0	0	0	0	0	0	0	0	0	0
LM coastal counties	1.627	5.089	0	0	1	1.627	0	0	0	0	0	0
Next to LM coastal counties	1.419	4.133	0	0	0	0	0	0	0	0	0	0
Operated the boat on LM	2.778	16.087	0	0	0	0	1	2.778	1	2.778	1	2.778
Income (45K-60K)	-0.460	0.631	0	0	0	0	0	0	0	0	0	0
Male	0.651	1.917	0	0	0	0	0	0	0	0	1	0.651
Constant	-1.409	0.244	1	-1.409	1	-1.409	1	-1.409	1	-1.409	1	-1.409
In odds				-1.029		0.598		1.749		2.400		2.400
y/(1-y)				0.357		1.818		5.749		11.023		11.023
y (P)				26%		65%		85%		92%		92%

LOGIT Model Evaluation and Correct Prediction

According to model chi-square statistics reported in Table 4.7, the final LOGIT model is strongly significant ($\chi^2=459.5$). The value of Nagelkerke's R^2 , the measures of the proportion of variation explained is around 48% for the final LOGIT model.

Overall, the percentage of correct predictions of boaters' awareness of Lake Michigan water level changes (Table 4.9) substantiates the predictive power of the Model 8, which yields a hit ratio of 82% with correct classification in the diagonal cells and incorrect classifications in the off-diagonal cells. In other words, this model correctly predicts almost 82% of respondents' awareness. This binary LOGIT model correctly classifies 87% of boaters who were aware of the water level changes, and 70% of the boaters who were not aware of the water level changes.

Compared to the maximum chance criterion-72%, the percent of correct classification of the LOGIT model resulted in an increase of 10%. The percent of correct classification (82%) is also higher than the proportional chance criterion (60%).

Table 4.9. Accuracy of final LOGIT model classifications of boaters who were and were not aware of Lake Michigan water level fluctuations.

Observed	<u>Model classification/prediction</u>		Percentage Correct
	Aware of LM water level fluctuations	Not aware of LM water level fluctuations	
Aware of LM water level fluctuations (Row Pct.)	713 (87%)	108 (13%)	821 87%
Not aware of LM water level fluctuations (Row Pct.)	97 (30%)	224 (70%)	321 70%
Model Predicted (total)	810	332	1,142
Summary Statistics			
Percentage of cases correctly classified		82%	
Maximum chance criterion		72%	
Proportional chance criterion		60%	

4.2.2 Assessment of Lake Michigan Water Level Changes

Of 1,177 recreational boaters, who were aware of Lake Michigan water level fluctuations, 74% believed that Lake Michigan water level had dropped “a lot”, while 26% believed that they had either remained constant or dropped “a little” (Table 4.10).

Table 4.10. Boaters’ assessments about the extent of Lake Michigan water level fluctuations.

	Number	Percent
Water level had dropped “a lot”	870	74%
Water level had remained the same or had dropped a little	<u>307</u>	<u>26%</u>
Total*	1,177	100%

* This number only included the boaters who were aware of Lake Michigan water level changes.

Hypothesis Testing

The hypothesis that framed the development of the second binary LOGIT model is that boaters' assessment of the extent of Lake Michigan water level changes is significantly influenced by their socioeconomic characteristics, type and size of the boats they own, the number of years they have owned their boats, where they stored their boats, boating volume and where they operated their boats, and types of their boating activities.

Hypothesis tests revealed no significant relationship between assessment of the degree of Lake Michigan water level changes and any of the socioeconomic characteristics including age, education, income and gender because 1,177 boaters are all aware of Lake Michigan water level changes. Two of the boat characteristics – “number of years the boat has been owned” and “length” influence their perceptions.

The state and county where boaters kept their boats are statistically related to their “extent of change” perceptions. Type of storage are statistically related to how much they perceived Lake Michigan water level had changed, but not related to their awareness about the Lake Michigan water level changes at all. Boaters who stored their boats in marinas or who kept their boats in Lake Michigan coastal counties are both more likely to assess Lake Michigan water level had dropped a lot. The types of boating activities they participate in (e.g., fishing and cruising) do not significantly determine their perceptions. However, their Great Lakes boating experiences during the previous three years are, as was expected, significant factors in determining their perceptions of the magnitude of changes in Lake Michigan water levels.

Table 4.11. Relationships between boater and boat characteristics and boater perceptions of the magnitude of Lake Michigan water level changes.

	Perceptions of Lake Michigan water level changes		χ^2 / F-value (df)	<i>P-value</i>
	Dropped “a lot”	Remained the same		
Boater characteristics				
Age	53	51	1.959(1)	0.162
Education				
Under college	67%	33%	0.171(2)	0.918
College	69%	31%		
Graduate	<u>77%</u>	<u>23%</u>		
	72%	28%		
Income				
Under \$45K	76%	24%	1.859(2)	0.395
\$45K to \$60K	70%	30%		
Over \$60K	<u>73%</u>	<u>27%</u>		
	72%	28%		
Gender				
Female	65%	35%	0.005(1)	0.526
Male	<u>72%</u>	<u>28%</u>		
	72%	28%		
Boat characteristics				
Boat type				
Outboard motor boat	75%	25%	4.389(4)	0.356
Inboard-outboards	73%	27%		
Inboard motor boat	70%	30%		
Powered sailboat	84%	16%		
Pontoon boat	<u>72%</u>	<u>28%</u>		
	72%	28%		
Boat size	22	19	7.25(1)	0.010
Number of years, the boat has been owned	8	7	3.13(1)	0.077
Boat storage characteristics				
Boat storage				
Permanent home	79%	21%	15.92(2)	0.001
Cottage and second home	56%	44%		
Marina	<u>81%</u>	<u>19%</u>		
	72%	28%		

Table 4.11. Relationships between boater and boat characteristics and boater perceptions of the magnitude of Lake Michigan water level changes – cont'd.

	Perceptions of Lake Michigan water level changes		χ^2 / F-value (df)	P-value
	Dropped “a lot”	Remained the same		
Boat storage location (state)				
Michigan	82%	18%	12.109(4)	0.017
Wisconsin	80%	20%		
Indiana	80%	20%		
Illinois	65%	35%		
Others	<u>72%</u>	<u>28%</u>		
	72%	28%		
Boat storage location (county)				
Lake Michigan coastal counties	82%	18%	8.437(1)	0.002
Other counties	<u>72%</u>	<u>28%</u>		
	72%	28%		
Boating activity				
Fishing	79%	21%	1.359(1)	0.143
Cruising	76%	24%	0.746(1)	0.218
Skiing	70%	30%	4.374(1)	0.027
Boating pattern				
Boating days (Mean)	23	26	1.161(1)	0.204
Operated the boat during the past three years				
Yes	74%	26%	1.303(1)	0.179
No	<u>64%</u>	<u>36%</u>		
	72%	28%		
Operated the boat on the inland lakes during the past three years				
Yes	70%	30%	1.527(1)	0.126
No	<u>79%</u>	<u>21%</u>		
	72%	28%		
Operated the boat on other Great Lakes during the past three years				
Yes	76%	24%	7.925 (1)	0.003
No	<u>70%</u>	<u>30%</u>		
	72%	28%		
Operated the boat on Lake Michigan during the past three years				
Yes	76%	24%	1.89(1)	0.096
No	<u>72%</u>	<u>28%</u>		
	72%	28%		

Model Specification

Variables that have significant differences between the boaters with different “extent of change” perceptions are used to develop the LOGIT model. Those are: (1) boat length, (2) boat type, (3) number of years the boat has been owned, (4) where the boat was operated (e.g. on Lake Michigan, on other Great Lakes), (5) boat storage type, (6) boat storage state location, (7) boat storage county location, and (8) water skiing. The category variables (boat type, boat storage type, boat storage state and county location) are recorded as dummy variables before entering the LOGIT model.

Of the 1,177 boaters who were aware of changes in Lake Michigan water level, only 569 were available for model formation because some cases had a missing value for one or more of the independent variables. Again, a stepwise-backward procedure was used to identify alternative forms of the model and to arrive at the “best” final model.

Four variables were excluded from stepwise-backward procedure – (1) boats stored in marinas during the boating season, (2) water skiing is a boating activity, (3) outboards as a type of boat, and (4) boats stored in Illinois during the boating season. Eleven variables remained in final model but one variable (pontoon) was not significant according to Wald’s test.

Ten significant variables incorporated as part of the final binary LOGIT model have significant effects on the probability that boaters assess Lake Michigan water levels had dropped “a lot” (Table 4.12). Those are boat length (at the 0.05 level), number of years the boat has been owned (at the 0.05 level), boat type - inboard-outboards (at the 0.10 level), and inboards (at the 0.05 level), operating experience on other Great Lakes (at the 0.10 level), state where the boat was stored during the boating season - Wisconsin

(at the 0.05 level), Indiana (at the 0.10 level) and Michigan (at the 0.05 level), county where the boat was stored during the boating season – Lake Michigan coastal counties (at the 0.10 level), and type of storage - cottage and second home (at the 0.01 level).

LOGIT Model and Parameter Estimations

The estimated LOGIT model is (Table 4.12):

$$\log it(p) = 0.035 + 0.052LENGTH + 0.048YEAR - 0.432INOUT - 1.045INBOARD - 0.680OGL + 0.790WI + 0.724IN + 0.891MI + 0.377SLM - 1.267SECOND$$

P = The probability that a boater assessed Lake Michigan water level had dropped a lot

LENGTH = Boat size

YEAR = Number of years the boat has been owned

INOUT, INBOARD = Boat type – Inboard-outboards and inboards

OGL = Boats were operated on other Great Lakes

WI, IN, MI = Boats were stored in these states during the boating season – Wisconsin, Indiana, and Michigan

SLM = Boats were stored in Lake Michigan coastal counties during the boating season

SECOND = Boats were stored at cottage or second homes

According to the results, the values of the independent variables including boat length, number of years boat has been owned, boat storage state location (e.g. Wisconsin,

Indiana & Michigan), boat storage county location increase, the probability of the boaters' assessment that Lake Michigan water level had dropped "a lot" increases too.

The results from the LOGIT model reveal some important expected and unexpected relationships between different independent variables and perceptions of the degree of Lake Michigan water level changes (Table 4.12). Some of these relationships are easy to explain, others are much more difficult. For example, owners of larger size boats are more likely to have perceived that Lake Michigan water levels had dropped "a lot" in large part because the draft and maneuverability of their boats they are more likely to be impacted by low water. With every 1 foot increase in boat size, the probability that the boater assess that Lake Michigan water level had dropped "a lot" will increase around 1%.

The results also indicated that boaters, who owned their boats for a longer time, are more likely to assess that the Lake Michigan water levels had dropped "a lot." One year longer, which the boaters owned their boats, will increase 1% in the probability of their assessment that Lake Michigan water level had dropped "a lot". The low water level significantly happened since 1997. If the boaters had the boating experience earlier than 1997, they would be able to compare the change of Lake Michigan water levels before and after 1997.

The LOGIT model also shows differences in perceptions depending on which Lake Michigan states (e.g., Michigan, Wisconsin, Indiana and Illinois) where the boat was stored at during the boating season. The owners who stored their boats in Michigan during the boating season are almost 2.5 times more likely to assess that Lake Michigan water level had dropped "a lot" than boaters who did not keep their boats in Michigan.

This is consistent with previous low water studies, which found that Lake Michigan water levels have had a greater impact on boating in Michigan than other Lake Michigan states. Besides boat owners who kept their boats in Lake Michigan coastal counties are more likely to assess that water levels had dropped “a lot.”

Unexpectedly, boaters who stored their boats at cottages or second homes are more likely to perceive that Lake Michigan water levels had not dropped a lot or dropped a little. This is in part due to the fact that many of the second homes and cottages are located on inland lakes and these boats are used more often on inland lakes. It is not clear why the boaters who had either “inboard-outboards” or “inboards” are less likely to assess the Lake Michigan water level had dropped a lot. While this makes sense for inboard-outboards since they are generally smaller boats, it is unexpected for inboards, which are on average larger boats.

By using the results of model parameter estimates, the probability of boaters’ assessment that Lake Michigan had dropped “a lot” can be calculated for different types of boaters. For example, the probability of assessing that Lake Michigan had dropped “a lot” is 83% for a boater who owned a 20’ boat for ten years with the default values of all other variables (Table 4.13). For a boater who owned a 30’ boat for ten years, the probability will increase from 83% to 89%. Furthermore, the probability will decrease if the boater owned an inboard-outboard motorboat. The probability of assessing that Lake Michigan had dropped “a lot” is 84% for a boater who owned a 30’ inboard-outboard for ten years. Then if a boater owns a 30’ inboard-outboard boat for ten years and also kept the boat in Michigan, the probability will increase from 84% to 93%.

Table 4.12. The result of the final binary LOGIT model for boaters' assessments of the degree of Lake Michigan water level changes.

	β	S.E	Wald	df	Sig.	Exp(β)
Boat length	0.052	0.022	5.402	1	0.020	1.053
Number of years the boat has been owned	0.048	0.020	5.739	1	0.017	1.049
Boat type						
Inboard-outboards	-0.432	0.244	3.128	1	0.077	0.649
Inboards	-1.045	0.337	9.602	1	0.002	0.352
Operated the boat on other Great Lakes	-0.680	0.355	3.663	1	0.056	0.507
Boat storage state location						
Wisconsin	0.790	0.290	7.412	1	0.006	2.204
Indiana	0.724	0.400	3.280	1	0.070	2.062
Michigan	0.891	0.281	10.024	1	0.002	2.437
Boat storage county location – Lake Michigan coastal counties	0.377	0.220	2.916	1	0.088	1.457
Boat storage type - Cottage/second home	-1.267	0.341	13.781	1	0.000	0.282
Constant	0.035	0.624	0.003	1	0.955	1.036
Summary Statistics						
Model chi-square [df] =61.157[9]*						
Nagelkerke R^2 = 0.156						
% Correct predictions=79%						

* P -value < 0.05

** P -value < 0.10

Table 4.13. The probability for the boaters who assessed Lake Michigan water level had dropped a lot by selected boater characteristics.

	<u>Example 1</u>			<u>Example 2</u>			<u>Example 3</u>			<u>Example 4</u>		
	β	Exp(β)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)
Boat length	0.052	1.053	20	1.04	30	1.56	30	1.56	30	1.56	30	1.56
Number of years the boat has been owned	0.048	1.049	10	0.48	10	0.48	10	0.48	10	0.48	10	0.48
Inboard-outboards	-0.432	0.649	0	0	0	0	1	-0.432	1	-0.432	1	-0.432
Inboards	-1.045	0.352	0	0	0	0	0	0	0	0	0	0
Operated the boat on other Great Lakes	-0.68	0.507	0	0	0	0	0	0	0	0	0	0
Boat storage county			0	0	0	0	0	0	0	0	0	0
Wisconsin	0.79	2.203	0	0	0	0	0	0	0	0	0	0
Indiana	0.724	2.063	0	0	0	0	0	0	0	0	1	0.891
Michigan	0.891	2.438	0	0	0	0	0	0	0	0	0	0
Boat was kept in LM coastal counties in Michigan	0.377	1.458	0	0	0	0	0	0	0	0	0	0
Boat was kept at second homes	-1.267	0.282	1	0.035	1	0.035	1	0.035	1	0.035	1	0.035
Constant	0.035	1.036										
In odds				1.555		2.075		1.643		2.534		
y/(1-y)				4.735		7.965		5.171		12.604		
y (P)				83%		89%		84%		93%		

LOGIT Model Evaluation and Correct Prediction

According to model chi-square statistic, the final LOGIT model is significant at the 0.01 level ($\chi^2=61.157$) in terms of overall model fit (Table 4.12). The value of model chi-square is still strongly significant. The performance of the Nagelkerka R^2 is about 16%.

The percentage of model correct predictions (79%) of the degree of Lake Michigan water level changes provides a measure of its predictive power (Table 4.14). The table shows correct classifications in the diagonal cells and incorrect classifications in the off-diagonal cells. Overall, this model correctly predicts almost 79% of respondents' assessments of the extent of Lake Michigan water level changes. Furthermore this model correctly classifies 97% of boaters who assessed the Lake Michigan water levels had dropped "a lot" but only 12% of boaters, who assessed the Lake Michigan water levels had remained the same or just dropped "a little." The possible reason of low prediction percentage (12%) is the fewer cases of boaters who assess the Lake Michigan water level had remained the same. Besides higher variations are usually found existing in the respondents who checked the "No" answer.

This model only increase 5% in correct prediction by comparing the difference between the values of overall model correct prediction (79%) and maximum chance criterion (74%). But this model can still adequately predict boaters' assessment of Lake Michigan water level changed because the overall model correct prediction percentage (79%) is still higher than the value of proportional chance criterion (53%).

Table 4.14. Accuracy of final LOGIT model classifications of boaters who assessed the Lake Michigan water levels had dropped a lot and remained the same.

Observed	<u>Model classification/prediction</u>		
	Remained the same	Dropped “a lot”	Percentage Correct
Remained the same (Row Pct.)	15 (12%)	111 (88%)	126 (12%)
Dropped “a lot” (Row Pct.)	12 (3%)	432 (97%)	444 (97%)
Model Predicted (total)	27	543	570
Summary Statistics			
Percentage of cases correctly classified		79%	
Maximum chance criterion		74%	
Proportional chance criterion		53%	

4.3 Who was Affected by Low Water Levels (Study Objective #2)

This section reports the analyses focused on identifying significant relationships between water level related boating behavior changes and various independent variables including: boat and boater characteristics, boat storage location and type, amount/volume of boating days and boating locations. It also reports on the binary LOGIT model formulated to predict boaters who are affected by low water levels. The data for the analyses is taken from the 2001 Lake Michigan Potential Damages Study mail survey. Approximately a third (33%) of the 1,386 recreational boaters, who responded to the mail survey, were influenced by low water levels, 67% were not.

Hypothesis Testing

It was hypothesized that various boater and boat characteristics, boat storage location and type, and boating volume and locations would influence whether they would be influenced by low water level concerns. The hypotheses testing result is listed in Table 4.15.

There is no statistically significant relationship between low water responsive behaviors and boater ages or incomes and also total number of boating days. Type and size of boats are statistically related to whether a boater's behavior is influenced by low water levels. Generally the owners of larger boats, as would be expected, are more influenced behaviorally by low water than small boat owners. Whether a boater's behavior is influenced by low water levels is significantly related to where the boats are stored during the boating season. A higher percentage of the owners whose boats were stored at marinas were influenced by low water levels in large part because of dredging problems in waterways accessing many Lake Michigan marinas.

Owners of boats stored in Michigan and especially in Lake Michigan counties were also more likely to alter their behaviors due to low water levels. Again this is consistent with studies showing that low water problems were more dramatic in Michigan than other Great Lakes states. The behavior of boaters who boated more days on Lake Michigan and the other Great Lakes were more likely to have been impacted by low water levels. Also boaters who trailered their boats to boating locations were more likely to be influenced by low water levels because many of the launch sites were negatively impacted by low water levels.

Table 4.15. Relationships between boater and boat characteristics and whether a boater's behavior was influenced by concerns relating to low water levels.

	<u>Influenced</u> <u>by low water concerns</u>		χ^2 / F-value (df)	<i>P-value</i>
	Yes	No		
Boater characteristics				
Age (Mean)	53	53	0.051(1)	0.822
Income				
Under \$60K	33%	67%	0.534(2)	0.766
\$60 K-\$99K	31%	69%		
Over \$100K	<u>34%</u>	<u>66%</u>		
	32%	68%		
Boat characteristics				
Boat type				
Inboard motor boat	35%	65%	23.434(4)	0.000
Inboard-outboards	37%	63%		
Outboard motor boat	29%	71%		
Powered sailboat	44%	56%		
Pontoon boat	<u>22%</u>	<u>78%</u>		
	32%	68%		
Boat length (Mean)	24.3	21.6	34.215(1)	0.000
Boat storage characteristics				
Boat storage				
Marina	44%	56%	29.549(3)	0.000
Waterfront permanent home	31%	69%		
Cottage & second home	24%	76%		
Non-waterfront home	<u>29%</u>	<u>71%</u>		
	32%	68%		
Boat storage state location				
Michigan	38%	62%	13.404(3)	0.004
Wisconsin	27%	73%		
Indiana	28%	72%		
Illinois	<u>27%</u>	<u>73%</u>		
	32%	68%		
Boat storage county location				
Lake Michigan coastal counties	36%	64%	9.291(1)	0.001
Other counties	<u>27%</u>	<u>73%</u>		
	32%	68%		

Table 4.15. Relationships between boater and boat characteristics and whether a boater's behavior was influenced by concerns relating to low water levels – cont'd.

	<u>Influenced</u> <u>by low water concerns</u>		χ^2 / F-value (df)	<i>P-value</i>
	Yes	No		
Number of boating days (Mean)				
Total boating days	32	32	0.000 (1)	0.998
Lake Michigan boating days	14	9	15.971(1)	0.000
Days on other Great Lakes	5	2	9.296(1)	0.002
Number of different boating counties/locations	2.2	1.7	25.328(1)	0.000
 The boat was trailered to launch				
Yes	42%	58%	28.371(1)	0.001
No	<u>28%</u>	<u>72%</u>		
	32%	68%		
 Requested/received any information concerning water levels				
Yes	58%	42%	79.921(1)	0.000
No	<u>27%</u>	<u>73%</u>		
	32%	68%		

Model Specification

The results of the hypothesis testing identified a statistically significant relationship between whether they were influenced by low water levels and some variables including (1) boat type, (2) boat length, (3) boat storage type, (4) boat storage state location, (5) boat storage county location, (6) number of Lake Michigan boating days, (7) number of boating days on other Great Lakes, (8) number of different boating counties/locations, (9) whether the boat was trailered to launch, and (10) whether the boater requested any information concerning low water levels. Those variables are then used to develop the LOGIT model. Again the category variables (boat type, boat storage

type, boat storage state location, and boat storage county location) are recorded to different dummy variables before entering the LOGIT model.

Information on 743 was available to develop the binary LOGIT model. The stepwise-backward method formed alternative models, each with a different collection of independent variables, which were determined by the result of hypothesis testing. The first model contained all the entire set of statistically significant hypothesized independent variables. The stepwise process eliminated “boat storage type: waterfront permanent home,” “number of boating days on other Great Lakes and on Lake Michigan,” “boat type – outboards,” “number of years the boat has been owned,” “boat storage type – marina,” and “boat storage location: Illinois and Wisconsin.”

The seven remaining significant independent variables incorporated as part of final LOGIT model are (1) boat length (at the 0.05 level), (2) boat type: inboard-outboards (at the 0.05 level), (3) boat storage type: non-waterfront home (at the 0.10 level), (4) state where their boat are stored: Michigan (at the 0.105 level), (5) number of different boating counties/locations (at the 0.05 level), (6) whether information concerning water levels was requested/received (at the 0.05 level), and (7) whether they trailered their boats to launch (at the 0.05 level).

LOGIT Model Parameter Estimations

The estimated LOGIT model is (Table 4.16):

$$\text{logit}(p) = -2.504 + 0.028LENGTH - 0.456INOUT + 0.529NWH + 0.421MI \\ + 0.135NDBC + 0.979REQUEST + 0.546TRAIL$$

P = The probability that a boater who was influenced by low water levels

LENGTH = Boat size

INOUT = Boat type – Inboard-outboards

NWH = Boats were kept at non-waterfront homes

MI = Boat storage state location – Michigan

NDBC = Number of different boating counties/locations

REQUEST = Requested/received any information concerning water levels

TRAIL = Boat was trailered to launch

As would obviously be expected the owners of bigger boats are more likely to be influenced by low water levels. Owners of inboard-outboards are just somewhat less likely to be influenced by low water levels. This result is consistent with the result from previous model. The boaters who owned inboard-outboards are not only less likely to be influenced by low water level but also less likely to assess Lake Michigan had dropped “a lot” because most inboard-outboards are smaller than other types of boats (e.g., sailboat, and inboards).

Owners of boats stored at non-waterfront homes during the boating season are more likely to be influenced by low water levels. Boaters who kept their boats at non-waterfront home are 1.698 times more likely to be influenced by the low water level concerns than the boaters who did not keep their boats at non-waterfront homes. This result is in part because boats kept at non-waterfront homes must be trailered and launched and as previously stated many launch sites were low water impacted.

This result is also confirmed by the model finding that boaters who trailered their boats to operate on Lake Michigan are 1.73 times more likely to be influenced by the low water level concerns than the boaters who did not trailer their boats to operate on Lake Michigan. According to the investigation of the 2001 LMPDS, eighteen ramps of the 55 ramps located in Allegan and Ottawa counties in Michigan and Manitowoc, Ozaukee and Sheboygan counties in Wisconsin were closed due to the drop or little water for a sizable boat (Planning & Zoning Center, Inc. et al., 2001). Moreover in 2002, thirty-five of the 134 public launch ramps located in 34 Lake Michigan coastal counties in Michigan, Wisconsin, Indiana and Illinois were closed due to the same reason (Planning & Zoning Center, Inc. et al., 2002).

The results of the LOGIT model also show that owners of boats kept in Michigan during the boating season were significantly more likely to be influenced by the low water level concerns than the owners who kept their boats in Wisconsin and Illinois. The more different locations a boat is operated during the boating season, the more likely the owner/operator will be influenced by low water levels.

Interestingly, boaters who requested/received any information concerning water levels are more likely to be influenced by the low water concerns than boaters who did not. However, the question is whether they request/received any information because they are sensitive to low water levels, or they alter their behaviors because of some combination of their heightened sensitivities and the information they receive. So boaters who requested any information about low water levels are 2.662 times more likely to be influenced by the low water level concerns than the boaters who did not.

Different examples showed different probability that boaters can be influenced by the low water level concerns with different characteristics (Table 4.17). For a boater who owned a 20-foot boat, the probability that he/she will be influenced by low water levels is about 13% with the default values of other variables (not inboard-outboards, did not keep the boat at non-waterfront, did not keep the boat in Michigan, did not request any information concerning low water levels and did not trailer the boat to launch) (Example 1). The probability will decrease from 13% to 8% if he/she owned a 20-foot inboard-outboard motor boat (Example 3). If this boater owned a 20-foot inboard-outboard motor boat and also kept this boat at non-waterfront home in Michigan, the probability of being influenced by the low water level concerns will be around 19% (Example 4). If this boater trailered his/her boat to launch, operated this boat in three different locations and also requested the information about low water levels, the probability of being influenced by low water level concerns will increase to 62% (Example 7).

Table 4.16. The result of the final binary LOGIT model for classifying boaters who were influenced and not influenced by concerns relating to low water levels.

	β	S.E	Wald	df	Sig.	Exp(β)
Boat length	0.028	0.012	5.363	1	0.021	1.028
Boat type						
Inboard-outboards	-0.456	0.194	5.501	1	0.019	0.634
Powered sailboat	-0.419	0.312	1.797	1	0.180	0.658
Pontoon boat	0.274	0.284	0.930	1	0.335	1.315
Boat storage type						
Non-waterfront home	0.529	0.279	3.598	1	0.058	1.698
Boat storage state location						
Michigan	0.421	0.169	6.183	1	0.013	1.524
Indiana	0.865	0.559	2.389	1	0.122	2.374
Boat storage county location						
Lake Michigan costal counties	0.214	0.175	1.495	1	0.221	1.238
Number of different boating counties/locations	0.135	0.067	4.017	1	0.045	1.145
Requested/received any information concerning water levels	0.979	0.212	21.278	1	0.000	2.662
The boat was trailered to launch to Lake Michigan	0.546	0.206	7.023	1	0.008	1.727
Constant	-2.504	0.625	16.040	1	0.000	0.082
Summary Statistics						
Model chi-square [df] =85.92[11]*						
Nagelkerke R^2 = 0.15						
% Correct predictions=69.0%						

* P -value<0.05

Table 4.17. The probability for the boaters who were influenced by concerns relating to low water levels by selected boater characteristics.

	<u>Example 1</u>			<u>Example 2</u>			<u>Example 3</u>			<u>Example 4</u>		
	β	Exp(β)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)
Boat length	0.028	1.028	20	0.56	20	0.56	20	0.56	20	0.56	20	0.56
Inboard-outboards	-0.456	0.634	0	0	1	-0.456	1	-0.456	1	-0.456	1	-0.456
Boat was kept at non-waterfront home	0.529	1.697	0	0	0	0	1	0.529	1	0.529	1	0.529
Boat was kept in Michigan	0.421	1.523	0	0	0	0	0	0	1	0.421	1	0.421
Number of different boating counties/locations	0.135	1.145	0	0	0	0	0	0	0	0	0	0
Requested/received any information concerning water levels	0.979	2.662	0	0	0	0	0	0	0	0	0	0
The boat was trailered to launch	0.546	1.726	0	0	0	0	0	0	0	0	0	0
Constant	-2.504	0.082	1	-2.504	1	-2.504	1	-2.504	1	-2.504	1	-2.504
In odds		-1.944		-2.4		-1.871		-1.450				
y/(1-y)		0.143		0.091		0.154		0.235				
y (P)		13%		8%		13%		19%				

Table 4.17. The probability for the boaters who were influenced by concerns relating to low water levels by selected boater characteristics – cont'd.

	Example 5			Example 6			Example 7		
	A boater who owned 20' a inboard-outboard boat, which was kept at non-waterfront home in Michigan and was operated in three different locations			A boater who owned a 20' inboard-outboard boat, kept at non-waterfront home in Michigan, and this boater operated the boat in three different locations and requested the information about low water levels			A boater who owned a 20' inboard-outboard boat, kept at non-waterfront home in Michigan. The boat was launched to operate in three different locations and the boat owner requested the information about low water levels		
	β	$\text{Exp}(\beta)$	X	$\text{Exp}(\beta X)$	X	$\text{Exp}(\beta X)$	X	$\text{Exp}(\beta X)$	
Boat length	0.028	1.028	20	0.56	20	0.56	20	0.56	
Inboard-outboards	-0.456	0.634	1	-0.456	1	-0.456	1	-0.456	
Boat was kept at non-waterfront home	0.529	1.697	1	0.529	1	0.529	1	0.529	
Boat was kept in Michigan	0.421	1.523	1	0.421	1	0.421	1	0.421	
Number of different boating counties/locations	0.135	1.145	3	0.405	3	0.405	3	0.405	
Request/received any information concerning water levels	0.979	2.662	0	0	1	0.979	1	0.979	
The boat was trailered to launch	0.546	1.726	0	0	0	0	1	0.546	
Constant	-2.504	0.082	1	-2.504	1	-2.504	1	-2.504	
In odds				-1.045		-0.066		0.480	
y/(1-y)				0.352		0.936		1.616	
y (P)				26%		48%		62%	

LOGIT Model Evaluation and Correct Prediction

According to model chi-square statistic, the final LOGIT model is significant at the 0.01 level in terms of overall model fit (Table 4.16). The Nagelkerka R^2 for final LOGIT model is around 15%, an acceptable number in social science research.

The classification presented in Table 4.18 shows how well the model predicts whether boaters were influenced (e.g., their behaviors) by low water level concerns. The LOGIT model correctly classifies 446 boaters (90%), who were not influenced by low water level concerns and misclassifies 47 of these boaters (10%). On the other hand, model 9 correctly classifies 67 (27%) of the boaters influenced by low water level concerns but misclassifies 183 boaters. The overall accuracy of classification is the weighted average of the two values - 69%.

This model only increase 2% in correct prediction by comparing the difference between the values of overall model correct prediction (69%) and maximum chance criterion (67%). But this model can still adequately predict whether boaters were influenced by low water level concerns because the overall model correct prediction percentage (69%) is still higher than the value of proportional chance criterion (56%).

Table 4.18. Accuracy of final LOGIT model classifications of boaters who were influenced and not influenced by concerns relating to low water levels.

Observed	<u>Model classification/prediction</u>		
	Influenced by low water levels	Not influenced by low water levels	Percentage Correct
Influenced by low water levels (Row Pct.)	67 (27%)	183 (73%)	250 (27%)
Not influenced by low water levels (Row Pct.)	47 (10%)	446 (90%)	493 (90%)
Model Predicated (total)	114	629	743
Summary Statistics			
Percentage of cases correctly classified		69%	
Maximum chance criterion		67%	
Proportional chance criterion		56%	

4.4 Recreational Boater Behavioral Changes Resulting from Low Water Levels (Study Objective #3)

This section reports on the analyses employed in the development of two binary LOGIT models developed to explain recreational boater behavioral changes resulting from low water levels. The models utilized data generated by the 2001 Lake Michigan Potential Damages Study mail survey. Only the data from 451 boaters who actually experienced low water related problems on Lake Michigan is used to formulate two binary LOGIT models, one to predict/classify boaters who changed locations as a result of low water problems and the other to predict/classify boaters who boated less when they encountered these problems.

4.4.1 LOGIT Model to Predict/Classify Boaters Who Change Their Boating Locations in Response to Low Water Levels

More than three quarters (79%) of the 451 boaters, who were influenced by low Lake Michigan levels, changed their boating locations.

Hypothesis Testing

Statistical tests on a set of various hypothesized independent variables determined that age was the only socio-economic characteristic significantly related to whether boaters changed where they boated in response to low water levels (Table 4.19). Older boaters are less likely to change their boating locations. In part this was because most of them stored their boats at second homes and cottages making a move very difficult. Younger boaters are more likely to store their boats at their permanent homes and trailer them to various boating locations.

The length and type of boats and number of years the boat has been owned are also related to the likelihood that an owner will change the boating location in response to low lake levels. Powered sailboats are most likely to change locations due to low water levels. Because rarely are they ever operated on the Great Lakes, owners of pontoon boats are less likely to change locations in response to low water levels. Contrary to other LOGIT models, state and county (e.g., Lake Michigan county) where the boats were stored during the boating season does not statistically significantly change the likelihood that their owners will change their boating places. Boaters with their boats kept in Michigan during the boating season are still more likely to change boating locations in response to low Lake Michigan water levels.

Amount of boating days is related to whether a boater changes locations in response to low water levels. More frequent boaters, and boaters who boat more often on the Great Lakes and in more different locations/counties are statistically more prone to change where they boat in response to low water levels. Moreover boaters who requested or received any information concerning water levels or do not own a waterfront home are more likely to change their boating locations.

Table 4.19. Relationships between boater and boat characteristics and whether boaters changed their boating locations in response to low water levels.

	<u>Changed boating locations</u>		χ^2 / F-value(df)	<i>P</i> - value
	Yes	No		
Boater characteristics				
Age (Mean)	51	58	15.478(1)	0.000
Income				
Under \$60K	33%	67%	1.158(2)	0.560
\$60K to \$99K	31%	69%		
Over \$100K	<u>33%</u>	<u>67%</u>		
	32%	68%		
Boat characteristics				
Boat type				
Inboard motor boat	35%	65%	13.613(4)	0.009
Inboard-outboards	36%	64%		
Outboard motor boat	29%	71%		
Powered sailboat	44%	56%		
Pontoon boat	<u>22%</u>	<u>78%</u>		
	32%	68%		
Boat length (Mean)	25	21	6.108(1)	0.014
Number of years the boat has been owned (Mean)	9	11	6.960(1)	0.009

Table 4.19. Relationships between boater and boat characteristics and whether boaters changed their boating locations in response to low water levels – cont'd.

	<u>Changed boating locations</u>		$\chi^2/$ F-value(df)	<i>P-</i> <i>value</i>
	Yes	No		
Boat storage type				
Marina	44%	56%	6.824 (3)	0.078
Waterfront permanent home	31%	69%		
Cottage and second home	24%	76%		
Non-waterfront home	<u>29%</u>	<u>71%</u>		
	32%	68%		
Where boat is stored during season				
Michigan	38%	62%	1.513 (3)	0.679
Wisconsin	27%	73%		
Indiana	28%	72%		
Illinois	<u>27%</u>	<u>73%</u>		
	32%	68%		
Boat storage county location				
Lake Michigan costal counties	36%	64%	0.028(1)	0.498
Other counties	<u>28%</u>	<u>72%</u>		
	32%	68%		
Boating days & locations (Mean)				
Total number of boating days	33	25	4.378(1)	0.037
Lake Michigan boating days	16	6	11.420	0.001
Number of boating days on other Great Lakes	4.4	2.4	1.514(1)	0.219
Number of different boating counties/locations	2.3	1.5	19.855(1)	0.000
Requested or received any information concerning water levels				
Yes	58%	42%	4.593	0.020
No	<u>28%</u>	<u>72%</u>		
	32%	68%		
Own a waterfront home				
Yes	27%	73%	6.724(1)	0.008
No	<u>37%</u>	<u>63%</u>		
	32%	68%		

Model Specification

Variables having significant relationships with boaters who changed and did not change where they boated for use in the LOGIT model are (1) age, (2) boat length, (3) number of years the boat has been owned, (4) number of different boating counties/locations, (5) number of boating days, (6) boat type, (7) whether the boat owner requested any information concerning low water levels, and (8) whether the boat owner owns a waterfront home. The default category for boat type is pontoon boat.

The stepwise- backward begins with those independent variables described above. Seven variables have significant effects on the probability that a boater changed his/her boating locations in response to low water levels. Those variables are number of years the boat has been owned (at the 0.01 level), number of different boating counties/locations (at the 0.01 level), requested/received any information concerning water levels (at 0.10 level) and boat types: inboards (at the 0.01 level), inboard-outboards (at the 0.01 level), outboards (at the 0.01 level) and sailboat (at the 0.01 level).

LOGIT Model Parameter Estimations

The estimated LOGIT model is (Table 4.20):

$$\log it(p) = -143.795 + 0.072YEAR + 0.471NDBC + 0.782REQUEST + 1.414INBOARD + 1.217INOUT + 1.816OUTBOARD + 1.996SAIL$$

P = The probability that a recreational boater will change the boating locations in response to low water levels

YEAR = Number of years the boat has been owned

NDBC = Number of different boating counties/locations

REQUEST = Requested/received any information concerning water levels

INBOARD, INOUT, OUTBOARD, & SAIL = Boat types

The type of boats owned by boaters is significantly related to the likelihood that they will move “where they boat” because of their concerns about low water levels. The owners of sailboats are much more likely (7.4 times) to move locations in response to fluctuating water levels than the owners having pontoon boats. As would be expected, owners of pontoon boats are unlikely to move where they boat in large part because these boats are rarely found on the Great lakes and they are not very transportable.

Boaters who boat at more locations/counties are more likely to change boating locations to avoid problems associated with low water. The more different counties where they operate their boats, the more likely they are to move where they boat in response to low water levels. The probability that they will change their boating locations increases 1.6 times for one more different county/location where they boat. A majority of these boaters, who operated their boats in more than four different counties/locations, own outboards (average size 22 feet) that can be trailered to different locations, and many of them stored their boats at permanent homes (around 65%) and trailered (74%) them to boating locations rather than keeping them at marinas or second homes.

Boaters who requested information about low water are also more likely to change their boating locations. The boaters who requested any information about low water levels are 2.186 times more likely to change their boating locations in response to low water levels than the boaters who did not request the information about low water

levels. Again, it is not clear whether these boaters changed boating locations because they obtained this information, or they requested the information because they are just more sensitive and responsive (including changing boating locations).

Table 4.20. The result of the final binary LOGIT model for predicting/classifying boaters who changed boating locations in response to low water levels.

	β	S.E	Wald	df	Sig.	Exp(β)
Number of years the boat has been owned	0.072	0.023	9.930	1	0.002	1.074
Number of different boating counties/locations	0.471	0.164	8.221	1	0.004	1.601
Requested/received any information concerning water levels	0.782	0.414	3.566	1	0.059	2.186
Boat type						
Inboard motor boat	1.414	0.527	7.198	1	0.007	4.111
Inboard-outboards	1.217	0.457	7.081	1	0.008	3.378
Outboard motor boat	1.816	0.540	11.305	1	0.001	6.147
Sailboat	1.996	0.728	7.511	1	0.006	7.361
Pontoon	-	-	14.900	4	0.005	-
Constant	-143.795	45.462	10.005	1	0.002	0.000

Summary Statistics

Model chi-square [df] =44.048[11]*

Nagelkerke R^2 = 0.212

% Correct predictions=85%

* P -value < 0.05

LOGIT Model Evaluation and Correct Prediction

According to model chi-square statistics reported in Table 4.20, the final LOGIT model is strongly significant ($\chi^2=44.048$). The value of Nagelkerke's R^2 , the measures of the proportion of variation explained is around 21% for the final LOGIT model.

The percentage of correct predictions of whether a boater would change where they boat in response to low water levels is reported in Table 4.21. The LOGIT model has an overall prediction accuracy of 85%. As for previous models, correct classifications are shown in the diagonal cells and incorrect classifications in the off-diagonal cells. This binary LOGIT model correctly classifies 98% of boaters, who changed boating locations due to their experience with low water levels but it only correctly distinguishes 13% of boaters who did not change boating locations. It incorrectly classifies 2% of boaters who changed their boating locations as not changing locations and 87% of boaters who did not change their boating locations as changing their boating locations.

Compared to the maximum chance criterion-79%, the percent of correct classification of the LGOIT model resulted in an increase of 6%. The percent of correct classification (85%) is also higher than the proportional chance criterion (70%).

Table 4.21. Accuracy of final LOGIT model classifications of boaters who changed and did not change their boating locations in response to low water levels.

Observed	<u>Model classification/prediction</u>		
	Changed the boating location	Did not change the boating location	Percentage Correct
Changed the boating location (<i>Row Pct.</i>)	277 (98%)	5 (2%)	232 (98%)
Did not change the boating location (<i>Row Pct.</i>)	46 (87%)	7 (13%)	53 (13%)
Model Predicted (total)	273	12	285
Summary Statistics			
Percentage of cases correctly classified		85%	
Maximum chance criterion		79%	
Proportional chance criterion		70%	

4.4.2 LOGIT Model to Predict/Classify Boaters who Reduce their Boating in

Response to Low Water Levels

Of 451 boaters, who were influenced by low water levels, over half (54%) did less boating in response to low water levels.

Hypothesis Testing

The same independent variables used to develop the LOGIT model that classifies/predict boaters who change boating locations in response to low water levels are also used to formulate this model.

The result of the hypotheses testing identified a statistically significant relationship between whether a recreational boater will reduce the boating days in response to low water and their ages, number of years, a boat has been owned, total number of boating days, number of Lake Michigan boating days, number of different boating counties/locations, whether a boater requested/received any information concerning water levels, and whether a boater owns a waterfront home (Table 4.22).

Again age is the only socio-economic variable related to whether boaters reduced their boating (days) in response to low water. Boat type is not statistically significantly associated with reduced boating levels in reaction to low water levels. The number of years the boat has been owned and boat length are statistically related to a low water induced decrease in boating activity. The boaters who reduced their boating days have owned their boats longer than the boaters who did not reduced their boating days. This could in part be attributable to the fact that they are “older boats.”

During the boating season boat storage location (state or county) and type of storage (e.g., marina, waterfront permanent home, second home and non-waterfront home) are both not statistically significantly related to a propensity to reduce boating in response to low water levels and related problems. However, a greater proportion (about 44%) of the owners of boats kept at marinas reduced their boating.

Less active boaters, that is boaters who do less days of boating, and boaters who boat less days on Lake Michigan and other Great Lakes are more likely to reduce their boating as one response to low water levels. In all probability due to the fact that more frequent boaters are more experienced and knowledgeable about lake conditions including waste level and its impact on boating access and quality. Or, it may be due to

the fact that frequent boaters are more enthusiastic and just will not let water levels get in the way of their boating.

Table 4.22. Relationships between boater and boat characteristics and whether boaters did less boating in response to low water levels.

	<u>Did less boating</u>		$\chi^2/$	P -
	Yes	No	F-value(df)	value
Boater characteristics				
Age (Mean)	54	50	6.494(1)	0.001
Income				
Under \$60K	33%	67%	0.330(2)	0.330
\$60K to \$99K	31%	69%		
Over \$100K	<u>33%</u>	<u>67%</u>		
	32%	68%		
Boat characteristics				
Boat type				
Inboard motor boat	35%	65%	5.517 (4)	0.238
Inboard-outboards	36%	64%		
Outboard motor boat	29%	71%		
Powered sailboat	44%	56%		
Pontoon boat	<u>22%</u>	<u>78%</u>		
	32%	68%		
Boat length (Mean)	22	24	3.550(1)	0.055
Number of years the boat has been owned (Mean)	10	8	3.400(1)	0.066
Boat storage characteristics				
Boat storage				
Marina	44%	56%	2.399(3)	0.494
Waterfront home	31%	69%		
Cottage and second home	24%	76%		
Non-waterfront home	<u>29%</u>	<u>71%</u>		
	32%	68%		

Table 4.22. Relationships between boater and boat characteristics and whether boaters did less boating in response to low water levels – cont'd.

	Did less boating		$\chi^2/$	P -
	Yes	No	F-value(df)	value
Boat storage characteristics				
Boat storage state location				
Michigan	38%	62%	1.926(3)	0.588
Wisconsin	27%	73%		
Indiana	28%	72%		
Illinois	<u>27%</u>	<u>73%</u>		
	32%	68%		
Boat storage county location				
Lake Michigan coastal counties	36%	64%	0.910(1)	0.200
Other counties	<u>28%</u>	<u>72%</u>		
	32%	68%		
Boating days & locations (Mean)				
Total number of boating days	26	37	13.689(1)	0.000
Number of Lake Michigan boating days	10	16	10.638(1)	0.001
Number of boating days on other Great Lakes	3.5	4.8	0.194(1)	0.660
Number of different boating counties /locations	1.9	2.4	7.717(1)	0.006
Requested/received any information concerning water levels				
Yes	58%	42%	2.929(1)	0.054
No	<u>28%</u>	<u>72%</u>		
	32%	68%		
Own a waterfront home				
Yes	27%	73%	7.020(1)	0.005
No	<u>37%</u>	<u>63%</u>		
	32%	68%		

Model Specification

Variables having statistically significant relationships with the awareness of water level fluctuations for use in the binary LOGIT model are (1) boater's age, (2) boat length, (3) number of years the boat has been owned, (4) total number of boating days, (5) number of different boating counties/locations, (6) boating days (e.g. number of boating days on Lake Michigan and on other Great Lakes), (7) whether the owner requested or received any information concerning water levels, and (8) boat owner owns a waterfront home.

The stepwise-backward method begins with those independent variables described above. Then variables eliminated through the stepwise-backward models are "age," "type of boat," "number of years the boat has been owned," "number of boating days on other Great Lakes," and "whether they requested/received any information concerning water levels."

Five different variables have significant effects on the probability that a boater will reduce the volume of boating days in response to low water levels. The five variables are boat length (at 0.01 level), total number of boating days (at 0.05 level), number of different boating counties/locations (at 0.10 level), number of Lake Michigan boating days (at 0.10 level), and whether the boat owner also owns a waterfront home (at 0.05 level).

LOGIT Model Parameter Estimations

The estimated LOGIT model is (Table 4.23):

$$\log it(p) = -0.350 + 0.044LENGTH - 0.012NBD - 0.159NDBC - 0.017NBDLM + 0.589OWH$$

P = The probability that a recreational boater will reduce the volume of boating days in response to low water level

LENGTH = Boat length

NBD = Number of boating days

NDBC = Number of different boating counties/locations

NBDLM = Number of Lake Michigan boating days

OWH = The boater owns a waterfront home

The results show that more active boaters are less likely to respond to do less boating in response to low water levels. Every additional boating day reduces the probability that a boater will decrease their boating in response to low water levels. So one more day a recreational boater operate his/her boat, the boat owner is 0.988 times less likely to reduce the amount of his/her boating days in response to low water levels.

Boaters who boat in more different locations are also less likely to reduce boating days when confronted with low water levels. Possibly, these boaters are aware of and have more experiences at different locations and therefore have more alternatives available to them. One more different county/location a recreational boater operates his/her boat, the probability that the boat owner will reduce the amount of his/her boating days will decrease around 4%.

The model also indicates that boaters who own waterfront homes are more likely to reduce the number of days they boat because of low water. Boaters who own waterfront homes are almost 2 times higher to reduce the amount of boating days in response to low water levels than boaters who do not own waterfront homes. This is most likely because they are less able to move their boating to other locations. According to the result of previous LOGIT model, this variable is not related to the prediction of whether boaters will change their boating locations in response to low water levels. For a boater who owns a waterfront home, the possibility of reaction on reducing the boating days is significantly higher than the reaction on changing boating locations.

The equation produced by the LOGIT model can be used to predict the odds and the probability of a recreational boater who did less boating in response to low water levels for given values of those independent variables. Table 4.25 illustrates the calculation of probabilities that recreational boaters who did less boating in response to low water levels. If the boater owned a 20-foot boat, the probability for this boater to reduce the boating days in response to low water level is 63% with the default values (0) of four other variables (number of boating days, number of different boating locations, number of Lake Michigan boating days and own a waterfront home). The probability decreases to 45% if the boater operated the boat for 60 days during the boating season. If this boat was operated in three different locations, the probability will change from 45% to 30%. The probability will be 48 % if the boat owner has all of the earlier characteristics and also has a waterfront home.

Table 4.23. The result of the final binary LOGIT model for predicting/classifying boaters who did less boating locations in response to low water levels.

	β	S.E	Wald	df	Sig.	Exp(β)
Boat length	0.044	0.016	7.860	1	0.005	1.045
Number of boating days	-0.012	0.005	5.775	1	0.016	0.988
Number of different boating counties/locations	-0.159	0.096	2.753	1	0.097	0.853
Number of Lake Michigan boating days	-0.017	0.009	3.685	1	0.055	0.983
Own a waterfront home	0.589	0.262	5.069	1	0.024	1.802
Constant	-0.350	0.375	0.873	1	0.350	0.704

Summary Statistics

Model chi-square [df] =31.244[5]*

Nagelkerke R^2 = 0.126

% Correct predictions=64%

* P -value < 0.05

Table 4.24. The probability for the boaters who did less boating in response to low water levels by selected boater characteristics.

	<u>Example 1</u>			<u>Example 2</u>			<u>Example 3</u>			<u>Example 4</u>		
	β	Exp(β)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)	X	Exp(β X)
Boat length	0.044	1.045	20	0.88	20	0.88	20	0.88	20	0.88	20	0.88
Number of boating days	-0.012	0.988	0	0	60	-0.72	60	-0.72	60	-0.72	60	-0.72
Number of different boating counties/locations	-0.159	0.853	0	0	0	0	0	3	-0.477	3	-0.477	-0.477
Number of Lake Michigan boating days	-0.017	0.983	0	0	0	0	0	0	0	0	0	0
Own a waterfront home	0.589	1.802	0	0	0	0	0	0	0	1	0.589	0.589
Constant	-0.35	0.705	1	-0.35	1	-0.35	1	-0.35	1	-0.35	1	-0.35
In odds				0.53		-0.19		-0.667		-0.078		-0.078
y/(1-y)				1.699		0.827		0.513		0.925		0.925
y (P)				63%		45%		34%		48%		48%

LOGIT Model Evaluation and Correct Prediction

According to model chi-square statistics reported in Table 4.23, the final LOGIT model is strongly significant ($\chi^2=31.244$). The value of Nagelkerke's R^2 , the measures of the proportion of variation explained is around 13% for the final LOGIT model. The low R-square indicates there is a need for adding more other independent variables to improve this model's performance.

The percentage of right classification/prediction of whether recreational boaters will reduce their boating days in response to low water levels substantiates the predictive power of the final LOGIT model, which yields a hit ratio of 64% with correct classification in the diagonal cells and incorrect classifications in the off-diagonal cells (Table 4.25). It correctly classifies 67% of boaters, who did less boating because of low water levels, and 61% of boaters who did not respond to low water levels by reducing their boating activity level. However, the model incorrectly classifies 33% of boaters who did less boating as boaters who did not reduce their boating activity levels. Conversely, 39% of boaters who did not reduce their boating because of the low water were incorrectly classified as having reduced their boating.

Compared to the maximum chance criterion-54%, the percent of correct classification of the LGOIT model resulted in an increase of 10%. The percent of correct classification (64%) is also higher than the proportional chance criterion (50%).

Table 4.25. Accuracy of final LOGIT model classifications of boaters who did and did not do less boating in response to low water levels.

Observed	<u>Model classification/prediction</u>		
	Did less boating	Did not do less boating	Percentage Correct
Did less boating (<i>Row Pct.</i>)	106 (67%)	52 (33%)	158 (67%)
Did not do less boating (<i>Row Pct.</i>)	61 (39%)	96 (61%)	157 (61%)
Model Predicted (total)	167	148	315
Summary Statistics			
Percentage of cases correctly classified		64%	
Maximum chance criterion		54%	
Proportional chance criterion		50%	

CHAPTER 5

CONCLUSIONS

This final chapter is presented in four sections: (1) a summary of the principal study findings from the five binary LOGIT models, (2) the implications and applications of the results from the data analyses and five binary LOGIT models, (3) the limitations of the study, and (4) the recommendations for future research.

Boating is an extremely important recreation activity and tourism industry in the Great Lakes. In 2001, over 2 million recreation watercraft were registered in Michigan, Wisconsin, Indiana and Illinois. Of these boats, over 370,000 were registered to owners in 34 Lake Michigan coastal counties. Recreational boaters support a major boating industry and bring the positive economic impact including \$760 million from boating trips and \$635 million from boat purchases in 2002 for Michigan. There is a mounting concern relating to a host of challenges confronting recreational boaters and the boating industry including efforts to limit access to boating waters, regulations limiting the development and improvement of boating facilities and services, insufficient funding of state boating programs, lack of a comprehensive boating plan, and fluctuating Great Lakes water levels. Great Lakes water levels fluctuate over time because of the differences in precipitation, temperature and other climatologic factors. However, over the past five years, Lake Michigan-Huron are experiencing the lowest water levels in 35 years. This fact, in combination with other factors, is having a major impact on marine businesses, especially many small marinas that service boaters on the Great Lakes.

A number of recent studies focused on the actual revenue and cost impacts of fluctuating Great Lakes water levels. These economic and financial impacts were caused in part by changes in boater behavior (e.g., reduced boating) in response to low Great Lake water levels about the affects of boater behaviors. This study instead focused on creating a better understanding whether and how boaters perceive Lake Michigan water levels and how these perceptions affect their boating. Five binary LOGIT models were estimated in order to assess and determine various factors, which influence recreational boaters' awareness and assessment about water level changes. The LOGIT models also assess the relationship of various boat and boater characteristics in determining how boaters perceive, are influenced by, and if and how they adjust their boating (e.g., amount, locations) in response to their awareness of low Lake Michigan water levels.

5.1 Summary of Major Findings

The main purpose of this study was to develop a series of LOGIT models to better understand the relationship between boater and boating characteristics and awareness, perceptions and responses to low Lake Michigan water levels. The five binary LOGIT models that were developed and evaluated are summarized in Table 5.1. The summary includes the relevant study objective, data sources, number of boaters included in the model building analyses, dependent variables, the number of stepwise LOGIT models that were formulated, significant independent variables comprising the final models, and the prediction percentage for each LOGIT model. The parameters and P-values for the significant independent variables incorporated in the five final LOGIT models are presented in Table 5.2.

Table 5.1. Summarized results for the five Lake Michigan water level binary LOGIT models.

	Objective 1		Objective 2	Objective 3
Objective	To assess recreational boaters' awareness and appraisal of the magnitude of changes in Lake Michigan water levels		To identify which types of boaters are most likely to be influenced by water level changes	To identify the relationships between the possible behavioral changes influenced by water level changes and boat and boater characteristics, boat storage segments and locations and boating days & locations
Data source	Telephone survey	Telephone survey	Mail survey	Mail survey
Cases analyzed	1,646 boaters	1,177 boaters	1,386 boaters	451 boaters
Dependent variables	Boaters are aware of Lake Michigan water level changes	Boaters perceived or assessed that Lake Michigan water levels had dropped a lot	Boaters are influenced by concerns relating to low Lake Michigan water levels	Boaters reduced their boating (days) in response to low Lake Michigan water levels
Significant independent variables identified by hypotheses testing	1. Income 2. Education 3. Gender 4. Permanent state of residence 5. Location of permanent residence 6. Boat length 7. Boat type 8. Where boats were operated (e.g. on Lake Michigan & on other Great Lakes)	1. Boat length 2. Boat type 3. Number of years the boat has been owned 4. Where boats were operated (e.g. on Lake Michigan, on other Great Lakes) 5. Boat storage type 6. Boat storage state location 7. Boat storage county location 8. Boating activity (e.g. water skiing)	1. Age 2. Boat length 3. Number of years the boat has been owned 4. Number of different boating counties/locations 5. Number of different boating counties/locations 6. Boat type 7. Whether the owner requested or received low water information 8. Owned a waterfront home	1. Age 2. Boat length 3. Number of years the boat has been owned 4. Total number of boating days 5. Number of different boating counties/locations 6. Boating days (e.g. the total boating days on Lake Michigan, and on other Great Lakes) 7. Whether the owner requested or received low water information 8. Boat owner owns a waterfront home

Table 5.1. Summarized results for the five Lake Michigan water level binary LOGIT models – cont'd.

Number of stepwise- backward LOGIT models	Objective 1			Objective 2		Objective 3	
	8 models	5 models	9 models	9 models	6 models	9 models	
Significant independent variables comprising the final model	1.Income 2.Gender 3.Permanent state of residence (e.g., Michigan, Wisconsin & Indiana) 4.Location of permanent residence (e.g., Lake Michigan counties & next to Lake Michigan counties) 5.Where boats are operated (e.g., on Lake Michigan)	1.Boat length 2.Boat type (e.g., inboard-outboards, inboards & pontoon boat) 3.Number of years the boat has been owned 4.Where boats are operated (e.g., on other Great Lakes) 5.Type of boat storage (e.g., cottage & second home) 6.State where boats are stored during the boating season (e.g., Wisconsin, Indiana, & Michigan) 7.County where boats are stored during the boating season (e.g., in Lake Michigan coastal counties)	1.Boat length 2.Boat type (e.g., inboard-outboards, sailboat & pontoon) 3.Number of different boating counties/locations 4.Type of boat storage (e.g., Non-waterfront home) 5.State where boats are stored during the boating season (e.g., Michigan & Indiana) 6.Whether the owner requested or received low water information 7.Whether boats are trailered to launch sites	1.Number of years the boat has been owned 2.Number of different boating counties/locations 3.Boat type (e.g., inboard-outboards, outboards, sailboat & pontoon) 4.Whether the owner requested or received low water information	1.Boat length 2.Number of boating days 3.Number of different boating counties/locations 4.Number of Lake Michigan boating days 5.Boat owner owns a waterfront home		

Table 5.2. A summary of statistically significant independent variable parameters comprising the Lake Michigan water level binary LOGIT models.

	Objective 1		Objective 2		Objective 3	
	Awareness of Lake Michigan Water Level Model	Perceptions of the Drop in Water Levels Model	Concerns about Low Water Level Influences Boaters Model	Low Water Levels Change Boating Locations	Low Water Levels Reduce Boating Amount	
	β	β	β	β	β	Sig.
Boater characteristics 1. Income 2) \$45K to \$60K 2. Gender 3. Permanent state of residence 1) Michigan 2) Wisconsin 3) Indiana 4. Location of permanent residence 1) LM coastal counties 2) Adjacent to LM coastal counties	-0.456					
	0.046					
	0.020					
	1.885					
	0.380					
	0.624					
Boat characteristics 1. Boat length 2. Boat type 1) Inboard-outboards 2) Inboards 3) Sail boat 4) Pontoon boat 3. Number of years the boat has been owned	1.627					
	0.000					
	1.419					
	0.052	0.020	0.028	0.021	0.044	0.005
	-0.432	0.077	-0.456	0.019	1.217	0.008
	-1.045	0.002			1.414	0.007
	0.048	0.017			1.996	0.002
					0.072	0.002

Table 5.2. A summary of statistically significant independent variable parameters comprising the Lake Michigan water level binary LOGIT models – cont'd.

	Objective 1		Objective 2		Objective 3	
	Awareness of Lake Michigan Water Level Model		Perceptions of the Drop in Water Levels Model		Concerns about Low Water Level Influences Boaters Model	
	β	Sig.	β	Sig.	β	Sig.
Boat storage characteristics						
1. Type of boat storage						
1) Non-waterfront home						
2) Cottage & second home						
2. State where boats are stored during the boating season						
1) Michigan						
2) Wisconsin						
3) Indiana						
3. County where boats are stored during the boating season						
Lake Michigan coastal counties						
Boating locations and number of boating days						
1. Number of different boating counties/locations						
2. Boating days						
1) Total boating days						
2) Lake Michigan boating days						

Table 5.2. A summary of statistically significant independent variable parameters comprising the Lake Michigan water level binary LOGIT models – cont'd.

	Objective 1				Objective 2		Objective 3			
	Awareness of Lake Michigan Water Level Model		Perceptions of the Drop in Water Levels Model		Concerns about Low Water Level Influences Boaters Model		Low Water Levels Change Boating Locations		Low Water Levels Reduce Boating Amount	
	β	Sig.	β	Sig.	β	Sig.	β	Sig.	β	Sig.
Boating locations and number of boating days										
3. Where boats are operated										
1) on Lake Michigan	2.778	0.000								
2) on other Great Lakes			-0.680	0.056						
Other types of information										
1. Whether the owner requested or received low water information					0.979	0.000	0.782	0.059		
2. Whether boats are trailered to launch sites					0.546	0.008				
3. Boat owner owns a waterfront home									0.589	0.024
Constant	-1.409	0.000	0.035	0.955	-2.504	0.000	143.795	0.002	-0.350	0.350
Model Chi-Square [df]	456[9]		61[9]		86[11]		44[11]		31[5]	
Nagelkerke R²	48%		16%		16%		21%		13%	
Percent of cases correctly classified	82%		79%		69%		85%		64%	
Maximum chance criterion	72%		74%		67%		79%		54%	
Proportional chance criterion	60%		63%		56%		70%		50%	

The LOGIT Models and Related Findings

The first LOGIT model reveals that boat owners, who have higher incomes (more than \$60K), register their boats in Michigan and especially in Lake Michigan coastal counties, and operate their boats on Lake Michigan, are much more likely to be aware of Lake Michigan water level changes. This could be anticipated because the water level situation on Lake Michigan received a significant amount of media coverage, which is more than the other three states. Also, and as will be discussed later, previous studies including the Lake Michigan Potential Damages Study indicate that low water levels had a more dramatic impact on boating facilities on Michigan's Lake Michigan boating facilities and access to boating including marinas and boating services.

As might be anticipated, the more frequently boaters boat on Lake Michigan, the more likely they are to be aware of fluctuations in Lake Michigan water levels. Owners of boats that are operated on Lake Michigan are 16 times more likely to be aware of Lake Michigan water levels than registered boaters who do not boat on Lake Michigan. Also, as would be expected the closer boat owners live relative to Lake Michigan, the greater the likelihood they are aware of changes in the lake's water levels. Interestingly, the characteristics of the boats they own and where they store their boats during the boating season do not appreciably shape their awareness of Lake Michigan water levels. This is unexpected given that owners of boats kept at marinas and waterfront homes and cottages are more susceptible to low water because they are less able in the short term to shift locations (e.g., trailer their boats to different locations) to avoid low water problems. Also, larger boats and sailboats because of their drafts are more likely to be impacted by low water conditions.

Conversely, the second LOGIT model that focused on boaters' assessment/perceptions of the extent of Lake Michigan water level changes shows that assessment/perceptions of the extent of Lake Michigan water level fluctuations is significantly related to the characteristics of the boats that owners operate and also the type and locations where boats are stored during the boating season. Boater characteristics are not significant in this second sequential model because only boaters who were aware of low water levels (which is related to socio-economic characteristics) were included in the development of the model so their effects are already incorporated. Owners of larger boats who are more liable to be impacted by low water levels are more likely to perceive that Lake Michigan water levels had dropped "a lot." This is in part due to the fact that even relatively small drops in water levels can have a significant affect on access by larger boats. Also, large boats are generally stored at marinas and many marinas, because of their locations and reduced dredging, were significantly impacted by lower water levels. Boaters who store their boats in Lake Michigan coastal counties, especially in Michigan, are much more prone to perceive that water levels had dropped "a lot." This substantiates previous studies discussed in the literature review that shows the impact of low water levels (e.g., on marinas and boat launches) was much greater in Michigan than the other Lake Michigan states.

On average boaters who perceive that water levels had dropped "a lot" estimate they dropped 3 feet during the past three years compared to a 1.6 feet drop estimated by boaters who perceive they had remained constant or dropped just "a little." Interestingly the estimate/perception that the Lake Michigan levels had dropped of 3 feet is very close to the actual change in Lake Michigan water levels, which was 3.4 feet between 1997 and

2001. This indicates that the owners of larger boats (who were more likely to perceive that water levels had dropped a lot) are more accurately informed about Lake Michigan water levels. Also, larger boats are more likely to be outfitted with more sophisticated equipment including depth indicators and boat-to-boat communications. Small boat owners, since they are impacted less directly by low water levels, appear to be less informed about the degree of water level changes.

The third LOGIT model is intended to determine factors that influence whether boaters' behavior is actually influenced by low Lake Michigan water levels. Similar to the previous model, whether a boater is influenced by low water levels is influenced by the characteristics of their boats and where they store their boats, and is also related to whether they trailered their boat to the launch site and if they sought information relating to low water levels. As would be expected, owners of larger boats, boats that are kept in Lake Michigan coastal counties, and boats that are trailered are more likely to be influenced by low water levels. Low water has a major impact on accessibility of boat launch sites. In 2002, thirty-five of the 134 public launch ramps located in 34 Lake Michigan coastal counties were closed due to the same reason (Planning & Zoning Center, Inc. et. al, 2002). It is also more probable that boaters who requested information about water levels are influenced by low water levels. Whether boaters request information is a result of low water conditions, or they are aware of low water and change behaviors because they requested and had available the information is not evident from the results. It is assumed that boaters who are more sensitive to low water, or who had experienced low water problems (e.g., damage, inaccessible facilities) are more prone to seek out information on the topic.

The fourth LOGIT model shows that boaters are more likely to change their boating locations because of low water if they own inboard-outboards, inboards, or sailboats and if they boat at more different counties. Sailboaters are most likely to change where they boat to avoid low water situations because they are very susceptible to being damaged or denied access because of insufficient water levels. Boaters who boat at more locations appear more flexible, capable and willing to change where they boat. So, while low lake levels significantly impacted access to many Lake Michigan boat launch sites used by trailered boats, the fact that these boats can be moved more easily to different locations provides them access to more substitute areas. This, in part, confirms the importance that boating programs in the Great Lakes states has been directed at providing boating access to different locations along the Great Lakes.

Boaters who boat more often and at more locations are less likely to reduce their boating in response to low water. This may be because of their enthusiasm for boating (“low water is not going to get in their way”), or because they are more knowledgeable about locations where low water will not impede their boating. Boaters who own larger boats are more prone to reduce their boating days because of low water levels. Also, boaters who own waterfront homes are also more likely to reduce their boating because of low water levels in large part because they are less able to move to other boating places. During 2001 and 2002 there was a backlog in dredging and many channels that provide access to larger boats were either inaccessible or had very limited access. Many privately owned docks and piers where large boats are stored were also inaccessible because of an inability to do maintenance dredging.

Evaluations of the LOGIT Models

The models were assessed for multicollinearity by looking at the number of the iterations and estimated standard errors. The number of iterations for five models (10 for Model 1, 5 for Model 2, 13 for Model 3, 6 for Model 4, and 9 for Model 5.) indicate there is no a signal of multicollinearity in the data set. Besides, the value of the estimated standard errors for all estimation outputs are less than 1, which also indicates no multicollinearity in the data set.

Each of the five final LOGIT models developed through the stepwise-backward process is significant at the 0.01 level (chi-square statistic). Again this suggests that the amount of the variation in boaters' awareness and perceptions about the Lake Michigan water level changes, whether they are influenced by low water level concerns, and if they respond to low water levels by changing boating locations and/or reducing their amount of boating that are explained by the binary LOGIT models is significantly different from zero.

Nagelkerke's R^2 (a measure of success of predicting the dependent variable from independent variables) is another way of assessing LOGIT models. The "Awareness of Lake Michigan Water Level Model" explains about 48% of the variation in the data, the "Perceptions of the Drop in Water Levels Model" explains 16% of the variation and the "Concerns about Low Water Level Influences Boaters Model" explains 15%. The last two models "Low Water Levels Change Boating Locations" and "Low Water Levels Reduce Boating Amount" Models explain 20% and 13%. In the social sciences, it is quite rare to have the highest R^2 (e.g., over 90%), which might indicate the problem of high multicollinearity and unreliable of the estimations of those independent variables.

McFadden (1979) has suggested that Pseudo R^2 values¹ between 0.2 and 0.4 should be taken to represent a very good fit of the model. The values of 13%, 15% and 16% are still accepted number in the social science research. The small R-square (like 13%) might indicate we need to include more other independent variables in the model.

The binary LOGIT accurately predicts 85% of boaters who change their boating locations due low water levels. The “Awareness of Lake Michigan Water Level Model” correctly predicts 82% of the boaters who are aware of Lake Michigan water level. These two models (about their awareness model and the changes on the volume of their boating days) have almost the same values (both over 60%) in prediction percentages for the respondents who answered “Yes” and “No”. However three other models (the assessment, whether boaters are influenced by low water, and whether they changed their boating location) have extremely high prediction percentage in one group, whose response is equal to “YES” but extremely low prediction percentage in the other group.

5.2 Interpreting and Applying the Results of the LOGIT Models

The LOGIT model can be used to identify associations between dependent variables and independent variables. The LOGIT model can also be used to explore how various explanatory variables affect the probability of an event (e.g., boaters reduce their boating or change locations) occurring. They can be used additionally to forecast or make predictions concerning the likelihood that boaters will be aware of Lake Michigan water level, be influenced by low water, change their boating locations or reduce their amount of boating given certain boat owner, boat storage and boat characteristics.

¹ Pseudo R^2 is another type of R-square, produced by the LOGIT models and very similar to the Nagelkerke’s R^2 .

Since the LOGIT model is nonlinear, the magnitude of the change in the outcome probability associated with a change in one of the independent variables depends on the levels of all of the independent variables incorporated as part of the model. This makes interpretation of the estimates of the parameters for the independent variables more difficult. It is even more difficult to interpret the estimates of parameters for categorical data.

The study shows that certain boater segments (e.g., large boats, sailboats, boats stored at waterfront homes) respond to low water levels in various ways and that some boaters (e.g., boaters who live in coastal counties) are more aware of water levels. The five LOGIT models can provide agencies and marine businesses a better understanding of how fluctuating Great Lake water levels can affect on boater's behavior including how much boating they do and where they boat.

The model also provides additional verification of the findings from previous studies. The Lake Michigan Potential Damages Study showed that Lake Michigan boating facilities in Michigan were more severely impacted by low water. In part this is because many of these facilities were built many years ago during a period of relatively high water levels. Many were situated in locations that are very susceptible with lake level fluctuations using technologies (e.g., fixed docks, launch ramps) that do not adjust well to water level fluctuations. Conversely in Wisconsin, Lake Michigan boating facilities were situated in locations less vulnerable to low water using technologies like floating docks that adjust better to fluctuations. As a result, boaters in Michigan are more aware (because they are more impacted) of water level fluctuations and more likely to reduce their boating and change their boating locations because of low water. This

suggests that boating agencies and private marine businesses need to be more cognizant of lake level fluctuations when situating and designing boating facilities. It may be economically justifiable to consider relocating and redesigning boating facilities to make them less susceptible to fluctuating water levels especially in light of the implications of possible long-term weather changes (e.g., climatic warming). Further development and testing of LOGIT models intended to understand factors that influence boater behaviors, could aid in deciding where to best invest redesign and relocating investments.

The LOGIT model results also suggest the potential long-term importance of factors that may reduce the accessibility and quality of boating opportunities. The LOGIT models suggest that more avid and involved boaters are less likely to let low water reduce their boating. However, the models show that less involved and inactive boaters are more prone to reduce or stop boating when confronted by additional costs and barriers. Given the large number of inactive boaters (as many as 400,000 annually of 1.1 million Michigan registered boaters) and concerns about increasing dropout rates, the impacts of low water and deterioration in other environmental factors (e.g., water quality, crowding) could have significant long-term impacts on future boating participation and the well-being of the boating industry.

The LOGIT models show that boaters are far from homogenous in terms of their sensitivity and responsiveness to environmental factors that influence accessibility and quality of their recreational experiences. Some boaters will reduce their boating activity and change the locations where they boat if environmental factors, in this case water level, change or deteriorate. The water level is just one of many environmental factors (e.g., water quality, aesthetics), or product attributes, that influence the “demand” for

recreational boating opportunities. Better understanding how recreation boaters – the demand side of boating industry are aware and perceive about this water environment changes, how they are influenced by this water environment and how they react to this water environment are all very important to the policy, investment and management decisions for public boating authorities and agencies, and the recreational boating industry.

The LOGIT models can also assist businesses, agencies and coastal communities anticipate and take action to mediate the negative impact of low water. It also provides evidence that boaters may be more sensitive to other boating environmental factors than originally believed. Given that the Great Lakes water levels are cyclic and impacted by climatic conditions, boating agencies and businesses must more seriously consider investments in facilities and maintenance to mediate against low and high water conditions. The impact of low and high water conditions should be taken into consideration when setting boating facilities and services. Also, the Department of Natural Resources should use the results of the Lake Michigan Damages Study to evaluate redesign of their Great Lake boat launch sites.

The LOGIT models also reveal that boaters indicate that most boaters have varying perceptions of the degree that water levels had dropped. Only 15% of all boaters requested the information about Lake Michigan water level changes. However, more than half (58%) of the boaters, who were influenced (location, amount of boating), requested the information about water levels. The results indicated that the majority of boaters have inadequate information and incomplete knowledge concerning water level changes in the Great Lakes. Many are making decisions including whether and where to

boat based on inaccurate perceptions. And, these decisions have a significant economic impact on marine businesses and coastal communities. Making information concerning water levels and their impact on boating facilities and services more conveniently available can minimize the negative influence of the low water level on recreational boaters. This will require an effort from public agencies, boating organization and business to develop and disseminate information about the water levels and the resultant impact on boating facilities and services.

5.3 Limitations

Several limitations related to the method and model utilized as part of this study are evident. First the data used to develop the LOGIT models was collected as part of a larger study with multiple purposes. While a primary purpose was to develop a more comprehensive understanding of how low water impacts on boater behaviors, the two surveys were also required to collect data to produce the Lake Michigan Potential Damages Study. If the sole purpose of the study had been to develop and test the LOGIT models, additional different information could have been collected.

In relation to the potential limitations of the data, two distinct collection methods (mail, telephone) were utilized where each has its own purpose, sample, and method. So, there might be some differences between the two data sets. The “Awareness of Lake Michigan Water Level” and “Perceptions of the Drop in Water Levels” Models were developed using data collected in the 2001 Lake Michigan Damages Study telephone survey. The other three binary LOGIT models were developed by using the data from the 2001 Lake Michigan Damages Study mail survey. Although both surveys relied on

samples of registered boats the sampling proportions were different. There might be a bias by using two different datasets. Furthermore with the same dataset, more statistical models such as nested LOGIT model can be considered to use in this study.

The 2001 Lake Michigan Potential Damages Study was designed to assess boater awareness and perceptions of Lake Michigan water level and the impact of the low water levels on recreational boating. The emphasis was on collecting information from Lake Michigan boaters. However, no list of Lake Michigan boaters was available to be used as a sampling frame. The only list available was the Registered Boat Owner list from four states. A stratified sampling method was employed to identify as many Lake Michigan boaters as possible. Half of the sample was boaters who registered their boats in 34 Lake Michigan coastal counties. A higher proportion of owners of larger boats were drawn for the 2001 Lake Michigan Potential Damages Study mail survey. The concern is that the owners of smaller boats who live in inland counties but boat on Lake Michigan were less likely to be sampled and surveyed. The extent of the bias that could have been introduced because of this sampling method is unknown.

A primary emphasis of study is to determine if, and how water levels induce changes in boating behavior – how much boater's boat and where they boat. The influence of low water on other boater behaviors was not analyzed. For example, some boaters did not put their boats in the water in 2002 because of low water, and some moved where they stored their boats (e.g., marinas) because of low water. Even though a large number of registered boaters were sampled and a high response rate was realized, not enough responses from persons exhibiting these low water induced behaviors to develop LOGIT models.

5.4 Overall Implications and Recommendations

This study only focused on modeling recreational boaters' awareness and response to a certain boating related environmental factor – water levels. Obviously, while water level is important there are many other environmental factors that can influence boating behaviors such as water quality/ pollution, lake erosion, boating crowding, and aesthetics. This study suggests that there is both a need and potential to conduct additional studies that focus specifically on boater responses to various environmental factors. Future studies employing LOGIT models could model the boaters' attitudes or responses to the water quality changes. Boaters could be studied to determine their awareness and sensitivity to various measures of quality including clarity and sight depth (Adamowicz, 1994; Lupi, 1998; Siderelis & Moore, 1998; Soutukorva, 2000). Since a great deal of boating is fishing related, it would also be useful to conduct studies to better understand how contaminants and reduced catch rates of fish influence boater behaviors.

There is also the potential to monitor awareness and behavioral responses to quality and quantity of boating facilities and services and also boating accessibility. According to LMPDS results, many marinas' slips and public boat launch sites are not accessible due to the fluctuating water levels. In some areas of the state the quality of boating facilities has declined and it would be interesting to determine whether boaters are sensitive to these changes and how the changes affect the amount and location of their boating. It would also be interesting to assess boater awareness and responsiveness to crowding and conflicts with other water users.

Some previous studies have found that often people do not change their behaviors in ways that are consistent with their perceptions related to environmental changes (Tarrant & Green, 1999). So while they may perceive reduced environmental quality, they may not reduce their boating or the locations in a way that is obviously consistent with their perceptions. There may be mediating circumstances such as available substitutes and the awareness of these substitutes that need to be identified and better understood. Unfortunately, because this study utilized two different data sets to develop the different LOGIT models, it is not possible to completely understand and describe the relationship between boater awareness and behavioral response to low water levels. Future research on low water levels and other environmental factors and their relationship to boating behavior should collect data in such a way to permit the researchers to assess a correlation between perceptions and behaviors.

The study also suggests the boating industry and boating agencies that develop and operate boating facilities and services (e.g., fuel facilities, launch ramps) need to focus more attention on water fluctuations and environmental factors in relationship to how they design and where they locate boating facilities. Actual and anticipated changes in environmental factors may warrant consideration of changing the design and location of existing boating facilities. This study and the Lake Michigan Potential Damages Study indicate that some boaters are impacted by low water and some actually alter their behaviors in response to low water conditions and probably other environmental factors. Recognizing this, businesses and communities that are heavily involved and dependent on recreational boating need to be more cognizant of the implications of changes in

environmental factors on boater behaviors and incorporate this information in their decisions regarding investments in boating facilities and services.

This study also suggests that state and federal boating agencies with the support of the boating industry must be more involved in efforts to protect and enhance the environment that supports Great Lakes boating. Current industry efforts to secure funds for environmental protection, dredging and redevelopment of boating facilities (both public and private) in response to changes in the environment are supported by this study. Industry efforts such as the Clean Marinas Program are also consistent with the findings of this study.

The findings also show that only certain segments of boaters were aware of low Lake Michigan water levels, and many did not have an accurate understanding of how significantly water levels had dropped up until 2001. Clearly, there is a benefit of more carefully targeting information aimed at boaters in order to develop a broader and more accurate understanding of water level fluctuations. This same conclusion applies to changes in other environmental factors.

Another recommendation to future research is to increase the sample size and collect more exact data on which to develop the LOGIT models. Modeling boater response to various environmental factors, facilities and services, access, and possibly crowding will require more precise information on their perceptions and behaviors in response to changes in these factors. The sample size (1,386 boaters who responded to the mail survey) was still not large enough to develop LOGIT models for specific types of behavioral changes (e.g., changes of boat storage locations). A larger number of cases would have permitted the development of nested LOGIT model. A three-level nested-

LOGIT (aware or not aware of low water levels, influenced or not influenced by low water levels, and the different types of response to low water levels) could have been attempted.

Data should be collected immediately after the boating season or possibly through a diary of boaters' boating activity. The 2001 Lake Michigan Potential Damages telephone survey interviewed recreational boaters from December 2001 to January 2002. Questions should exact information about how they changed boating (amount, locations) when they perceived changes in various environmental factors.

Most previous boating studies have focused on boater characteristics, use levels and boater spending. This study has demonstrated the potential benefits of modeling boater awareness and behavioral responses to environmental factors. In the future, more attention and effort need to be given to the modeling of recreational boaters' awareness/attitudes/responses toward the quality of boating environment including water level, water quality, boating facilities and services or boating accessibility.

APPENDICES

APPENDIX A

Application for Certificate of Watercraft Title and/or Registration of Michigan



Application for Michigan Watercraft Title



TRANSACTION TYPE		MC NUMBER		EXPIRES ON:		COUNTY OF RESIDENCE		CODE		REG. FEE	
YEAR		MAKE		LENGTH		HULL IDENTIFICATION NUMBER				TITLE FEE	
HULL MATERIAL		CODE		TYPE		CODE		POWER		CODE	
FUEL		CODE		MODEL OR SERIES NUMBER		OWNER'S DRIVER LICENSE NUMBER		DATE OF BIRTH		REG. TRANSFER	
OWNER'S NAME(S) AND ADDRESS										TOTAL	
										FULL RIGHTS TO SURVIVOR	

FIRST SECURED PARTY		FILING DATE		SECOND SECURED PARTY		FILING DATE	

APPLICANT IDENTIFICATION	
☐ Owner	☐ Other Name _____
I.D. presented _____	
Reason for Exempt Title: ☐ Lost ☐ Stolen ☐ Misused (attached)	

LEGAL PAPERS		
TYPE OF DOCUMENT	COUNTY	STATE
COURT	FILE OR POCKET	DATE EXAMINED
BRANCH OF DCI	EXAMINER (PH)	

CLAIM FOR TAX EXEMPTION		USE TAX RETURN		PURCHASE DATE:	
REASON:		1. Purchase price or retail value, whichever is greater.		SELLER'S NAME AND ADDRESS:	
		2. 6% Tax			
I certify the tax exemption shown above is valid. Initial box: ☐		3. Credit for tax paid to a reciprocal state (proof attached)			
I certify I own this watercraft and all information on this application is correct to the best of my knowledge.		4. Tax Being Paid			
New Owner's/Applicant's Signature		HULL MATERIAL		TYPE	
☒		1. Wood		1. Open	
☒		2. Steel		2. Cabin	
		3. Fiberglass		3. Sail	
		4. Aluminum		4. Row	
		5. Other		5. Canoe	
				6. Pontoon	
				7. Personal WC	
				POWER	
				1. Inboard	
				2. Outboard	
				3. Sail	
				4. Sail/W Power	
				5. Other	
				6. No Power	
				7. Jet Propulsion	
				USE	
				1. Pleasure	
				2. Commercial	
				3. Sail	
				4. Other	
				5. Commercial Freight	
				6. Commercial Fishing	
				FUEL	
				1. Gas	
				2. Diesel	
				3. Electric	

Contact a Secretary of State branch office if you do not receive your title within 60 days.

Final determination of the correct tax liability will be made by the Michigan Department of Treasury. You may be required to document your tax return or prove you are entitled to the exemption claimed. If you cannot support your claim, minimum penalties include the added tax, a negligence penalty, plus interest from the date of filing this application. Additional penalties can be imposed including criminal prosecution or assessing up to 175% of the tax due.

EXEMPTION - TRANSFERS BETWEEN RELATIVES: An exemption from use tax is allowed when the new owner is the spouse, father, mother, brother, sister, child, stepparent, stepchild, stepbrother, stepmother, half brother, half sister, grandparent, grandchild, legal ward, or legally-appointed guardian of the previous owner. Documentation proving the relationship may be requested by the Michigan Department of Treasury.

VALIDATION:

Candice S. Miller, Secretary of State
Authority granted under Public Act 160 and Public Act 303 of 1967 as amended.

AMOUNT RECEIVED	CHANGE

APPENDIX B

Application for Certificate of Watercraft Title and/or Registration of Wisconsin

Wisconsin Boat Registration and Titling Application

Form 9400-193 (R 7/01)

Please Check Application Types - See Instructions

BOAT REGISTRATION (Including fleet boats)

☐ Original Registration ☐ Transfer and Renewal
☐ Transfer ☐ Renewal

Fleet Number (if any) _____ Dealer ID _____ Original Cert. _____
 Renewal Cert. _____

REPLACEMENT MATERIAL Reason: _____

☐ Certificate ☐ Title ☐ Decals

DNR Hunting / Fishing Cust ID (9 digits) (optional) _____

Leave Blank - DNR Use Only

Date _____

Verified Tax Due _____ Verified Total Amount Rec'd _____

Reg. # _____ Type _____

WS _____ C M _____ BR BF BD DV _____

Verification _____ Filt. Ct. # _____ Att _____

N O S T W _____ N Y _____

Trans. Type _____ Initials _____

O T R D C DD DT RT _____

Owner's Name - Last, First, Middle Initial (Print) _____ Daytime Telephone () _____

Mailing Address _____ Check here if address change ☐ Date of Birth _____

City _____ State _____ ZIP Code _____ County _____

State of Principal Use _____ U.S. Citizen ☐ Yes ☐ No

Wisconsin WISCONSIN

Wis Registration # (If Any) _____ Boat Hull Identification # (Verify numbers on boat) _____ Boat Make or Manufacturer _____

Out of State Registration # (If Any) _____ Series or Model _____ Boat Length _____ ft _____ in _____ Model Year _____ Purchase Date _____ County Where Boat Kept _____

Engine _____ Propulsion _____ Type of Boat _____ Hull Material _____ Fuel _____ Type of Use _____

1. ☐ Outboard 1. ☐ Propeller 1. ☐ Open 6. ☐ Pontoon 1. ☐ Wood 5. ☐ Rubber 1. ☐ Gasoline 1. ☐ Pleasure 5. ☐ Other
 2. ☐ Inboard 2. ☐ Water Jet 2. ☐ Cabin 7. ☐ Sailboat 2. ☐ Aluminum 6. ☐ Other 2. ☐ Diesel 2. ☐ Rental
 3. ☐ Inboard- 3. ☐ Air Thrust 3. ☐ House 8. ☐ Inflatable 3. ☐ Steel 3. ☐ Electric 3. ☐ Commercial
 4. ☐ Sterndrive (I/O) 4. ☐ Manual 4. ☐ Canoe/Kayak 3. ☐ Fiberglass 4. ☐ Passenger
 5. ☐ Sailboat 5. ☐ Sail Only 5. ☐ Personal Watercraft 4. ☐ Commercial Fishing

BOAT LIEN INFORMATION - MANDATORY for Titled Boats 16' and Over

Lien on Boat? ☐ Yes ☐ No Lien Holder Name _____ Address _____ City, State and Zip Code _____

Note: Documented Boats Only

Documentation # _____ Boat Name _____ Hailing Port _____ Make of Engine (Inboard/Outboard/Out Only) _____ Engine Serial # _____

Engine 1 _____ Engine 2 _____

Sales Tax Information and Fee Computation - See Back Page For Instructions

1. Full Purchase Price (include motor, trailer, accessories) \$ _____ Trade-In (Description of boat or property traded) Year, Make & Hull ID # _____

2. Less Trade-In Allowance \$ _____

3. Taxable Receipts (Line 1 minus line 2) \$ _____ If Tax Exempt, Enter Exemption Code and Reason (See instructions on back) Code _____ Reason _____

4. 5% State Tax (Line 3 X .05) \$ _____

5. 1/2% County Tax (Line 3 X .005) (if applicable) \$ _____

6. 1/2% Football Stadium Tax (Line 3 X .005) (if applicable) \$ _____

7. 1/10% Baseball Stadium Tax (Line 3 X .001) (if applicable) \$ _____

Subtotal Tax Due \$ _____

8. Lien Filing Fee \$5.00 _____

9. Registration Fee (See Fee Schedule) _____

10. Replacement Decal Fee \$2.50 _____

11. Replacement Certificate Fee \$2.50 _____

12. Replacement Title Fee \$5.00 _____

13. \$1.00 Voluntary Contribution For Lake Research/ "Clean Water" _____

14. Total Tax and Registration Due \$ _____

This Boat Was Obtained From: (Please complete information below)

Dealer or Seller Name _____ ☐ Private Sale ☐ Dealer

Address _____ Seller's Permit / Tax # _____

City, State, ZIP Code _____ Telephone Number () _____

Signature of Dealer _____ Date Signed _____

I certify with my signature that to the best of my knowledge the information and statements on this application are true and correct. Any person who knowingly makes a false statement on an application for title may be punished under s. 30.547, Wis. Stats., by fines up to \$5,000 or imprisonment up to five years or both.

☐ Withhold personal identifiers collected on this form from disclosure on any list of 10 or more individuals that the DNR is requested to provide to another person [s. 23.45, Wis. Stats.]

Signature of Owner _____ (Additional owner's signature is not required) Date Signed _____ Social Security Number _____ (required on behalf of Department of Revenue for tax purposes)

* You may make a voluntary contribution of \$1.00. This fee is to be in addition to the registration fee and will be used exclusively for research conducted by the Dept. of Natural Resources to determine methods of improving the quality of the lakes in Wisconsin.

Mail to: Attn: Boat Registration and Titling
 Department of Natural Resources
 PO Box 7236
 Madison, WI 53707-7236

APPLICANT MUST KEEP A COMPLETED COPY of this page while boat is being OPERATED UNTIL certificate is received.

APPENDIX C

Application for Certificate of Watercraft Title and/or Registration of Indiana



AFFIDAVIT OF POLICE OFFICER
Physical Inspection of an Indiana Resident's WATERCRAFT
State Form 39530 (R3 / 9-06)

INSTRUCTIONS: Use reverse side for vehicle.

Indiana Code does not permit watercraft inspections by watercraft dealers.

NOTE: There are no provisions in the Indiana Code for assessing an inspection fee.

NOTE TO LAW OFFICER

1. A Title or Certificate of Origin does not have to be present to complete this affidavit.
2. You are required to physically inspect the watercraft to verify the existence and condition of the Hull Identification Number.

Name of owner	Address of owner
---------------	------------------

WATERCRAFT INFORMATION

I, the undersigned law enforcement officer, hereby swear or affirm that I have personally examined the watercraft described as follows:

Year	Make	Model	Length ft.
Indiana Registration Number		Hull Identification Number (HIN)	

NOTE TO LAW OFFICER
THE BMV WILL NOT ACCEPT THIS AFFIDAVIT IF THE INFORMATION REQUESTED IN THIS BOX IS NOT COMPLETE AND LEGIBLE

Printed name of inspecting officer		Title of inspecting officer	
Name of department	City	State	
ID number	Telephone number ()		
I swear or affirm that the information I have entered on this form is correct. I understand that making a false statement on this form may constitute the crime of perjury.			
Signature of inspecting officer		Date signed (month, day, year)	

APPENDIX D

Application for Certificate of Watercraft Title and/or Registration of Illinois



↑ THIS AREA FOR OFFICE USE ONLY ↑

☐ NEW See other side for fee and enter amount → \$	☐ TRANSFER RENEWAL See other side for fee and enter amount → \$	☐ RENEWAL See other side for fee and enter amount → \$	RENEWAL BY PHONE SEE OTHER SIDE FOR DETAILS	☐ UNITED STATES COAST GUARD DOCUMENTED See other side for USCGC fee and enter amount → \$
☐ DEALER OR MANUFACTURER \$10 (NO TITLE)	☐ DUPLICATE TITLE \$5 (COMPLETE A,B,E & F)	☐ CORRECTED TITLE \$5	☐ TITLE SEARCH \$5	☐ DUPLICATE REGISTRATION CARD \$1
		☐ CORRECTED REGISTRATION CARD \$1	☐ DUPLICATE DECALS (2) \$1	

A ILLINOIS REGISTRATION NUMBER (enter NONE if none) **IL** OTHER STATE REGISTRATION NUMBER **6 - 30 -** CURRENT REGISTRATION EXPIRES

MANUFACTURER NAME _____ MODEL NAME _____

HULL IDENTIFICATION NUMBER * SEE OTHER SIDE FOR FORMAT *

LENGTH FEET ONLY _____ MODEL YEAR _____ MO _____ DAY _____ YEAR _____

PURCHASE DATE _____

INSERT CODE NUMBER 1 WOOD 4 FIBERGLASS 7 OTHER 2 STEEL 5 OTHER 8 INFLATABLE 3 ALUMINUM 6 INFLATABLE	HULL MATERIAL (PRIMARY) 1 WOOD 4 FIBERGLASS 7 OTHER 2 STEEL 5 OTHER 8 INFLATABLE 3 ALUMINUM 6 INFLATABLE	WATERCRAFT TYPE 1 OPEN 5 PONTOON 8 CANOE/KAYAK 4 HOUSEBOAT 3 SAILBOAT 7 OTHER	USE 1 LEASE 2 RENT 3 RENT/LEASE 4 MANUFACTURER CODES	PROPULSION 1 OUTBOARD 2 INBOARD 3 O/E 5 OTHER	FUEL 1 GAS 2 DIESEL 3 OTHER	HORSEPOWER	WATERCRAFT COLORS-SEE OTHER SIDE FOR COLOR CODES (1) _____ (2) _____
---	--	---	--	---	---------------------------------------	-------------------	--

YES ☐ THE OWNERS SHOWN BELOW WISH TO BE RECORDED AS OWNERS IN JOINT TENANCY WITH RIGHT OF SURVIVORSHIP

CHECK ONE BOX AND ENTER NUMBER →

☐ DRIVERS LICENSE ☐ SOCIAL SECURITY ☐ TAX ID

DRIVERS LICENSE STATE _____

B OWNER(S) LAST NAME, FIRST NAME, MIDDLE INITIAL _____ SEX ☐ M ☐ F DATE OF BIRTH _____

(1) _____ MO _____ DAY _____ YEAR _____

(2) _____ MO _____ DAY _____ YEAR _____

(3) _____ MO _____ DAY _____ YEAR _____

(4) _____ MO _____ DAY _____ YEAR _____

STREET ADDRESS OR P.O. BOX NUMBER _____ COUNTY OF RESIDENCE _____

CITY _____ STATE _____ ZIP CODE _____

LIENHOLDER NAME (enter NONE if none) _____ MO _____ DAY _____ YEAR _____

STREET ADDRESS _____ SECURITY AGENT DATE _____

C CITY _____ STATE _____ ZIP CODE _____

D PURCHASED FROM _____ STREET ADDRESS _____

CITY _____ COUNTY _____ STATE _____ ZIP CODE _____

SIGNATURE(S) _____ DATE SIGNED _____

THE SELLER HEREBY TRANSFERS INTEREST IN THE ABOVE DESCRIBED WATERCRAFT TO THE NEW OWNER(S). SIGNATURE OF PREVIOUS OWNER NOT REQUIRED WHEN TITLE IS PROPERLY ENDORSED AND SURRENDERED WITH THIS APPLICATION.

E SIGNATURE(S) (1) _____ (2) _____ DATE SIGNED _____

(3) _____ (4) _____

I/WE HEREBY AFFIRM THAT THE INFORMATION PROVIDED IS TRUE AND CORRECT. YOUR SIGNATURE AUTHORIZED THE DEPT. OF NATURAL RESOURCES TO LOWER THE AMOUNT OF YOUR CHECK IF FEE SUBMITTED IS GREATER THAN THE REQUIRED FEE.

F STATE REASON(S) FOR TITLE SEARCH OR NEED FOR DUPLICATE OR CORRECTED TITLE _____ PLEASE GIVE US A PHONE NUMBER where you may be reached on weekdays.

Phone _____ (area code) _____ (number) _____

SEND THIS COPY ONLY TO DEPARTMENT OF NATURAL RESOURCES

APPENDIX E

The 2001 Lake Michigan Potential Damages Study Mail Survey

2001 LAKE MICHIGAN RECREATIONAL BOATING SURVEY

Michigan State University is conducting a study of recreational boating with a special focus on the impacts of low water levels on boating activity and behaviors. This is part of a larger study that includes surveys of dealerships, marinas and charter boats. The results of the study will be reported to the U.S. Army Corps of Engineers and state recreational boating agencies for use in boating, harbor and launch site facility planning and policies. You have been randomly selected from a list of registered boaters in your state. We sampled different size boats to obtain a sample that represents the population of recreational boaters. Your response is very important because we are only sending questionnaires to 3,000 registered boat owners in Michigan, Wisconsin, Indiana and Illinois. **SOME OF THE QUESTIONS WILL RELATE SPECIFICALLY TO THE REGISTERED BOAT IDENTIFIED ABOVE YOUR NAME ON THE MAILING LABEL. PLEASE, DON'T DISPOSE OF THE ENVELOPE UNTIL YOU COMPLETE THE SURVEY.** We have included maps to assist you in identifying locations where you boat, launch your boat and where you may have encountered problems related to low water. You will remain anonymous. We will not have a record of your name or boat registration number on your completed survey. Participation in this survey is voluntary and you may choose not to answer some of the questions. If you have any questions regarding the importance of this survey, contact Dr. Ed Mahoney by phone at 517.353.5190 x113 or e-mail mahoneye@msu.edu. Questions regarding your rights related to this survey can be addressed to Dr. Ashir Kumar, MD, Chair of the University Committee on Research Involving Human Subjects (517.355.2180). Please take ten minutes to complete and return **this important survey. The only way we can gather this information is with the cooperation of recreational boaters. Thank you.**

Ed Mahoney, MSU professor

1. Do you still own the boat identified on the mailing label?

- ☐ No ☐ Yes

1a. Do you own another boat currently registered in Michigan?

- ☐ Yes. **Complete this survey for the other boat and skip to Question 2a.**
☐ No. Do not answer the remaining questions. Please return the questionnaire today

2. Please help us verify information about the registered boat identified on the mailing label.

2a. What type of boat?

- ☐ Inboard ☐ In/Outboard ☐ Outboard ☐ Sail, unpowered ☐ Sail, with power
☐ Pontoon ☐ Canoe or Row ☐ Personal watercraft (e.g. Jet ski) ☐ Other (specify) _____

2b. Boat length? _____ Feet

2c. When did you acquire this boat? _____ Year

2d. Did you purchase it new or pre-owned? ☐ New ☐ Pre-owned

3. Was this boat put in the water in Michigan in 2001? _____ Month [Skip to Question 3c]

- ☐ Yes ☐ No

3b. Why did you not put this boat in the water in 2001? (Check all that apply)

- ☐ Health reasons ☐ Cost of fuel ☐ Economic reasons ☐ Poor weather
☐ Concerns about low water ☐ Unable to get a space in a marina ☐ Planned to sell this boat ☐ Lost interest in boating
☐ Other recreation activities ☐ Boating congestion/crowding ☐ Boat was not operable ☐ Other, Specify _____

3c. Are you planning to put this boat in the water in 2002? ☐ Yes ☐ No

4. How many days was this boat operated (under power or sail) so far in 2001?
 _____ Days of boating in 2001. (If it was not operated, put "0" **Skip to Q 6**)
 _____ Number of days you will likely operate the boat after completing this survey

4a. In what counties did you operate this boat in 2001? (See Map)
 Record counties (code #s) _____

4b. Did you operate this boat more or less days in 2001 than you did in 2000?

- ☐ More days
☐ Same number of days
☐ Less days

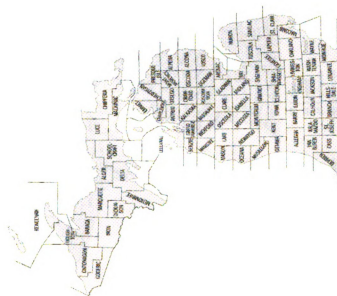
4c. Why did you operate this boat less days in 2001 than in 2000?

- ☐ Health reasons ☐ Cost of fuel ☐ Boat needed repairs
☐ Economic reasons ☐ Poor weather ☐ Low water
☐ Other recreation ☐ Lost interest in ☐ Other
 activities boating

4d. How many days was this boat operated on Lake Michigan or connecting waters?
 _____ Days of boating on Lake Michigan in 2001

4f. How many days was this boat operated on other Great Lakes or connecting waters in 2001?
 _____ Days of boating in 2001 on Lakes Huron, Superior, Erie, and St. Clair; the St. Mary's, St. Clair and Detroit River and lakes and rivers that provide direct access to these Great Lakes.

5. How many additional days (NOT COVERED ABOVE) was this boat used in 2001 when it was in the water, but not underway (e.g. used at a dock, lodging, repairs, entertaining, fishing etc.)?
 _____ Additional days



1 Alcona	18 Clare	35 Isosco	52 Marquette	69 Otsego
2 Alger	19 Clinton	36 Iron	53 Mason	70 Ottawa
3 Alpena	20 Crawford	37 Isabella	54 Mecosta	71 Presque Isle
4 Benzie	21 Delta	38 Jackson	55 Menominee	72 Roscommon
5 Benzie	22 Dickinson	39 Kalamazoo	56 Midland	73 Saginaw
6 Branch	23 Eaton	40 Kalamazoo	57 Missaukee	74 St. Clair
7 Branch	24 Emmet	41 Kent	58 Monroe	75 St. Joseph
8 Branch	25 Emmet	42 Keweenaw	59 Montcalm	76 Shiawassee
9 Branch	26 Gladwin	43 Lake	60 Montgomery	77 Shockell
10 Branch	27 Gladwin	44 Leelanau	61 Mackinac	78 Shiawassee
11 Branch	28 Grand	45 Leelanau	62 Mackinac	79 Shiawassee
12 Branch	29 Grand	46 Leelanau	63 Mackinac	80 Verbeke
13 Branch	30 Hillsdale	47 Leelanau	64 Mackinac	81 Washington
14 Branch	31 Hillsdale	48 Leelanau	65 Mackinac	82 Wayne
15 Branch	32 Huron	49 Mackinac	66 Mackinac	83 Westland
16 Branch	33 Ingham	50 Mackinac	67 Mackinac	
17 Chippewa	34 Ionia	51 Manistee	68 Oscoda	

6. Where did you keep this boat during the 2001 boating season?

Location	Type of facility	Type of storage	Access
City / Port	☐ Permanent residence ☐ Cottage/second home ☐ Public marina ☐ Commercial marina ☐ Owned space in marina/dockminium ☐ Yacht/Boat Club ☐ Other, Specify _____	☐ On land ☐ In a dry stack facility ☐ In the water (wetslip mooring, dockside) ☐ Attached to or on a larger boat ☐ Other, Specify _____	☐ A waterfront site with access to Lake Michigan & connecting waters ☐ A waterfront site with access to other Great Lakes & connecting waters ☐ An inland lake waterfront site ☐ A river or stream waterfront site ☐ A non-waterfront site
County (See Map)			
State			

7. How many miles is it from your permanent residence to where your boat was kept, or where you normally use it? _____ Number of miles

7a. How long does it normally take you to travel from your permanent residence to where your boat is kept, or where it is used? _____ Number of hours

8. Is this a different location than where you stored this boat during 2000 boating season?

☐ No, Same location, or I didn't own the boat in 2000. [Skip to Question 9]

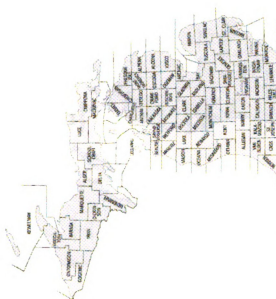
☐ Yes

8a. What was the reason(s) why you changed locations? (Check all that apply)

- ☐ Lack of marina/yacht club space
☐ Increase in marina/yacht club fee
☐ To be closer to permanent home
☐ Moved my permanent residence
☐ Access to different water body
☐ Moved my permanent residence

8b. Where did you keep this boat during the 2000 boating season?

Location	Type of facility	Type of storage	Access
City / Port	☐ Permanent residence ☐ Cottage/second home ☐ Public marina ☐ Commercial marina ☐ Owned space in marina/dockminium ☐ Yacht/Boat Club ☐ Other, Specify _____	☐ On land ☐ In a dry stack facility ☐ In the water (wetslip mooring, dockside) ☐ Attached to or on a larger boat ☐ Other, Specify _____	☐ A waterfront site with access to Lake Michigan & connecting waters ☐ A waterfront site with access to other Great Lakes & connecting waters ☐ An inland lake waterfront site ☐ A river or stream waterfront site ☐ A non-waterfront site
County (See Map)			
State			



- 1 Alcona
 2 Alger
 3 Allegan
 4 Alpena
 5 Antrim
 6 Arenac
 7 Baraga
 8 Barry
 9 Bay
 10 Benzie
 11 Berrien
 12 Branch
 13 Calhoun
 14 Cass
 15 Charlevoix
 16 Cheboygan
 17 Chippewa
 18 Clatsop
 19 Clinton
 20 Crawford
 21 Delta
 22 Dickinson
 23 Eaton
 24 Emmet
 25 Genesee
 26 Gladwin
 27 Gogebic
 28 Grand Trv.
 29 Gratiot
 30 Hillsdale
 31 Houghton
 32 Huron
 33 Ingham
 34 Ionia
 35 Isabella
 36 Iron
 37 Jackson
 38 Kalamazoo
 39 Kalamazoo
 40 Kalamazoo
 41 Kent
 42 Keweenaw
 43 Lake
 44 Lapeer
 45 Leelanau
 46 Lenawee
 47 Livingston
 48 Lapeer
 49 Mackinac
 50 Macomb
 51 Manistee
 52 Marquette
 53 Mason
 54 Mecosta
 55 Menominee
 56 Midland
 57 Missaukee
 58 Monroe
 59 Montcalm
 60 Montcalm
 61 Muskegon
 62 Newaygo
 63 Oakland
 64 Oceana
 65 Ogemaw
 66 Ontonagon
 67 Oshtemo
 68 Oscoda
 69 Otsego
 70 Ottawa
 71 Presque Isle
 72 Roscommon
 73 Saginaw
 74 St. Clair
 75 St. Joseph
 76 Sanilac
 77 Schoolcraft
 78 Shiawassee
 79 Tuscola
 80 Van Buren
 81 Van Buren
 82 Wayne
 83 Washtenaw
 84 Washtenaw

8c. Did low water influence the number of days you operated this boat during the 2001 boating season?

- ☐ No ☐ Yes

→ **No [Skip to Question 9]**

8d. Did you use it more or less days than 2000?

- ☐ More days
☐ Same number of days
☐ Less days

9. Did you trailer this boat to a site for the purpose of launching it during the 2001 boating season?

- ☐ No ☐ Yes

→ **No [Skip to Question 10]**

9a. How many different times did you trailer this boat to launch sites during the 2001 boating season?

9b. What types of launch sites did you utilize? (Check all that apply)

- ☐ DNR/state operated ☐ County or locally operated ☐ Privately operated
9c. Did you launch your boat at any sites that provide access to Lake Michigan or connecting waters in 2001?

- ☐ No ☐ Yes

→ **No [Skip to Question 10]**

9d. In what counties did you launch your boat at sites that provide access to Lake Michigan connecting waters? (See Map)

Record Counties (code #s) _____

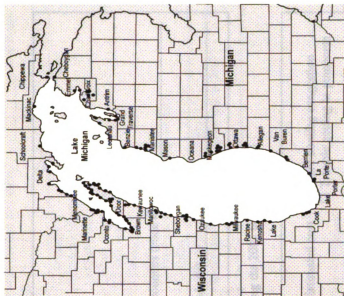
9e. Did you encounter any low water problems at sites that provide access to Lake Michigan or connecting waters?

- ☐ No ☐ Yes

9f. What type of problems did you encounter? (Check all that apply)

- ☐ Congested channel
☐ Launch site was closed ☐ Wait to retrieve boat ☐ Dangerous channel
☐ Unable to launch ☐ Turned away - "At capacity" ☐ Other, Specify _____
☐ Scraped bottom ☐ Reduced area to maneuver

9g. In what counties were the sites (that provide access to Lake Michigan or connecting waters) located that you encountered low water problems? (See Map) Record counties (code #s) _____



name	Code	Name	Code
Allegan	MI 3	Brown	MI 5
Antrim	MI 5	Door	WI 15
Benzie	MI 10	Kenosha	WI 30
Berrien	MI 11	Kewaunee	WI 31
Charlevoix	MI 15	Manitowoc	WI 36
Delta	MI 21	Marianette	WI 41
Emmet	MI 24	Milwaukee	WI 41
Leelanau	MI 45	Oconto	WI 46
Black Mac	MI 49	Ozaukee	WI 52
Manistee	MI 51	Racine	WI 52
Mason	MI 53	Shebogyan	WI 59
Menominee	MI 55	Jake	IN 45
Missigouin	MI 61	Laporte	IN 46
Oceana	MI 64	Pierce	IN 44
Ontonagon	MI 70	Cook	IL 16
Schoolcraft	MI 74	Lake	IL 49
Van Buren	MI 80		

10. Did low water concerns influence your boating during the 2001 boating season?

☐ No **[Skip to Question 11]**

☐ Yes →

10a. Did you do less boating in 2001 because of low water?

☐ Yes

☐ No

10b. Did low water influence the locations where you boated?

☐ Yes

☐ No **[Skip to Question 11]**

10c. Did you stop or reduce boating at certain locations because of low water?

☐ Yes. In what counties did you stop or reduce your boating? (See Map) Record counties (code #s) _____

☐ No

10d. Did you do more boating at certain locations because of low water?

☐ Yes. In what counties did you do more boating? (See Map) Record counties (code #s) _____

☐ No

11. Other than at launch sites, did you personally encounter/experience any low water related problems during the 2001 boating season?

☐ No **[Skip to Question 12]**

☐ Yes →

11a. What types of problems did you experience/encounter?

☐ Mooring/docking was inaccessible ☐ Boat damage/repairs \$ _____ Estimated cost ☐ More boating congestion
☐ Unable to boat at some locations ☐ Trouble getting to fuel pumps ☐ Trouble getting to pumpouts

☐ Other, Specify _____

11b. In what counties did you experience these low water related problems? (See Map)

Record counties (code #s) _____

12. Did you request or receive any information concerning water levels during the 2001 boating season?

☐ No **[Skip to Question 13]**

☐ Yes →

12a. What types of information did you request/receive? _____

12b. What were the sources of the information?

☐ Newspaper

☐ DNR agencies

☐ Other, Specify _____

☐ Magazine

☐ Boating Association

☐ Army Corps

☐ Radio

☐ Universities

☐ Sea Grant

☐ Web pages

13. Not counting the boat identified on the mailing label, how many other boats do you own that are currently registered in Michigan? _____ # of Boats
 13a. Please provide description(s) of your other boat(s) – Excluding the boat identified on the mailing label.

Boat # 1	Boat # 2	Boat # 3
☐ Inboard ☐ Inboard/outboard ☐ Outboard ☐ Sail, unpowered ☐ Sail, with power ☐ Pontoon ☐ Canoe or Row ☐ Personal watercraft (e.g. Jet ski) ☐ Other	☐ Inboard ☐ Inboard/outboard ☐ Outboard ☐ Sail, unpowered ☐ Sail, with power ☐ Pontoon ☐ Canoe or Row ☐ Personal watercraft (e.g. Jet ski) ☐ Other	☐ Inboard ☐ Inboard/outboard ☐ Outboard ☐ Sail, unpowered ☐ Sail, with power ☐ Pontoon ☐ Canoe or Row ☐ Personal watercraft (e.g. Jet ski) ☐ Other
Size of boat #1 _____ feet Days operated under power or sail in 2001? _____ Days	Size of boat #2 _____ feet Days operated under power or sail in 2001? _____ Days	Size of boat #3 _____ feet Days operated under power or sail in 2001? _____ Days

14. In what state and county is your permanent residence? State _____ County _____

15. Do you currently own a permanent waterfront or seasonal/vacation home or cottage?

☐ No **[Skip to Question 16]**
☐ Yes

15a. Permanent waterfront home?

☐ Yes In what state & county is it located? State _____ County _____
☐ No

15b. Waterfront seasonal/vacation home or cottage?

☐ Yes In what state & county is it located? State _____ County _____
☐ No

16. Age of the owner of the registered boat that you completed this survey for: _____ years

17. How many people, including yourself, reside in your household? _____ Adults _____ Children (under 18 years of age)

18. What was your annual gross household income in 2000?

☐ Under \$20,000
☐ \$20,000 - \$39,999
☐ \$40,000 - \$59,999
☐ \$60,000 - \$99,999
☐ \$100,000 - \$149,999
☐ Over \$150,000

Thank you for participating in this important study.

**Please return your completed survey as soon as possible in the postage-paid envelope provided.
 We believe with your help we will provide valuable information to Federal/State boating agencies.**

APPENDIX F

The 2001 Lake Michigan Potential Damages Study Telephone Survey

REVISED BY PZC AND EM 12/06/2001

Dec. 2001 Survey on Lake Michigan Boaters

SEQ# _____ ZIPCODE: _____ DATE: ____/____/_____
PHONE _____ STATE _____
COUNTY _____ JURIS _____ WARD _____ PRECINCT _____

=====

Hello, this is (NAME) from EPIC-MRA, a Lansing-based survey research firm. The Army Corps of Engineers has commissioned a random survey of boat owners to inquire about boating issues in [State being surveyed]. I am not selling anything, and you will not be contacted again because of your participation in this survey. The survey takes just a few minutes to complete, and I would like to include your opinions.

=====

May I please speak to (boat owner from list)? [IF NOT AVAILABLE, ASK] Is there a time when I can call back tonight when (he/she) might be available?

[IF YES, CALL BACK TIME] _____ [IF NOT AVAILABLE -- TERMINATE]

__01. In cooperation with The Army Corps of Engineers the State of [State Being Surveyed] has provided us with boat registration records for our use during this survey. These records indicate that you own a [Description of Foot Size of Boat From Call Sheet – e.g. twenty-seven foot boat] is that still correct?

- (1) Yes ----- GO TO Q. 6
- (2) No
- (3) Refused – TERMINATE INTERVIEW

__02. Do you own another boat registered in your name in the State of [Name of State]?

- (1) Yes
- (2) No ----- TERMINATE INTERVIEW
- (3) Refused ---- TERMINATE INTERVIEW

__03. What is the size, in feet of that boat?

of feet _____ IF UNDER 17 FEET, TERMINATE INTERVIEW

__04. For how many years have you owned your boat?

_____ Years

__05. Can you please tell me what kind of boat that is, is it a...?
[READ 01 TO 09--CODE RESPONSE]

- (01) Outboard motorboat
- (02) Inboard/Outdrive motorboat
- (03) Inboard motorboat
- (04) A powered sailboat
- (05) Pontoon boat
- (06) An unpowered sailboat ----- TERMINATE
- (07) Canoe or row boat ----- TERMINATE
- (08) Personal watercraft (jet skis) ----- TERMINATE
- (09) Or something else ----- TERMINATE
- (10) Undecided/Don't know ----- TERMINATE

__06. Have you operated the boat on the water in the past three years?

- (1) Yes
- (2) No ----- GO TO Q. 10

__07. Have you operated that boat on the water on an inland lake in the past three years?

- (1) Yes
- (2) No
- (3) Undecided/Don't know

__08. Have you operated that boat on the water on any of the other Great Lakes or a waterway connecting to the Great Lakes in the past three years?

- (1) Yes
- (2) No
- (3) Undecided/Don't know

__09. Have you operated that boat on the water on Lake Michigan or a waterway connecting to Lake Michigan in the past three years?

- (1) Yes ----- GO TO Q 13
- (2) No ----- CONTINUE
- (3) Undecided/Don't know ----- CONTINUE

__10. What is the main reason why you did not take your boat out in the past three years? [DO NOT READ -- CODE RESPONSE]

(1) Other competing interests (PROBE)

Write Comment as Stated or Code Appropriately

(IF REASON WAS LOW WATER LEVELS OR BOAT LAUNCH NOT AVAILABLE, CODE "2" OR "3" & CONTINUE)

(2) Didn't use it because of lower water levels --CONTINUE INTERVIEW

(3) Boat launch or marina slip was no longer available - CONTINUE INTERVIEW

(4) Lost interest (PROBE) "Did you lose interest because of a specific reason?"

Write Comment as Stated or Code Appropriately

(IF REASON WAS LOW WATER LEVELS OR BOAT LAUNCH NOT AVAILABLE, CODE "2" OR "3" & CONTINUE)

(5) Became too expensive ----- GO TO Q. 66

(6) Didn't use it for other reasons---- GO TO Q. 66

(7) Undecided/Don't know ----- GO TO Q. 66

__11. Based on your experience or what you have heard from others, would you say that Lake Michigan water levels have dropped or remained about the same over the past few years in your usual boating waters? [IF DROPPED, ASK] Do you think they have dropped a lot or just a little?

(1) Water levels dropped a lot

(2) Water levels dropped just a little

(3) Water levels have remained about the same

(4) Undecided/Don't know

__12. Specifically, over the past two or three years, how much, either in inches or in feet, would you say Lake Michigan levels have dropped?

_____ feet

_____ inches

GO TO Q. 66

__ 13. How many days did you operate the boat on Lake Michigan or connecting waters in 2001?

_____ Number of Days

__ 14. Is this more days in 2001 than in 2000 or less days?

- (1) More
- (2) About the same number of days in 2001 ----- GO TO Q. 18
- (3) Less days ----- GO TO Q 16

__ 15. What would you say is the main reason why you were out on the water more this past season than one or two years ago?

[DO NOT READ – CODE OR WRITE IN OTHER RESPONSE & GO TO Q. 18]

- (1) More income
- (2) More free time
- (3) Retired
- (4) Has a new boat
- (5) Other (Please specify): _____
- (6) Undecided/Don't know/Refused

__ 16. What is the main reason why you took your boat out fewer days in 2001 on Lake Michigan or on a connecting body of water to Lake Michigan than in 2000 or 1999? [DO NOT READ -- CODE RESPONSE]

- (1) Boat isn't large enough for Great Lakes waters
- (2) High fuel cost ----- GO TO Q. 18
- (3) Lower lake levels ----- GO TO Q. 18
- (4) Have no place to launch or keep boat ----- GO TO Q. 18
- (5) Public access problems/lack mooring space ----- GO TO Q. 18
- (6) Other (Please specify): _____ GO TO Q. 18
- (7) Undecided/Don't know ----- GO TO Q. 66

__ 17. When you say that your boat isn't large enough for the Great Lakes waters, do you mean that it cannot safely operate on the Great Lakes on a windy or stormy day and that it is fine on a calm day, or do you mean it is not big enough regardless of the weather?

- (1) Cannot safely operate on the Great Lakes on a windy or stormy day
- (2) Not big enough regardless of the weather ----- GO TO Q. 66
- (3) Undecided/Don't ----- GO TO Q. 66

__18. In what county and state do you usually keep your boat during the boating season?

- (01) (Please specify): _____
- (02) Undecided/Don't know

__19. Can you tell me in what port city or community you usually boat out of during the boating season? [WRITE COMMENT AS STATED]

__20. At what type of place or facility did you keep your boat in the 2001 boating season? [READ & ROTATE 1 – 6]

- (1) Permanent residence
- (2) Cottage/second home
- (3) Rented slip in a publicly operated marina
- (4) Rented slip in a privately operated marina
- (5) Owned space in a marina or dockaminium
- (6) Yacht/Boat Club
- (7) Other (please specify:) _____
- (8) Refused

__21. How did you keep the boat during the 2001 boating season? – Did you keep it . . .
[READ & ROTATE 1 – 3]

- (1) On land outdoors
- (2) In a dry stack facility
- (3) In the water -- that is, in a wet slip or at a dock or moored in the water
- (4) Other (please specify:) _____

__22. During the 2001 boating season, was the location you kept your boat different than in the 2000 boating season?

- (1) Yes
- (2) No ----- GO TO Q. 24

__23. What was the main reason why you moved your boat?
[DO NOT READ -- CODE RESPONSE OR WRITE-IN UNDER OTHER]

- (1) Lower water levels
- (2) Other (Please specify): _____
[PROBE to see if "other" reason is related to low water, if so, Code "1"]
- (3) Undecided/Don't know/Refused

__24. At what type of place or facility did you store your boat last winter?
[READ/ROTATE 1 – 7]

- (1) Permanent residence
- (2) Cottage/second home
- (3) Dry stack at a marina
- (4) Outdoor rented space at a marina
- (5) Outdoor rented space at a storage yard
- (6) Indoor rented space
- (7) Yacht/Boat Club
- (8) Other (please specify _____)
- (9) Refused

__25. From what type of place or facility did you typically operate your boat for trips onto Lake Michigan or waters connecting to Lake Michigan?

- (1) From a dock or mooring site in front of a waterfront home? GO TO Q 45
- (2) From a marina slip ----- CONTINUE
- (3) From a boat launch ramp GO TO Q. 28
- (4) Other (please specify) _____ -- GO TO Q 45
- (5) Refused ----- GO TO Q 45

__26. Can you tell me the name of the marina?

- (1) Marina [Name] _____

__27. Based on what you know or have heard or read, how available are slips in the area where you usually use your boat – very available, somewhat available, only slightly available, or not available at all?

- (1) Very available
- (2) Somewhat available
- (3) Only slightly available
- (4) Not available at all
- (5) Undecided/Don't know

GO TO Q. 45

__28. Can you tell me the name of the County where that boat launch is located?
[CODE RESPONSE OR WRITE IN UNDER OTHER]

- (1) (Please specify): _____
- (2) Undecided/Don't know

__29. Do you usually use the same boat launch or do you use others?
[CODE RESPONSE OR WRITE IN UNDER OTHER]

- (1) Yes, always uses the same boat launch
- (2) Uses other boat launches
- (3) Undecided/Don't know

__30. Thinking about the times that you used the facilities of public boat launches while taking your boat out during peak use times such as weekends and holidays...

Overall, how would you rate the facilities – such as launch ramp, parking, rest rooms, picnic areas -- available at the public boat launches you may have used in the past couple of years – would you give the facilities a positive rating of excellent or pretty good, or a negative rating of only fair or poor?

- (1) Excellent
- (2) Pretty good
- (3) Only fair
- (4) Poor
- (5) Undecided/Don't know

I'm going to read several characteristics of boat launch sites and I would like you to tell me how important each one is to you in your evaluation of a boat launch sites – Please tell me if the item Very Important, Fairly Important, Only a Little Important or Not Important at All in making your overall evaluation of a boat launch site?

[READ AND ROTATE Q'S 31 TO 37]	Very Impt.	Fairly Impt.	Little Impt.	Not. Impt	DK/ Undec
__31. The availability of parking.....	(1)	(2)	(3)	(4)	(5)
__32. The condition of the ramp surfaces...	(1)	(2)	(3)	(4)	(5)
__33. The repair and upkeep of the ramps....	(1)	(2)	(3)	(4)	(5)
__34. The quality and upkeep of restrooms...	(1)	(2)	(3)	(4)	(5)
__35. The condition and upkeep of the docks.	(1)	(2)	(3)	(4)	(5)
__36. The signs provided to help you find the facility.....	(1)	(2)	(3)	(4)	(5)
__37. Water depth at the end of the ramp.....	(1)	(2)	(3)	(4)	(5)

Which of the following problems have you experienced while using a launch site?
[ROTATE Q'S 38 TO 43]

Yes No DK

__38. A launch site closed because it was at capacity..... (1) (2) (3)

__39. Long wait launching..... (1) (2) (3)

__40. Delays in retrieving your boat..... (1) (2) (3)

__41. Dangerous channels out to open water..... (1) (2) (3)

__42. Boat congestion..... (1) (2) (3)

__43. Reduced area to maneuver your boat..... (1) (2) (3)

__44. What would you say is the longest amount of time you are willing to wait to use a boat launch before you can't wait any longer?

[WRITE IN MINUTES OR HOURS]

_____ Minutes _____ Hours

__45. How far a distance in miles is it from your home to where you most often operate or launch your boat for boating on Lake Michigan?

_____ - Miles

__46. How long does it normally take you to travel from your home to the place where you most often operate or launch your boat during the boating season for boating on Lake Michigan – a half hour or less, a half hour to an hour, more than an hour but less than 2 hours, more than 2 but less than 4 hours, or more than 4 hours?

- (1) A half hour or less
- (2) A half hour to an hour
- (3) More than an hour but less than 2 hours
- (4) More than 3 but less than 4 hours
- (5) More than 4 hours
- (6) Undecided/Don't know

__47. What boating activities do you like to do in Lake Michigan or connecting waters?

- (1) Fishing
- (2) Cruising
- (3) Water skiing, tubing or wakeboarding
- (4) Other (please specify) _____

___48. How well have officials at the federal, state, county, city and township levels dealt with low Lake Michigan water levels? Did they deal well with low water or deal poorly with low water?

- (1) Dealt well with low water
- (2) Dealt poorly with low water
- (3) Undecided/Don't know

___49. Tell me in terms of a percentage amount, How much of your boat registration fee you believe goes to help maintain launch facilities and channels?

- (1) All of them or, 100%
- (2) More than half of them, or 50% to 100%
- (3) Less than half or, 1% to 50%
- (4) None of them, or 0%
- (5) Not sure

___50. Would you be willing to pay a fee in which the revenues go toward dealing with water level problems and boating facilities?

- (1) Yes
- (2) No --- GO TO Q. 52
- (3) Uncertain

___51. How much would you be willing to pay in fees or taxes for improved facilities to deal with water level problems? [WRITE IN AMOUNT]

_____ per year _____ per use

___52. When you use your boat on Lake Michigan or connecting waters, how many people, on average, usually travel on the boat with you, including family and friends?

_____ people

___53. What organization or department, as you understand it, is in charge of boating in your state? [WRITE COMMENT AS STATED]

__54. Which of the following sources of revenue are used to pay for the development and maintenance of public launch facilities . . . is it
[ROTATE 1— 4, Code all responses]

- (1) Boat registration fees
- (2) A portion of the fuel taxes
- (3) Fees paid at the launch sites
- (4) From the general fund appropriated to the DNR
- (5) Other (Specify): _____
- (6) Undecided/Don't know

The Federal, State, and Local governments all use some taxpayer dollars to pay for public facilities and general welfare projects involving Lake Michigan and its connecting waterways. Specifically, can you tell me which level of government – Federal, State, or Local, is primarily responsible for: [ROTATE QUESTIONS 55-56]

__55. Developing and maintaining public boating access facilities – is that function the primary responsibility of the [READ & ROTATE 1-3]

- (1) Federal government
- (2) State government
- (3) Local county, city or township government
- (4) A combination of them (Volunteered)
- (5) Undecided/Don't know

__56. Dredging channels and harbors – is that function the primary responsibility of the [READ & ROTATE 1-3]

- (1) Federal government
- (2) State government
- (3) Local county, city or township government
- (4) A combination of them (Volunteered)
- (5) Undecided/Don't know

__57. Based on your experience or what you have heard from others, would you say that Lake Michigan water levels have dropped or remained about the same over the past few years in your usual boating waters? [IF DROPPED, ASK] Do you think they have dropped a lot or just a little?

- (1) Water levels dropped a lot
- (2) Water levels dropped just a little
- (3) Water levels have remained about the same ----- GO TO Q 60
- (4) Undecided/Don't know

__58. Specifically, over the past two or three years, how much, either in inches or in feet, would you say Lake Michigan levels have dropped?

_____ feet _____ inches

__59. What is the main problem you have noticed as a result of lower water levels over the past two or three years? [WRITE COMMENT AS STATED]

__60. In 2001, the water level of Lake Michigan as about 1 foot above its record low level recorded in 1964. If Lake Michigan water levels were to drop a foot below this past year 2001 levels, would that force you to seek alternative sites to operate your boat, or, would you say that you would not have a problem?

- (1) Would have to seek alternative sites ----- GO TO Q. 63
- (2) Would not have a problem
- (3) Undecided/Don't know

__61. If Lake Michigan water levels were to drop two feet below this past year 2001 levels, would that lower water level force you to seek alternative sites to operate your boat, or, would you say that you would not have a problem?

- (1) Would have to seek alternative sites ----- GO TO Q. 63
- (2) Would not have a problem
- (3) Undecided/Don't know

__62. If Lake Michigan water levels were to drop three feet below this past year 2001 levels, -- in other words, two feet below the lowest level recorded in 1964 -- would that lower water level force you to seek alternative sites to operate your boat, or, would you say that you would not have a problem?

- (1) Would have to seek alternative sites
- (2) Would not have a problem
- (3) Undecided/Don't know

___ **63.** How about the opposite problem? What kind of an impact would there be on boating on Lake Michigan if there was an increase in water levels in the next 10 or so years of about a foot over previously recorded high levels, which were recorded in 1986, which would be nearly 6 feet higher than this past summer -- would it have a major impact, a minor impact, or no real impact at all?

- (1) A major impact
- (2) A minor impact
- (3) No real impact at all ----- GO TO Q. 65
- (4) Undecided/Don't know ----- GO TO Q. 65

___ **64.** What would you say would be the main impact of that kind of an increase in water levels? [WRITE COMMENT AS STATED]

___ **65.** What would you say is the main problem confronting boaters in (Name of State)? [WRITE COMMENT AS STATED]

Finally, I would like to ask you a few questions about yourself, for statistical purposes only.

___ **66.** In terms of your job status, are you employed, unemployed but looking for work, retired, a student, or a homemaker?

- (1) Employed
- (2) Unemployed
- (3) Retired
- (4) Student
- (5) Homemaker
- (6) Other
- (7) Undecided/don't know
- (8) Refused

___67. Could you please tell me in what year you were born?
[RECORD YEAR HERE ____ AND THEN CODE BELOW]

- (1) 18 to 24 years -- (1977 to 1983)
- (2) 25 to 29 years -- (1972 to 1976)
- (3) 30 to 35 ----- (1966 to 1971)
- (4) 36 to 40 ----- (1961 to 1965)
- (5) 41 to 49 ----- (1952 to 1960)
- (6) 50 to 55 ----- (1946 to 1951)
- (7) 56 to 64 ----- (1937 to 1945)
- (8) 65 and over ----- (1936 or before)
- (9) Don't know/Refused

___68. What is the last grade or level of schooling you completed?
(DON'T READ--CODE RESPONSE)

- (1) 1st to 11th Grade
- (2) High School Graduate
- (3) Non-college post high school (technical training)
- (4) Some college
- (5) College graduate
- (6) Post graduate school
- (7) Undecided/Don't know
- (8) Refused

___69. Would you please tell me into which of the following categories your total yearly household income falls --- including everyone in the household? Please stop me when I get to the category that applies to you? (READ LIST --- 1 to 7)

- (1) Under \$15,000
- (2) \$15,000 to \$30,000
- (3) \$30,000 to \$45,000
- (4) \$45,000 to \$60,000
- (5) \$60,000 to \$75,000
- (6) \$75,000 to \$100,000
- (7) Over \$100,000
- (8) Retired (VOLUNTEERED - ASK: But is there an income category I read that would apply to your household?)
- (9) Refused

___70. Sex of respondent (BY OBSERVATION ONLY)

- (1) Male
- (2) Female

THANK RESPONDENT FOR HIS OR HER TIME AND TERMINATE

APPENDIX G

Five Binary LOGIT Model Results

Table G.1. The results of eight binary LOGIT models for boaters' awareness of Lake Michigan water level changes.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Permanent state of residence								
Michigan	1.823*	1.813*	1.798*	1.800*	1.797*	1.781*	1.823*	1.885*
Wisconsin	0.364	0.355	0.355	0.355	0.321	0.322	0.350	0.380*
Indiana	0.654*	0.651*	0.651*	0.631*	0.621*	0.616*	0.619*	0.624*
Location of permanent residence								
Lake Michigan counties	1.687*	1.686*	1.687*	1.670*	1.659*	1.648*	1.654*	1.627*
Next to LM counties	1.462*	1.463*	1.458*	1.451*	1.452*	1.440*	1.435*	1.419*
Boat length	-0.003	-0.003	--	--	--	--	--	--
Boat type								
Outboard motor boat	0.482*	0.485*	0.494*	0.489	0.213	--	--	--
Inboard-outboards	0.358	0.360	0.368	0.376	--	--	--	--
Pontoon boat	0.651*	0.660*	0.651	0.639*	0.365	0.262	--	--
Income								
Over \$60K	*	*	*	--	--	--	--	--
\$45K to \$60K	-0.528*	-0.512*	-0.503*	-0.484*	-0.479*	-0.458*	-0.436*	-0.456*
Under \$45K	-0.122	-0.105	-0.097	-0.092	-0.101	-0.083	-0.084	-0.092
Education								
Graduate	--	--	--	--	--	--	--	--
College	0.052	--	--	--	--	--	--	--
Under college	0.097	--	--	--	--	--	--	--

Table G.1. The results of eight binary LOGIT models for boaters' awareness of Lake Michigan water level changes – cont'd.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Gender	0.644*	0.645*	0.640*	0.637*	0.647*	0.671*	0.645*	0.651*
Where boats were operated								
On inland Lakes	-0.217	-0.223	-0.220	--	--	--	--	--
On other Great Lakes	0.391	0.387	0.381	0.385	0.376	0.380	0.353	--
On Lake Michigan	2.593*	2.590*	2.587*	2.590*	2.567*	2.533*	2.509*	2.778*
Constant	9.245*	9.269*	9.179*	9.164*	8.442*	8.154*	7.945*	7.955*
Step chi-square [df]	466.6[17]*	-0.2[2]*	-0.2[1]*	-0.7[1]*	-1.8[1]*	-1.4[1]*	-1.2[1]*	-1.7[1]*
Block chi-square [df]	466.6[17]*	466.5[15]*	466.3[14]*	465.6[13]*	463.8[12]*	462.4[11]*	461.2[10]*	459.5[9]*
Model chi-square [df]	466.6[17]*	466.5[16]*	466.3[14]*	465.6[13]*	463.8[12]*	462.4[11]*	461.2[10]*	459.5[9]*
-2 Log likelihood	890.00	890.18	890.39	891.08	892.84	894.20	895.43	897.12
Cox & Snell R^2	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.33
Nagelkerke R^2	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Goodness-of-fit chi-square [df]	11.76[8]	10.08[8]	12.13[8]	9.72[8]	16.30[8]*	15.17[8]*	17.48[8]*	16.55[8]*
% Correct predictions	82%	82%	82%	82%	82%	82%	82%	82%

* $P\text{-value} < 0.05$

** $P\text{-value} < 0.10$

Table G.2. The results of five binary LOGIT models for boaters' assessments of Lake Michigan water level changes.

	Model 1	Model 2	Model 3	Model 4	Model 5
Boat length	0.051*	0.052*	0.053*	0.051*	0.052*
Number of years, the boat has been owned	0.047*	0.047*	0.047*	0.047*	0.048*
Boat type					
Outboard motor boat	0.178	0.159	0.164	--	--
Inboard-outboards	-0.268*	-0.282*	-0.292*	-0.428*	-0.432*
Inboard motor boat	-0.887	-0.895	-0.911	-1.038*	-1.045*
Pontoon boat	5.857	5.843	5.852	5.714	5.702
Operated the boat on other Great Lakes	-0.686*	-0.686*	-0.684*	-0.679*	-0.680*
Boat storage type					
Marina	-0.036	--	--	--	--
Cottage and second home	-1.294*	-1.270*	-1.273*	-1.268*	-1.267*
Boat storage county location					
Wisconsin	0.595	0.594	0.590	0.595	0.790*
Indiana	0.539	0.538	0.512	0.521	0.724*
Illinois	-0.227	-0.227	-0.247	-0.244	
Michigan	0.692	0.691	0.687	0.695	0.891*
Boat was kept in Lake Michigan coastal counties	0.397*	0.399*	0.404*	0.399*	0.377*
Boating activity – water skiing	-0.068	-0.070	--	--	--
Constant	0.139	0.102	0.077	0.250	0.035
Step chi-square [df]	61.532[13]*	-0.014[1]	-0.060[1]	-0.099[1]	-0.210[1]
Block chi-square [df]	61.532 [13]*	61.517[12]*	61.457[11]*	61.358[10]*	61.157[9]*
Model chi-square [df]	61.532 [13]*	61.517 [12]*	61.457 [11]*	61.358[10]*	61.157[9]*

Table G.2: The results of five binary LOGIT models for boaters' assessments of Lake Michigan water level changes – Cont'd.

	Model 1	Model 2	Model 3	Model 4	Model 5
-2 Log likelihood	540.159	540.173	540.233	540.332	540.533
Cox & Snell R^2	0.102	0.102	0.102	0.102	0.102
Nagelkerke R^2	0.157	0.157	0.157	0.157	0.156
Goodness-of-fit chi-square [df]	10.24[8]	8.41[8]	7.51[8]	10.33[8]	9.73[8]
% Correct predictions	78.9%	78.7%	79.1%	78.9%	79.1%

* $P\text{-value} < 0.05$

** $P\text{-value} < 0.10$

Table G.3. The results of nine binary LOGIT models for the boaters who were influenced and not influenced by concerns relating to low water levels.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Boat length	0.027*	0.028*	0.028*	0.027*	0.025*	0.02*	0.02*	0.02*	0.02*
Number of years the boat has been owned	-0.008	-0.008	-0.008	-0.008	-0.008	-	-	-	-
Boat type									
Inboard-outboards	-0.528*	-0.527*	-0.524*	-0.528*	-0.451*	-0.451*	-0.455*	-0.45*	-0.45*
Outboard motor boat	-0.132	-0.134	-0.134	-0.139	-	-	-	-	-
Sail boat	-0.450	-0.449	-0.448	-0.440	-0.396	-0.398	-0.438	-0.420	-0.41
Pontoon	0.164	0.166	0.171	0.159	0.237	0.252	0.276	0.273	0.27
Number of different boating counties/locations	0.128*	0.129*	0.132*	0.130*	0.132*	0.12*	0.13*	0.13*	0.13*
Number of boating days									
On Lake Michigan	-0.002	-0.002	-0.002	-	-	-	-	-	-
On other Great Lakes	0.003	0.003	-	-	-	-	-	-	-
Boat storage type									
Marina	-0.196	-0.204	-0.203	-0.183	-0.167	-0.170	-	-	-
Waterfront permanent home	0.030	-	-	-	-	-	-	-	-
Non-waterfront home	0.492	0.485*	0.492*	0.491*	0.491*	0.49*	0.52*	0.52*	0.52*
The boat was kept in Lake Michigan coastal counties	0.244	0.246	0.234	0.215	0.214	0.213	0.216	0.214	0.214

Table G.3. The results of nine binary LOGIT models for the boaters who were influenced and not influenced by concerns relating to low water levels – cont'd.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Boat storage county location									
Michigan	3.579	3.601	3.605	3.573	3.597	3.419	3.533	0.435*	0.421*
Wisconsin	3.174	3.193	3.183	3.154	3.186	3.004	3.118	0.019	-
Illinois	3.157	3.180	3.172	3.139	3.170	2.985	3.112	-	-
Indiana	4.005	4.028	4.020	3.968	4.016	3.850	3.979	0.878	0.865
Requested/received any information concerning water levels	0.922*	0.922*	0.929*	0.934*	0.932*	0.953*	0.973*	0.980*	0.979*
The boat was trailered to launch	0.559*	0.561*	0.563*	0.564*	0.576*	0.578*	0.542*	0.547*	0.546*
Constant	10.183	10.274	9.897	10.445	11.018	-5.281	-5.592	-2.516*	-2.504*
Step chi-square [df]	87.91[19]*	-0.01[1]*	-0.14[1]*	-0.13[1]*	-0.22[1]*	-0.44[1]*	-0.48[1]*	-0.55[1]*	-0.01[1]*
Block chi-square [df]	87.91[19]*	87.90[18]*	87.76[17]*	87.62[16]*	87.40[15]*	86.96[14]*	86.48[13]*	85.93[12]*	85.92[11]*
Model chi-square [df]	87.91[19]*	87.90[18]*	87.76[17]*	87.62[16]*	87.40[15]*	86.96[14]*	86.48[13]*	85.93[12]*	85.92[11]*
-2 Log likelihood	861.15	861.16	861.31	861.44	861.66	862.10	862.58	863.14	863.14
Cox & Snell R^2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Nagelkerke R^2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Goodness-of-fit chi-square [df]	10.84[8]	12.07[8]	12.65[8]	13.37[8]	11.45[8]	10.21[8]	12.62[8]	11.61[8]	15.66[8]*
% Correct predictions	69.2%	69.3%	69.6%	69.2%	69.4%	69.4%	69.0%	69.0%	69.0%

* P -value < 0.05

** P -value < 0.10

Table G.4. The results of six binary LOGIT models for the boaters who changed their boating locations in response to low water levels.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age	-0.017	-0.017	-0.016	-0.018		
Boat length	0.023	0.023				
Year the boat was owned	0.051*	0.050*	0.052*	0.052*	0.066*	0.072*
Inboard motor boat	0.878	0.872	1.033*	1.081*	1.161*	1.414*
Inboard-Outboards	0.956*	0.953*	0.951*	1.002*	1.092*	1.217*
Outboard motor boat	1.564*	1.559*	1.498*	1.567*	1.701*	1.816*
Sail boat	1.331	1.335*	1.448*	1.510*	1.570*	1.996*
Number of different boating counties/locations	0.382*	0.374*	0.393*	0.414*	0.442*	0.471*
Number of boating days	-0.001					
Number of Lake Michigan boating days	0.015	0.014	0.016	0.017	0.017	
Requested/received any information concerning water levels	0.695	0.696	0.756*	0.759*	0.763*	0.782*
Own a waterfront home	-0.287	-0.307	-0.294			
Constant	-100.741*	-99.111*	-104.966*	-103.280*	-131.326*	-143.795*
Step chi-square [df]	48.969[12]*	-.043[1]	-.566[1]	-.720[1]	-1.609[1]	-1.983[1]
Block chi-square [df]	48.969[12]*	48.926[11]*	48.360[10]*	47.640[9]*	46.031[8]*	44.048[7]*
Model chi-square [df]	48.969[12]*	48.926[11]*	48.360[10]*	47.640[9]*	46.031[8]*	44.048[7]*
-2 Log likelihood	243.612	243.655	244.221	244.941	246.550	248.533
Cox & Snell R^2	0.136	0.136	0.134	0.133	0.128	0.123
Nagelkerke R^2	0.233	0.233	0.231	0.228	0.220	0.212
Goodness-of-fit chi-square [df]	11.466[8]	13.050[8]	13.324[8]	7.855[8]	12.022[8]	9.526[8]
% Correct predictions	84.2%	83.9%	84.5%	84.8%	84.8%	84.8%

* P -value < 0.05 ** P -value < 0.10

Table G.5. The results of nine binary LOGIT models for the boaters who did less boating in response to low water levels.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Age	0.016	0.016	0.016	0.016	0.015	0.014	0.010	-	-
Boat length	0.036*	0.036*	0.034*	0.038*	0.046*	0.050*	0.052*	0.054*	0.044*
Number of year the boat has been owned	0.029	0.028	0.028	0.028	0.026	0.025	-	-	-
Number of boating days	-0.012*	-0.012*	-0.013*	-0.013*	-0.013*	-0.013*	-0.013*	-0.013*	-0.012*
Number of Lake Michigan boating days	-0.023*	-0.023*	-0.021*	-0.018*	-0.019*	-0.018*	-0.017*	-0.018*	-0.017*
Number of boating days on other Great Lakes	-0.009	-0.009	-	-	-	-	-	-	-
Number of different boating counties/locations	-0.155	-0.155	-0.168*	-0.179*	-0.173*	-0.176*	-0.170*	-0.175*	-0.159*
Inboard motor boat	0.560	0.541	0.500	0.370	-	-	-	-	-
Inboard-Outboards	0.023	-	-	-	-	-	-	-	-
Outboard motor boat	0.663	0.644*	0.623*	0.568*	0.517	0.493	0.493	0.477	-
Sailboat	0.520	0.500	0.470	-	-	-	-	-	-
Requested/received any information concerning water levels	0.311	0.312	0.293	0.334	0.330	-	-	-	-
Own a waterfront home	0.549*	0.547	0.555*	0.549*	0.537*	0.557*	0.564*	0.617*	0.589*
Constant	-58.209	-57.878	-57.383	-56.254	-52.820	-51.323	-1.106*	-0.656	-0.350*

Table G.5. The results of nine binary LOGIT models for the boaters who did less boating in response to low water levels – cont'd.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Step chi-square [df]	40.111[13]*	-0.003[1]	-0.495[1]	-1.009[1]	-1.213[1]	-1.367[1]	-1.443[1]	-0.974[1]	-2.363[1]
Block chi-square [df]	40.111[13]*	40.109[12]*	39.613[11]*	38.604[10]*	37.391[9]*	36.024[8]*	34.581[7]*	33.607[6]*	31.244[5]*
Model chi-square [df]	40.111[13]*	40.109[12]*	39.613[11]*	38.604[10]*	37.391[9]*	36.024[8]*	34.581[7]*	33.607[6]*	31.244[5]*
-2 Log likelihood	396.568	396.571	397.066	398.075	399.288	400.655	402.099	403.072	405.435
Cox & Snell R^2	0.120	0.120	0.118	0.115	0.112	0.108	0.104	0.101	0.094
Nagelkerke R^2	0.159	0.159	0.158	0.154	0.149	0.144	0.139	0.135	0.126
Goodness-of-fit chi-square [df]	7.954[8]	5.173[8]	5.489[8]	8.934[8]	3.508[8]	5.473[8]	10.647[8]	6.108[8]	6.672[8]
% Correct predictions	66.3%	66.3%	66.3%	66.0%	64.1%	63.8%	64.1%	62.5%	64.1%

* P -value < 0.05

** P -value < 0.10

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