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Characterization of Unintentional Fatal Drowning within National Park Service Parks and Delaware Water Gap National Recreational Area

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2009

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An abstract of
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Abstract

Characterization of Unintentional Fatal Drowning within National Park Service Parks and Delaware Water Gap National Recreational Area

By Ellen G. Taetzsch

Background: Drowning is the third leading cause of unintentional deaths worldwide and seventh in the United States. Young children are more likely to drown in domestic bodies of water whereas adolescents and adults in natural bodies of water. Males are at a greater risk of drowning than females. The National Park Service is dedicated to preserving natural and historic treasures within the United States. Due to the nature of these parks, visitors are at risk for injuries, and drowning is the leading cause of unintentional fatality in the parks.

Objectives: The aim of this study is to characterize drownings within the National Park Service and Delaware Water Gap National Recreational Area by examining demographics, timing, location and other factors associated with a drowning event.

Methodology: A retrospective analysis was performed using data collected from the Public Risk Management Visitor Injury System for all national parks between July 21, 2006 and October 20, 2010. Univariate analyses were conducted. ANOVA and chi-square tests were run to determine associations. More detailed park level data were obtained from Delaware Water Gap. The time frame for these data were January 1, 1971 to October 20, 2010.

Results: The drowning rate within all parks was 2.4 per 10,000,000 visitor days. For Delaware Water Gap it was 6.1 per 10,000,000 visitor days. Drowning fatalities were concentrated among those 15 to 24 years and predominantly effected males. Seasonal, weekday and time of day variation was seen. Those parks whose main source of water were lakes or ponds had the highest rate of drowning. Parks located within the Northeast Region experienced the highest drowning rate.

Discussion: Increased exposure to water due to temperature and ability to participate in water events was primarily responsible for increases in drowning. The denominator used to calculate rates was visitor days, not those visitors that were exposed to water. Rates may be diluted since more visitors enter the park than those exposed to water. These findings allow for a better understanding of drowning within these parks.

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Chapter 1: Introduction and Rationale

Drowning is the third most common cause of death among unintentional injuries (1). It is the eleventh highest cause of death among 0 to 4 year olds, third among 5 to 14 year olds, and seventh among 15 to 29 year olds worldwide (2). Even though it causes a large number of deaths, experts believe that 80% of drowning deaths are preventable (3). In 2000 it was estimated that 449,000 people drowned worldwide and 1.3 million Disability Adjusted Life Years (DALYs) were lost due to disability or premature death caused by drownings(2). In 1997, the National Safety Council estimated that the cost of fatal drowning along coastlines where lifeguards were present was $273,420,000 (4). In addition to the fatalities the Council also determined that there is an estimated annual cost of $138,000 for an incapacitating injury and $180,000 for a catastrophic injury (4). Furthermore, it is believed that for each fatal drowning there are 500 to 600 non-fatal drownings (5). Due to this high incidence of drownings and the nature of preventability it is important to gain a better understanding of drowning for public health professionals so that they can better target those at risk for drowning.

Within the National Park Service unintentional injuries are the cause of the greatest number of fatalities and drowning comprises the largest proportion of unintentional injuries (6). In 2008, there were 48 fatal drowning and in 2009 there were 45, within the National Park Service. Thus, it is estimated that the numbers of non-fatal drownings would be between 24,000 and 28,800 in 2009. However, the ability to capture non fatal drownings is difficult and data available often do not accurately represent the actual problem.

The National Park Service in the United States is made up of 394 parks (7). These parks are established to conserve the parks natural and cultural resources and

provide opportunities for the public's enjoyment. It is the intent of the National Park Service to enable visitors to have an injury free park experience. In order to do this a better understanding of what causes injuries and risk factors is needed.

There has yet to be a descriptive analysis of drownings in parks over time to explore the burden, magnitude and trends in the National Park Service. This analysis will allow the National Park Service to more effectively target prevention efforts, direct resources more efficiently, and reduce the overall incidence of drowning events in parks, it is important to gain a better understanding of drowning incidents within the National Park Service.

The goal of this thesis is to rely on retrospective data to better understand unintentional fatal drowning trends, distributions, and characteristics within the National Park Service and Delaware Water Gap National Recreational Area. The Delaware Water Gap National Recreational Area was separated into its own category since it is one of the few parks with a comprehensive data collection system available on drownings. It had data available since 1971 and provided accessible collected data to be used. Characterization of unintentional fatal drownings will be achieved by studying characteristics of the drowning victim, location and timing of the event, and activities and factors contributing to the event.

In 2009 there was 285,579,941 recreation visits within the National Park Service (8). There are a great number of individuals at risk of drowning within the park system. It is important to increase knowledge of what the past trends and characteristics of drowning in order to determine how best to prevent this occurrence in the future.

Chapter 2: Literature Review

Drowning a Global Issue:

A Lancet Review published an editorial that indicated in 1990 death by drowning (504,000) was more common than death through war (502,000) and death from HIV (312,000)(9). The World Health organization estimates that 450,000 people die annually from drownings, at a rate of about 7.4 per 100,000(2, 3, 10, 11). Drowning is the third leading cause of unintentional deaths worldwide, accounting for 7% of all unintentional deaths (1, 12).

Drowning rates differ by both age and sex. Children under five years old have the highest drowning rate of 18.9 per 100,000 and it is the eleventh leading cause of death (2). The lowest rate is among those between the ages of 30 and 45 years with a rate of 4.3 per 100,000 (2). Drowning was ranked the third leading cause of death for those 5-15 years and seventh for those 15-29 years (2).

The locations that victims drown differ by age. Young children tend to drown in bathtubs, buckets, swimming pools and other domestic bodies of water, where as adolescents and adults tend to drown in natural bodies of water (13). Young children are at greatest risk for home drownings because at this age there is little perception of the risk of drowning and thus these individuals require more supervision when around bodies of water (14). Males have a higher rate of drowning than females, 9.9 per 100,000 compared to 4.9 per 100,000 (Table 1) (2). Approximately 96% of all unintentional drownings death occurs in low and middle income countries (1). Sixty percent of all unintentional drownings occur in the WHO Western Pacific and South East Asia Regions (1). However, Africa had the highest mortality rate, 13.1 per 100,000 (1; 2).

Table 1. Drowning Mortality Rates per 100,000 Population Worldwide, 2000 (2).

Age (years)	Male	Female	Both Sexes
0-4	21.7	15.8	18.9
5-14	12.0	6.7	9.5
15-29	7.5	2.4	5.0
30-44	6.2	3.1	4.3
45-59	6.9	2.5	4.7
60-69	6.6	4.0	6.2
70-79	11.8	6.8	8.9
80+	16.7	12.0	14.6
All ages	9.9	4.9	7.4

Within a target population, for each fatal drowning there have been estimates of between 2 to 20 or 500 to 600 non fatal drownings (5, 15, 16). Drownings can happen in less than a minute and often times victims show no signs of distress and are unable to call for help or wave their hands (4). This can make rescue difficult and the incident harder to characterize.

There has been a downward trend in drownings over the past 100 years in most countries, including the United States (3, 12). This may be attributed to an increase in urbanization which decreased exposure to water, increased swimming abilities among the general population, increased knowledge of first aid and CPR techniques, indoor leisure activities and less use of alcohol around water (3, 12).

Definitions:

There is no universally accepted definition of drowning; however, in 2002 a widely accepted definition was established. In 1981 Modell defined drowning as "suffocation by submersion, especially in water" (10). Since then many different definitions of drowning have been presented. Below are some of the definitions for drowning:

- "Death by suffocation by submersion in water within 24 hours with or without aspiration
- Suffocation by immersion or submersion in any liquid medium caused by the entrance of liquid into the airways, that partially or fully compromises ventilation or oxygen exchange
- Submersion that promotes death by decreasing oxygen delivery and creating tissue hypoxia"(15)

Prior to 2002, the definitions and language used to describe drowning was inconsistent. In 2002 the First World Congress on Drowning defined drowning as "the process of experiencing respiratory impairment from submersion or immersion in a liquid" (10, 17). This unified the definition of drowning (10). It established two classes of drownings: 1. Drownings, indicating a fatal incident and 2. Non-fatal drownings, indicating an incident where the victim survives (11). There are different ways to further classify this such as passive drowning which indicates that the drowning was observed and the victim had no motion where as active drowning indicates that there was motion (15). There is also a distinction between immersion and submersion. Immersion is when the head is out of the water indicating a brief time under water while submersion suggests that the head is under water (15).

In this study drowning was defined as a visitor who experienced an unintentional fatal drowning, as described by the park, within National Park Service jurisdiction.

Risk Groups:

Although drowning can affect anyone exposed to water certain groups are more at risk than others. Males are at greater risk of drowning than females. Male children under

the age of five years had the greatest drowning rate among any sex of any age group worldwide, as seen in (Table 1)(2).

Pre existing medical conditions can also increase an individual's risk of drowning; these conditions include epilepsy, physical and mental handicaps, myocardial infarction, seizure disorder and autism (11, 18).

Individuals exposed to water often are at greater risk of drowning than those who are not often exposed (1, 3, 19). Children who live near ditches, ponds, irrigation channels and pools are at greater risk (1). Adults who work in the fishing industry, boat refugees and in occupations that have high contact with water are also at increased risk (3).

Alcohol use increases one's risk of drownings. Alcohol intake may increase risky behaviors, decrease coordination and impair the sense of orientation (20). It is estimated that between 25 to 50 % of adult and adolescent water activity related deaths had alcohol involved (21). The relative risk of drowning was 31.8 among persons with a blood alcohol level of 21.7 mmol/L or greater compared with those without any alcohol in their system (20). The risk ratio of those with a blood alcohol level greater than 0 but less than 21.7 mmol/L was 4.6, indicating that having any alcohol within the body increases the risk of drowning (20).

Other risk factors are rural populations, since they are exposed to more natural bodies of water, unsupervised infants, unsafe water transport or those that take water transport (i.e. taking water transport that carries more people than the maximum capacity), tourists unfamiliar with local water conditions and flood situations (1).

Drowning also occurs more frequently in individuals with lower levels of education and income (11, 18), in indigenous communities, and less developed countries (13).

There is also emerging evidence that ocean drowning are more likely to occur in people who live inland or are tourists, possibly due to lack of knowledge of water conditions (22).

DALYS:

Drownings were responsible for 7% of the global injury related deaths worldwide, with half occurring in individuals under 15 years old (1, 2, 12). For each fatal drowning there are multiple survivors that are left with permanent disabilities (2). Non-fatal drownings can lead to brain damage that may create long term disabilities such as memory problems, learning disabilities and loss of basic functioning levels (23). Overall, of those who experience a non fatal drowning event, 5 to 10% have an outcome of severe neurological damage (18). These outcomes are more common when the drowning event occurs in open water, which is the case in National Parks (18). In 2000, 1.3 million disability adjusted life years (DALYs) were lost from premature death or injury related to drowning (11). These injuries create financial problems for the individual, family, hospital, society and may be great due to the cognitive impairment from drowning (3).

Drowning in the United States:

By the early 1900's in the United States as many as 9,000 people died each year from unintentional drowning. This was due to the increase leisure time spent in recreational waters and the lack of lifesaving skills because of the novelty of this pastime (4). Since then there has been a decrease in drowning numbers (Table 2) most recently, in 2007 there were 3,443 unintentional drowning deaths. Also, measured in 2001, 4,174

people on average were treated for non fatal drowning injuries in the United States in an emergency department from events occurring in recreational settings (24). It is important to note not only fatal drownings but also non-fatal drownings because the circumstances surrounding these events can provide critical prevention information.

Table 2. Number of Unintentional Drownings by Year in the United States

Year	Number of Unintentional Drowning Deaths	Citation
1981	6,300	(4)
1995	4,350	(20)
1998	4,000	(4)
2001	3,372	(24)
2007	3,443	(23)

Overall in 1995, the majority of drownings among individuals less than 20 years old occurred in fresh water, 47%, and artificial pools, 32% (Table 3) (16). Fifty five percent of infants that drowned died in bathtubs, 56% of children between 1 and 4 years who drowned did so in artificial pools and 26% in fresh bodies of water (16, 20).

Table 3. Location Where Individuals Under 20 Years Drowned in 1995(16)

Location	**Percent**
Freshwater	47%
Artificial Pools	32%
Domestic Water	9%
Salt Water	4%
Unspecified	8%

In 1995 drowning was the fourth leading cause of unintentional injury in the United States (20). By 2001 drowning was ranked seventh in all age groups and second among children between the ages of 1 and 14 (24).

In the United States the child to adult ratio of drowning is 3:1 (21). Children under five years had the highest rate of drowning in the United States, 2.5 per 100,000 As

a child becomes older a drowning incident is more likely to occur in natural bodies of water opposed to a domestic location (16).

The United States also experiences a difference in drowning rates by gender. Males, overall, were 3.7 times more likely to die from unintentional drowning than females (23). In 1995, 38% of drownings among females occurred in artificial pools and 33% in fresh water. Among males, 30% of drownings occurred in artificial pools and 52% occurred in freshwater (16). The non fatal drowning rate for males is about twice the non fatal drowning rate for females (24). Males were also more likely to be hospitalized than females for drowning events (1). This may be due to increased exposure to water, riskier behaviors like swimming alone, or increased likelihood to drink alcohol or use drugs before swimming or boating (1).

In the United States drowning rates differ by racial groups. Between 2000 and 2007 the unintentional drowning rate for blacks was 1.2 that of whites (23). For American Indians and Alaskan natives in the same time frame the unintentional drowning rate was 1.7 times that of whites (23). Among those white children under 20 years, 50% of fatal drownings occurred in freshwater and 31% occurred in artificial pools, however 38% of fatal drownings of blacks in this same age group occurred in artificial pools and 35% occurred in freshwater (16). These differences may be due to differences in physical environments such as access to swimming pools and social and cultural factors, such as participation in swimming lessons (23).

Drowning events in the United States have a temporal pattern. Drowning events are more likely to occur on weekends and in the summer months, June through August

(24). Between 2001 and 2002 51% of the fatal drownings occurred in these months (10, 24).

Prevention:

Prevention is the most important way to reduce the number of drownings (12). Treatment at a hospital does not substantially improve outcomes, therefore, both primary and secondary strategies are necessary (24). Some primary strategies include decrease the unintentional entry into water especially among the young, build barriers around bodies of water and drain unnecessary water areas (24). Some examples of secondary measures are the use of life jackets, avoidance of intake of alcohol before entering the water, promoting swimming lessons and water safety classes, educating individuals to choose swimming sites with lifeguards and promoting cardio pulmonary resuscitation (CPR) education (24).

Supervision is one of the most important ways to prevent drowning among young children and elderly (10, 12, 25). Supervision compensates for environmental hazards (21). A recent study examining causes of 496 fatal drownings determined 10% had no supervision (18). Of those supervising children less than 14 years, 38% admitted to talking to others, 18% to reading, 17% to eating, 11% to talking on the telephone while supervising their child in the water (18). Thus, even if a supervisor is present it does not mean that the quality of supervision is good. Who is supervising, especially in preschool aged and younger children, impacts the quality of supervision (adult versus peer) as well as the proximity of the supervisor. The supervisor should be within touching distance of children at all times (10, 25).

Another way to prevent drowning is the use of life jackets. Life jackets have a protective effect and all children and adults should wear them while boating or participating in activities that may lead to falling in the water (10). Only 9% of drowning victims in 2008 were wearing life jackets (18). A successful education and life jacket loan program could assist in the prevention of unintentional drownings (18).

The presence of lifeguards has a positive impact on the outcome of drownings (26). It is estimated that lifeguards save 100,000 people annually (4). However, the effectiveness of lifeguards does vary. Lifeguards watching the same water body often rely on other lifeguards to scan their area, assuming that the other lifeguards will make up for any lacking effort that they have (27).

An estimation for the likelihood of drowning on a beach patrolled by a lifeguard is less than 1 in 18 million persons on beaches (4). This may be due to the fact that lifeguards deter behaviors that put individuals at risk such as horse play or swimming in deep water (4). Despite the effectiveness of lifeguards, approximately 60 to 70% of beaches in the US are unguarded (4).

Swimming ability and water competence are also important in an individual's ability to survive a drowning episode. A working definition for swimming ability is "a recognizable stroke and breathing in such a manner as to permit a reasonable distance to be covered", however there is no universally accepted definition (28). Water competence is the "combination of aquatic skills, knowledge of water and affective dispositions;" affective dispositions meaning perceived consequences of actions and social interactions that influence actions in regards to swimming and social factors influencing swimming ability (28). A study from the Eunice Kennedy Shriver National Institute of Child Health

and Human Development discovered that individuals who drowned were less likely to have taken part in formal swimming lessons (3% compared with 26%) (18). However, some argue that swimming ability may lead to an increased risk of drowning because increased exposure to environments with water and over confidence in swimming ability (18, 28).

Once a drowning event has occurred, one way to reduce the medical damage is by initiating CPR. It is believed that CPR is administered in 40 to 60% of all drowning cases (3). Several studies have found that victims who initially survived were those who received CPR at the scene and of those 50 to 80% survived to hospital discharge (3).

Findings From Characteristics of Drowning by Different Age Groups By L Quan and P Cummings:

One study conducted in King County, Snohomish County, and Pierce County Washington analyzed drownings from January 1, 1980 through December 31, 1995. During this time period there were 709 unintentional drowning deaths (29). The highest rate of drowning was among children four years old or younger, 3.1 per 100,000, followed by 15 through 19 year olds, 3.0 per 100,000. Seventy eight percent of these drownings were males (29).

In this study, the location and activities associated with drowning differ by age categories. Seventy two percent of all drownings occurred in open water. Among those aged 15 to 39, 90% of drownings occurred in open water (29). In contrast, there were equal numbers of open water and swimming pool drowning among those 4 years and younger (29). Among those 65 years and older, 57% of drowning occurred in bathtubs (29). Fifty four percent of drowning occurred in rural settings (29). However, in those 65 years old and older, and 4 years and younger, urban settings were more common sites

of drowning than rural settings (29). Among those under five years, drowning was caused by falling into a body of water, 74%, followed by bathing, 24%. Among 5-14 year olds 39% of drownings were due to falling into water, followed by swimming, 37% (29). Thirty four percent of 15-19 year olds drowned while swimming and 31% drowned while boating (29).

There were also differences between racial groups. Eighty four percent of drownings occurred among white individuals; however blacks experienced a higher rate of drowning, 3.5 per 100,000, compared to whites, 1.7 per 100,000 (29).

Ten percent of all the unintentional drownings occurred in people with a history of seizures, and 18% had a history of heart disease (29). Twenty two percent had alcohol in their blood, but this was not detected in anyone under the age of 15 years (29). Thirty three percent of 20 through 34 year olds and 35% of 35 through 64 year olds had alcohol in their blood (29).

National Park Service:

This thesis will examine drownings within the National Park Service. On August 25, 1916 President Woodrow Wilson signed an Act creating the National Parks Service; however, Yellowstone National Park, the first national park, was established in 1872 by Ulysses S. Grant (7). There are currently 394 park units that comprise the National Park Service, which is composed of 84 million acres located in every state except Delaware (7). The mission of the National Park Service is to preserve natural and historic treasures within the United States so that future generations may enjoy these locations (30). The National Park Service Management Policy Section 8.2.5.1 of 2006 states “the saving of human life will take precedence over all other management actions as the Park Service

strives to protect human life and provide injury free visits," thus, human safety is also important (6). The wilderness nature of National Parks combined with the vast array of outdoor activities visitors enjoy in the parks, such as hiking, boating, and rock climbing, unintentional injuries do occur. Approximately fourteen people are seriously injured everyday and three visitors die per week within the National Park Service (31). Of the unintentional recreational fatalities, 76% are in males with a median age of 38 years and a range of 5 years old to 80 years old (31). The majority of fatalities are from common events such as motor vehicle accidents, swimming, suicides and hiking as opposed to less common causes such as being attacked by a bear (32). Drowning is the leading cause of unintentional fatalities within the National Park Service (6). During 2003 and 2004 swimming was the third most common activity associated with drownings, 11%, and boating was responsible for 5% (32). Rip currents, river currents and large waves were associated with over half of all swimming fatalities in this same time period (32). The National Park Service employs a number of measures to prevent unintentional injuries such as closing down access to dangerous areas, postings signs warning of danger, distributing brochures on safety and giving ranger talks to address safety within the park (6).

Chapter 3: Methods

There are two sections of this thesis. One portion looks at drownings within all the National Park Service Parks from July 21, 2006 to October 20, 2010. While the other portion examines Delaware Water Gap National Recreational Area covering the time frame of January 1, 1971 through October 20, 2010. The reason that Delaware Water Gap was split out into its own section is that there was more data available over a longer time frame, the consistent occurrence of drowning incidents within this park and the availability of data. This then gives a glimpse of the long term trends of drowning within one park and may give some insight into the situation among all the parks.

The definition used for drowning in this thesis was a visitor who experienced an unintentional fatal drowning, as described by the park, within National Park Service jurisdiction.

The Institutional Review Board (IRB) was consulted. The data used was secondary and de-identified, thus exempting it from IRB review.

All National Park Service Parks

A retrospective data analysis was performed using data gathered by the National Parks Service from July, 21, 2006 to October 20, 2010. The data that were used were collected through the Public Risk Management Visitor Injury System. Parks are required to report certain incidents such as deaths or incidents involving three or more people to the National Park Service headquarters in Washington D.C. The data came in three different data files and thus need to be merged into one data set with matching variables. The data from this time frame were then gathered and compiled into a database. More detailed information about the drowning event is available during this timeframe as

opposed to simply raw numbers. Of all the incidents reported, 269 drownings were listed as the cause of injury, or contributing factor of the incident or had immersion/submersion listed as a contributing factor. Those that were known to be a suicide were excluded from the analysis.

Data were then gathered about the parks. Maps of the parks were examined to determine if the park had a source of water. Then to determine the main source of water; creek, river, lake, pond, ocean, bay, sound, reservoir, marsh or bayou. Acreage and visitor day information was then collected on these parks. Visitor day information was collected for each month of those parks with water. Since July 2006 and October 2010 were not full months the visitor day information for these months adjusted accordingly.

There were three different types of variables that were examined, demographic information about the victim, information about the incidents, and information about the parks. The demographic variables were age and sex. The variables about the incident were time the event occurred, the date of the event, if the event was a fatal event, environment where the event occurred and the activity that the victim was participating just prior to drowning. The variables that were collected about the National Parks were the region of the National Park, number of drowning in the national park, visitor days in the national park and main type of water in the park. The main type of water in the park was divided into five categories; river, lake/pond, ocean/sound/bay, reservoir/bayou/marsh and creek. The activity prior to drowning was categorized into 18 categories. Age was also categorized into 5 year age groups. The date was used to determine the day of the week that the event occurred, and the season of the event. Seasons were categorized as followed: 1. Winter: December, January, and February 2.

Spring: March, April, May 3. Summer: June, July, August and 4. Fall: September, October, November.

The data were analyzed using SAS 9.2, excel and Open Epi. Prevalence rates of drownings were calculated. Frequencies and percentages of drownings were also calculated as well as demographic characteristics of those individuals who drown and characteristics of the drowning events, such as weekday and location. Chi square and ANOVA tests were run to see if there were differences between variables.

Delaware Water Gap National Recreational Area:

The data analyzed for this portion of the thesis was collected from January 1, 1971 through October 20, 2010. There were a total of 81 drownings during this time frame. Surveillance data from the Delaware Water Gap National Recreational Area from 1971 through 2008 as well as the information from the Public Risk Management Visitor Injury System given to headquarters of the National Park Service between July 21, 2006 and October 20, 2010 were examined. Duplicate records were deleted. Those that were determined to be a suicide were excluded from the analysis.

The variables that were examined for the Delaware Water Gap National Recreational Area portion of the thesis were again demographic variables and variables about the incidents. The demographic variables that were examined were age and aggregated sex information. The information about the event that was given in an aggregated form was the time of the event. Other variables examined were the date of event and activity prior to drowning. The visitor days about for each year were collected. Since 2010 was not a full year the visitor day numbers were adjusted accordingly. The date of the event was used to determine the weekday, the month and the season that the

drowning occurred. The activity prior to the event of drowning was divided into seven categories: boating which includes kayaking, canoeing and all other boats, camping, rafting, swimming and wading, tubing, hiking and walking, and jumping and falling.

SAS 9.2, excel and Open Epi were used to analyze this data. Prevalence rates and numbers of drowning by year and overall numbers were calculated using the number of drownings over the number of visitor days. Percentages and averages were calculated of the number the timing of drownings, the contributing factors and the state the drowning occurred. ANOVA tests were run to determine differences.

This study has small sample size. The analysis of all parks have data on less than five years. This limits the generalizability of the study. Also only fatal drownings were used in the analysis due to the inaccuracy of non fatal drownings. There also may not be a consistent definition of drownings within the parks thus leading to inaccuracies of what is considered a drowning in each park and what may be attributed to other causes. Some variables also had a large number of missing data for certain variables which limit the validity of some measures. The Delaware Water National Recreation Area is only one example of a park and it is unclear if the trends in this park over the 29 year period are similar to what has occurred throughout the parks of the National Park Service.

Chapter 4: Results

All National Park Service Drownings

Overall, between July 21st, 2006 and October 20th, 2010 there were 221 unintentional fatal drownings reported in 53 parks. The rate of fatal drownings during this time period was 2.4 drownings per 10,000,000 visitor days (Table 4) with an average of 4.3 drownings per month. The year 2010 had the greatest rate of drownings at 3.0 per 10,000,000 visitor days as well as the highest number of fatal drownings at 57, even though data was not fully available for this thesis in October, November or December (Table 4). The rates for 2006 and 2010 were adjusted.

Table 4. Frequency and Rates of Drownings within the National Park Service July 21, 2006 through October 20, 2010.

Year	Visitor Days	Number of Fatal Drownings	Rate of Fatal Drownings per 10,000,000 Visitor Days (95% Confidence Interval)
July 21, 2006-December 31, 2006	95,759,194	21	2.2 (1.4, 3.3)
2007	207,067,415	44	2.2 (1.6, 2.8)
2008	211,708,968	48	2.3 (1.7, 3.0)
2009	219,524,669	52	2.4 (1.8, 3.1)
January 1, 2010-October 20, 2010	186,616,719	56	3.0 (2.3, 3.9)
Total	920,602,687	221	2.4 (2.1, 2.7)

The total number of drownings have been increasing during this time frame, with seasonal variation (Figure 1). Seasonal variation is seen for rates of drowning; however, the rate has been decreasing unlike the overall number, (Figure 2).

Figure 1. Number of Fatal Drownings by Month within the National Park Service July 21, 2006 through October 20, 2010.

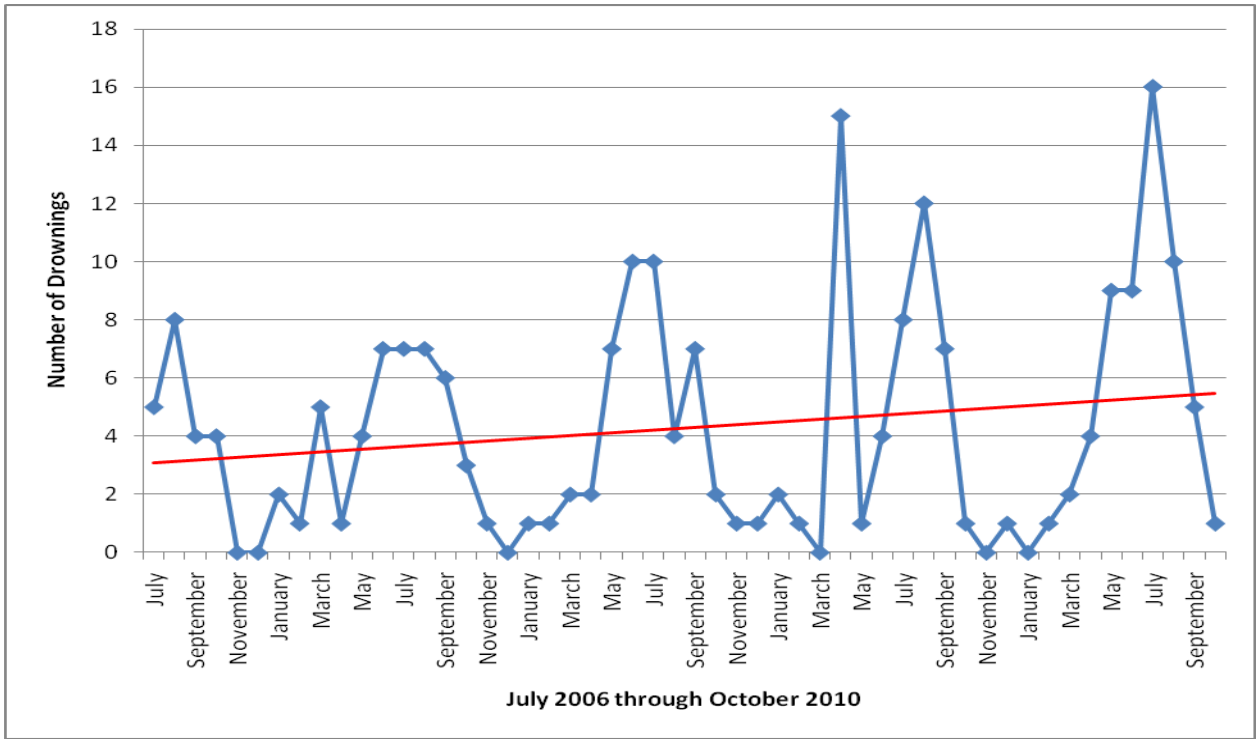
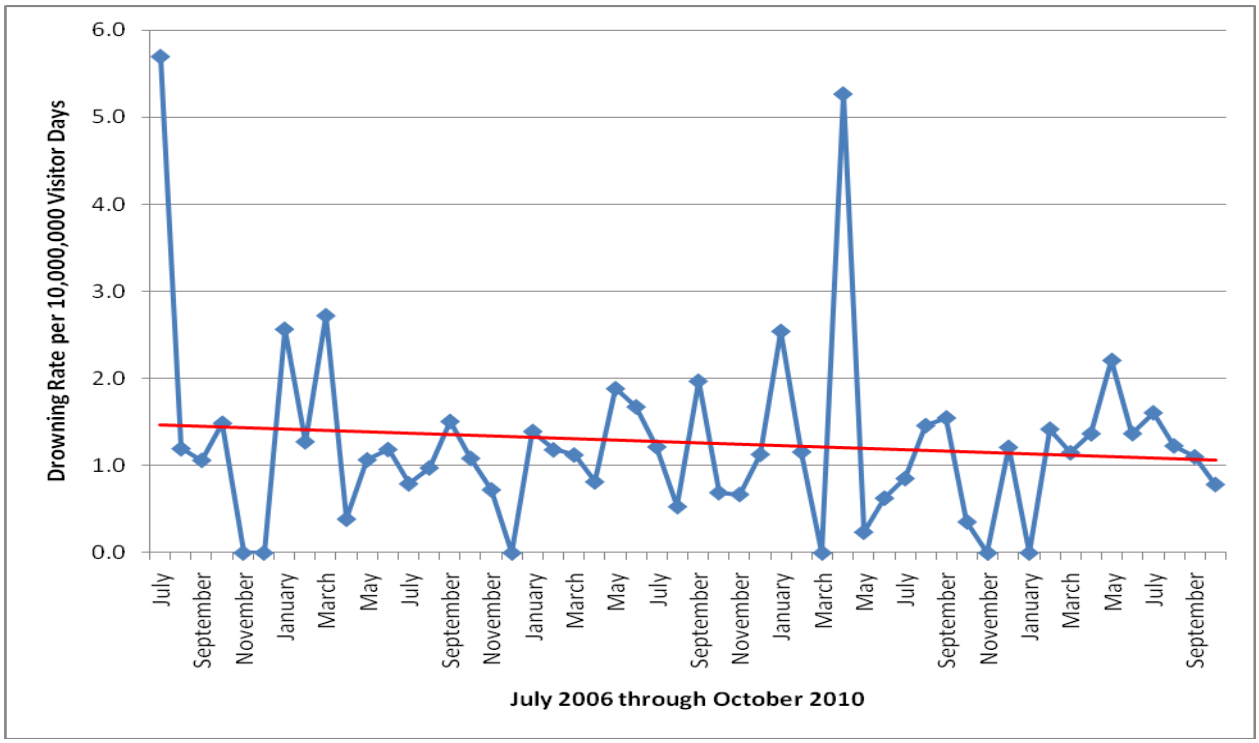


Figure 2. Rate of Fatal Drownings by Month within the National Park Service July 21, 2006 through October 20, 2010.



The parks with the greatest rates of drowning during this time frame were Big Thicket National Preserve, 181.1 per 10,000,000, Upper Delaware Scenic and Recreational River, 125.5 per 10,000,000, and Gauley River National Recreation Area, 96.9 (Table 5 and Appendix A for a full list of rates).

Table 5. Top Five National Parks with the Highest Rates of Drownings July 21, 2006 and October 20, 2010.

Park Name	Type of Unit	State	2006	2007	2008	2009	2010	Overall
Big Thicket	National Preserve	TX	387.7	9.5	50.6	22.8	434.6	181.1
Upper Delaware	Scenic & Recreational River	NY,PA	93.9	80.6	105.5	77.4	270.0	125.5
Gauley River	National Recreation Area	WV	0.0	84.6	89.1	0.0	310.7	96.9
Redwood	National and State Parks	CA	99.7	51.9	25.2	0.0	134.9	62.3
Little River Canyon	National Preserve	AL	0.0	0.0	101.2	0.0	121.3	44.5

The parks with the greatest number of drownings were not these parks. Lake Mead National Recreation Area had the greatest number of drownings, 31, followed by Cape Hatteras National Seashore, 18, and Glen Canyon National Recreation Area, 17, (Table 6). For a full list of the number of drownings by park see Appendix B.

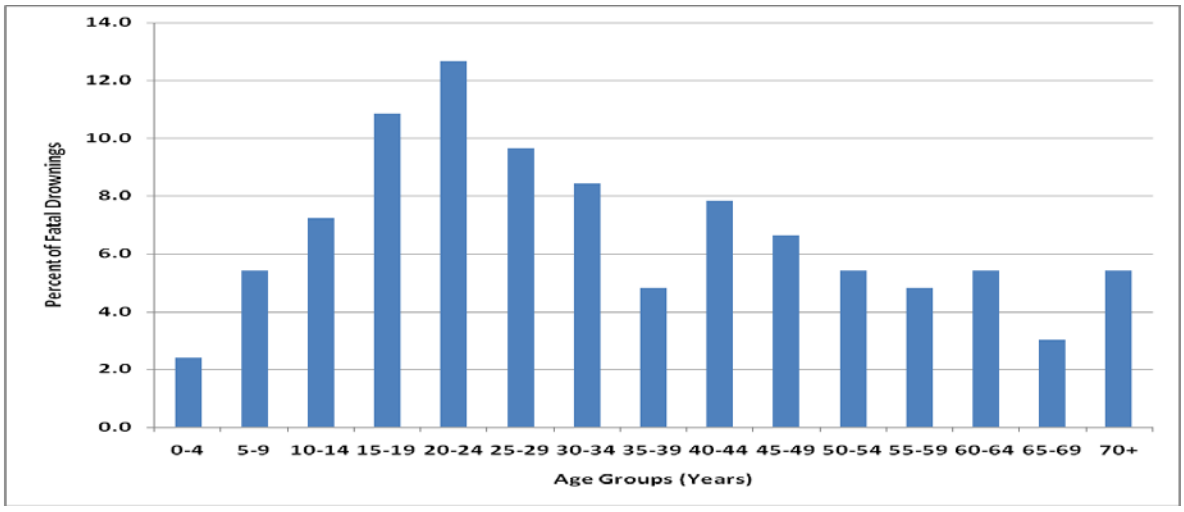
Table 6. Top Five National Parks with the Highest Number of Drownings Parks July 21, 2006 and October 20, 2010.

Park Name	Type of Unit	State	2006	2007	2008	2009	2010	Total
Lake Mead	National Recreation Area	AZ,NV	2	4	8	9	7	30
Cape Hatteras	National Seashore	NC	3	6	1	6	2	18
Glen Canyon	National Recreation Area	AZ,UT	2	2	6	7	0	17
Delaware Water Gap	National Recreation Area	NJ, NY, PA	0	2	5	1	1	9
Upper Delaware	Scenic & Recreational River	NY,PA	1	2	3	2	0	8

Age and Gender Characteristics of Fatal Drowning Victims within the National Park Service

Overall, between July 21, 2006 and October 20, 2010, the mean age of drowning was 34 years (median 31 years). The youngest victim was 2 years old and the oldest was 80 years old. The age groups with the greatest percentage of drownings were the 20 to 24 year olds, 12.7%, followed by those aged 15 to 19 years at 10.8% (Figure 7). The groups that comprised the lowest percentage were those under five years old, 2.4%, and the 65-69 year olds, 3.0% (Figure 3).

Figure 3. Fatal Drownings among Five Year Age Groups within the National Park Service July 21, 2006 through October 20, 2010.



There is a significant difference in the number of males and females that drown, p <.0001. Seventy nine percent of all fatal drowning victims were male. Among those under five years old there was equal number of males and females who drowned (Table 7). In the 5 to 9 year old age group there were a greater number of female victims than male victims but in all other age groups males drowned more frequently than females(Table 7). The average age of drowning for males is 35 years, whereas the average age of drowning is 29 years for females.

Table 7. Sex of Victims by Age Group within the National Park Service July 21, 2006 through October 20, 2010.

Age Group (Years)	Female	Male
Under 5	2	2
5-9	6	3
10-14	5	7
15-19	0	18
20-24	2	19
25-29	3	13
30-34	1	13
35-39	2	6
40-44	4	9
45-49	0	11
50-54	3	6
55-59	2	6
60-64	3	6
65-69	0	4
70+	0	9
Total	33	132
Unknown	57	

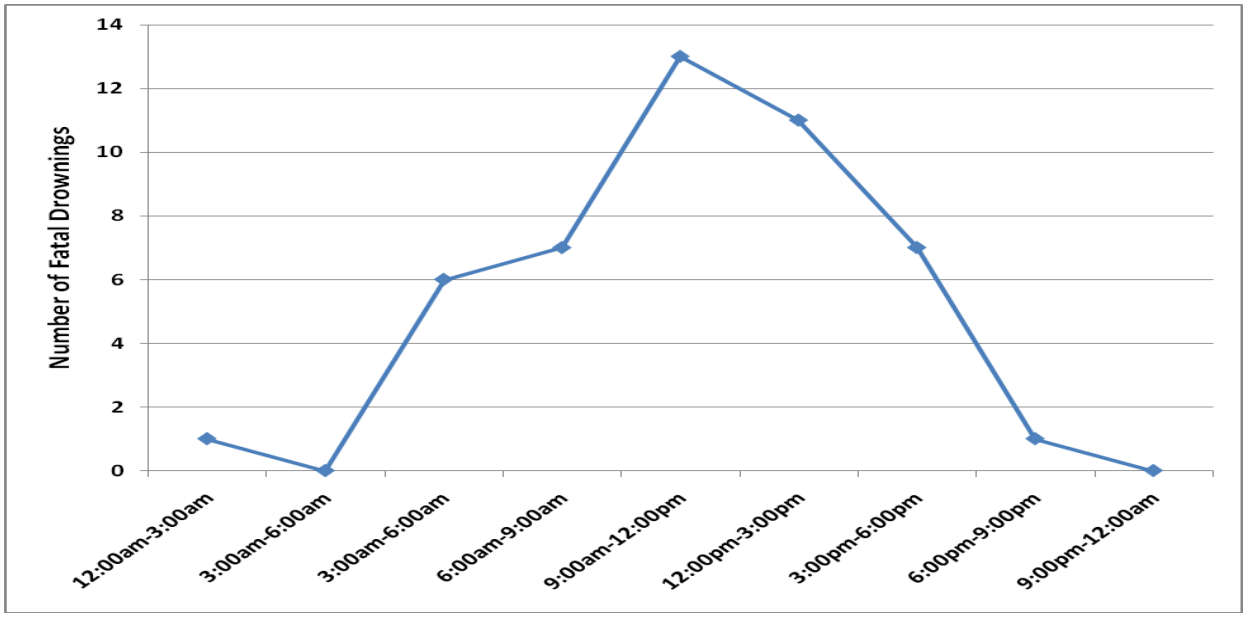
Timing of Drownings within the National Park Service

There are times of the day and year where drownings occur more often than other times, thus increasing the risk to park visitors.

Hour of Drowning:

The greatest percentage of drownings with a reported time occurred between 9:00am and 3:00 pm, 51.1%. No drownings were reported between 3:00am and 6:00am as well as 9:00 pm and 12:00 am (Figure 4).

Figure 4. Hour of Drowning Occurrence within the National Park Service July 21, 2006 through October 20, 2010.

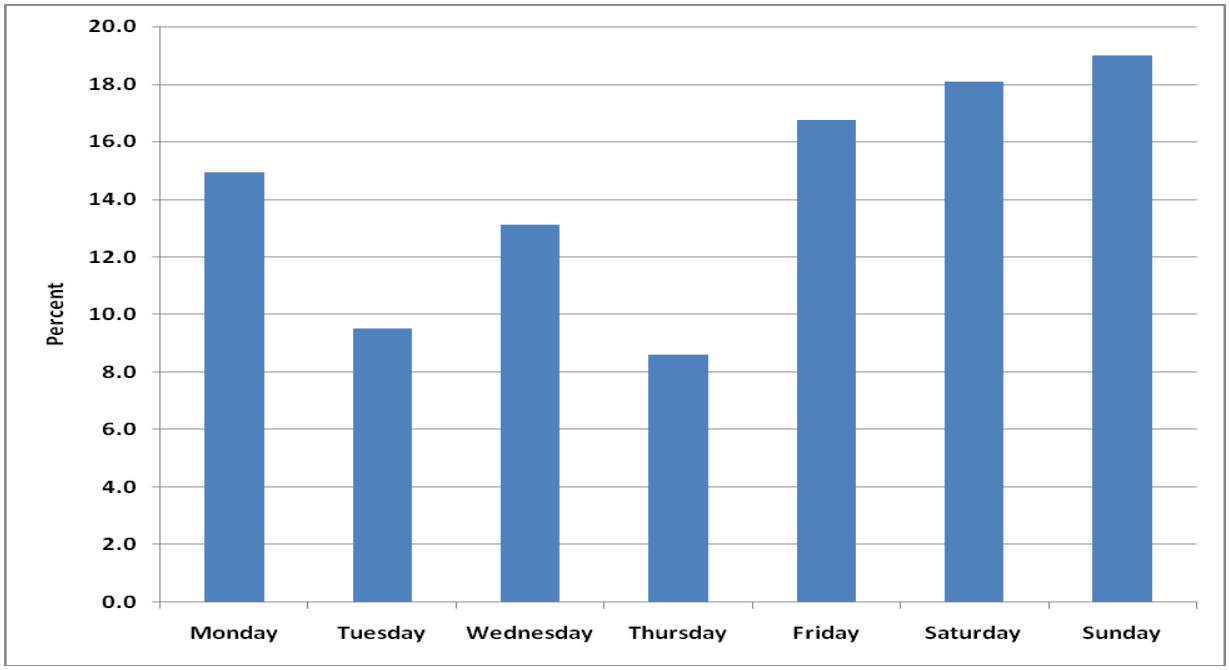


*175 missing

Weekday

The majority of drownings occurred on the weekend, 18.1% occurred on Saturday and 19.0% occurred on Sunday (Figure 5). The weekday with the lowest frequency of drownings was Thursday (Figure 5).

Figure 5. Percent of Drownings by Weekday within the National Park Service July 21, 2006 through October 20, 2010.



There is a significant difference in the age of the drowning victim and the day of the week the drowning occurred, p=0.006. The average age of drowning on Wednesday is 44.5 years, whereas on Sunday the average age is 27.3 years (Table 8).

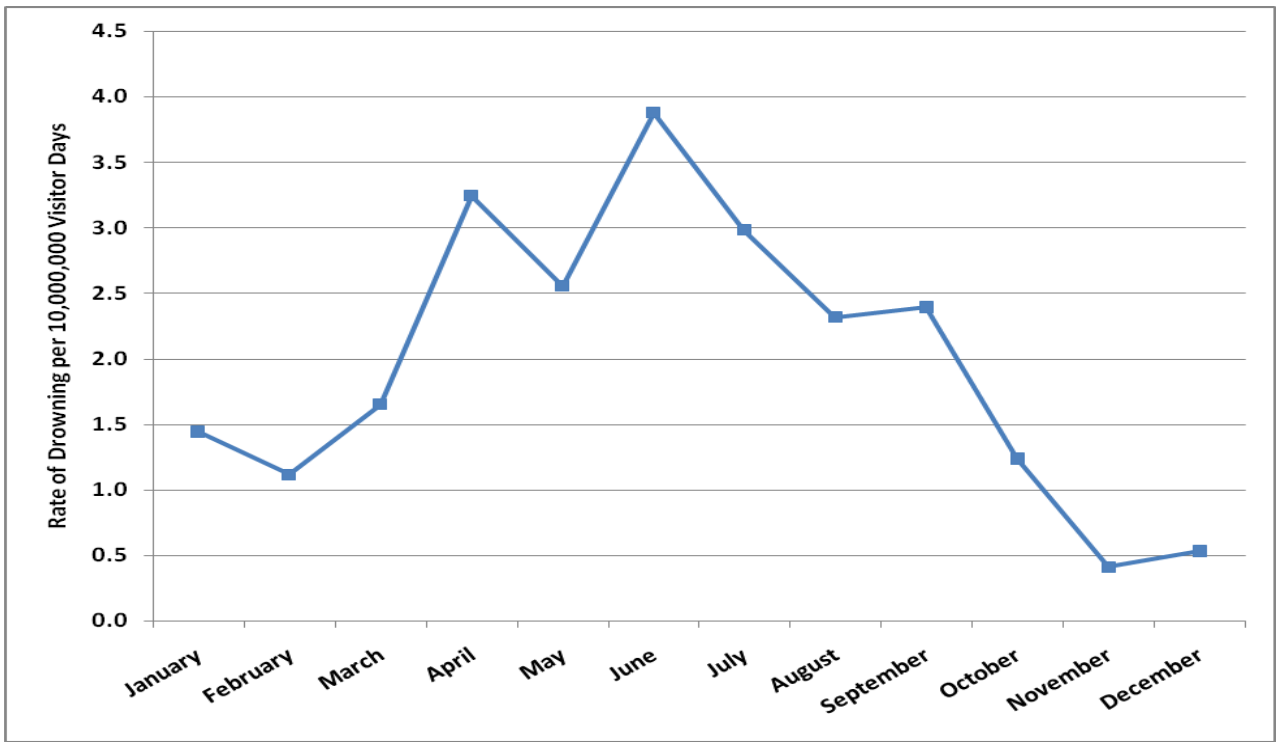
Table 8. Average age of Drowning by Weekday within the National Park Service July 21, 2006 through October 20, 2010.

	Number of Drownings	Age	
		Mean	SD
Sunday	33	27.3	16.4
Monday	27	28.4	16.6
Tuesday	16	39.1	19.5
Wednesday	16	44.5	16.6
Thursday	14	31.8	20.8
Friday	34	41.6	21.5
Saturday	26	32.0	17.9
Total	166	34.3	19.2
Unknown	56		

Month

The majority of drownings occur in the warmer months. The months with the highest rate of drowning was June, 3.9 per 10,000,000 visitor days , April, 3.2 per 10,000,000 visitor days, and July, 3.0 per 10,000,000 visitor days (Figure 6). The months with the lowest rate per 10,000,000 visitor days was November and December, 0.4 and 0.5 respectively (Figure 6).

Figure 6. Rate of Drownings per 10,000,000 Visitor Days from October 2006 to October 2010 by Month within the National Park Service.



There is a significant difference in the age of a victim and the month that the drowning occurred, p=0.040. The mean age of drowning for October is 27.1 years old, where as the mean age for March is 48.0 years old (Table 9).

Table 9. Mean Age of Drowning by Month within the National Park Service July 21, 2006 through October 20, 2010.

	Number of Drownings	Age	
		Mean	SD
January	3	63.0	15.7
February	4	40.5	15.7
March	6	48.0	10.9
April	14	29.1	15.0
May	14	34.6	20.7
June	27	32.7	17.5
July	36	31.5	18.4
August	30	30.6	20.3
September	23	40.4	19.8
October	7	27.1	22.2
November	1	69.0	N/A
December	1	43.0	N/A
Total	166	34.3	19.2
Unknown	56		

Activity Prior to Drowning Event within the National Park Service

The majority of people who drowned were participating in an activity with direct exposure to water such as swimming, wading, boating, rafting, fishing (Table 10). However, 5.4% of those drowning victims experienced a fatal drowning while walking, hiking or backpacking (Table 10). For a full list of activities see Appendix C.

Table 10. Top 5 Activities Prior to Drowning and Mean Age within the National Park Service July 21, 2006 through October 20, 2010.

Activity	Frequency	Percent	Age (years)	
			Mean	SD
Swimming/Wading	90	40.7	28.7	16.1
Boating (kayak, canoe, motor, etc)	47	21.3	47.0	20.3
Rafting	14	6.3	39.2	20.5
Walking/Hiking/Backpacking	12	5.4	37.3	14.1
Fishing	8	3.6	42.0	15.8

There is a statistical difference between the age of the drowning victim and the activity prior to drownings, p<.0001. The mean age of those who drowned while swimming was 28.7 years where as the mean age of those who were boating was 47.0 years (Table 10).

There is also a difference between gender and the activity prior to the drowning event, p= 0.0394. Nineteen percent of females drowned while hiking, backpacking or walking whereas only 2.5% of males drowned after this same activity (Table 11). Forty seven percent of males died while swimming or wading where as only 34.9% of females did (Table 11). However, the number of males and females who drowned while boating was similar, 21.9% and 20.9% respectively (Table 11). For a full list of activities prior to drowning based on sex see Appendix D.

Table 11. Percent of Males and Females who Drowned by Activity Prior To Drowning with more than Ten People Reporting within the National Park Service July 21, 2006 through October 20, 2010.

Activity		Female	Male
Boating (kayak, canoe, motor, etc)	Number	9	35
	Percent	20.9	21.9
Rafting	Number	3	10
	Percent	7.0	6.3
Swimming/Wading	Number	15	75
	Percent	34.9	46.9
Unknown	Number	3	9
	Percent	7	5.6
Walking/Hiking/Backpacking	Number	8	4
	Percent	18.6	2.5

Water Type in Park within the National Park Service

Water types of National Park Service parks were organized into five categories, River, Lake/Pond, Ocean/Bay/Sound, Reservoir/Bayou/Marsh and Creek. There was a greater number of parks whose main source of water was rivers (Table 12). The majority

of drownings occurred in parks that were primarily composed of either lakes or ponds, 33.5%, even though these parks only comprises 17.9% of all parks (Table 12). Rivers experienced the second greatest number of fatal drownings, 33.0% (Table 12). Lakes and ponds also experience the greatest rate of drowning per 10,000,00 visitor days, 3.7, followed by the reservoir, bayou and marsh category, 3.0 per 10,000,000 visitor days (Table 12). Parks classified as creeks experience both the fewest drownings, 1.4%, as well as the lowest rate of drowning, 0.3 per 10,000,000 (Table 12).

Table 12. Drownings by Water Type within the National Park Service July 21, 2006 through October 20, 2010.

	River	Lake/Pond	Ocean/Sound /Bay	Reservoir/Bayou/ Marsh	Creek
Fatal Drownings	73	74	66	5	3
Percent of Drownings	33.0	33.5	29.9	2.3	1.4
Number of Parks	91	40	48	6	39
Drowning Rate per 10,000,000 Visitor Days	2.5	3.7	2.2	3.0	0.3

There is a significant difference between the major type of water in the park where the drowning occurred and the age of the victim, p=0.033. The average age for drowning within rivers is 29.6 years old compared to the average age of drownings in Oceans at 41.8 years old (Table 13).

Table 13. Average Age of Drowning by Water Type within the National Park Service July 21, 2006 through October 20, 2010.

	Number of Drownings	Age (years)	
		Mean	SD
River	62	29.6	16.4
Lake/ Pond	62	34.5	21.3
Ocean/Bay/Sound	37	41.8	18.8
Reservoir/ Marsh/Bayou	3	43.3	13.5
Creek	2	25.5	2.1
Missing	55		

Region within the National Park Service

The National Park Service organizes parks into seven different regions, Alaska (AKR), Intermountain (IMR), Midwest (MWR), National Capital (NCR), Northeast (NER), Pacific West (PWR) and Southeast (SER). The region that experienced the greatest number of drownings was PWR with 62 accounting for 28.1% of all drownings, followed by IMR with 50 accounting for 22.6% of all drownings (Table 14). However, the region with the greatest rate of drowning was NER, 4.0 per 10,000,000 visitor days, followed by IMR, 3.2 per 10,000,000 visitor days (Table 14).

Table 14. Number of Drownings and Rate by Region within the National Park Service July 21, 2006 through October 20, 2010.

	AKR	IMR	MWR	NCR	NER	PWR	SER
Number	1	50	17	5	41	62	45
Percent	0.5	22.6	7.7	2.3	18.6	28.1	20.4
Rate per 10,000,000 Visitor Days (CI)	0.9 (0.0,4.6)	3.2 (2.4,4.1)	2.5 (1.5,3.9)	0.5 (2.0,12.1)	4.0 (2.9,5.3)	2.7 (2.1,3.5)	2.2 (1.6,2.9)

The majority of drownings occur in the summer months. The two regions where the summer season did not have the highest rate was in the IMR and NCR, where spring is the leading season (Table 15).

Table 15. Fatal Drownings by Season and Region within the National Park Service July 21, 2006 through October 20, 2010.

		AKR	IMR	MWR	NCR	NER	PWR	SER
Winter	Number of Drownings	0	1	0	0	0	6	4
	Rate per 10,000,000 Visitor Days	0.0	0.4	0.0	0.0	0.0	4.1	2.0
Spring	Number of Drownings	0	18	3	2	5	12	12
	Rate per 10,000,000 Visitor Days	0.0	4.5	1.1	0.6	2.1	5.5	2.6
Summer	Number of Drownings	1	16	13	2	29	33	22
	Rate per 10,000,000 Visitor Days	0.5	2.5	3.3	0.3	6.9	7.3	2.9
Fall	Number of Drownings	0	15	1	1	7	11	7
	Rate per 10,000,000 Visitor Days	0.0	3.3	0.3	0.2	2.8	3.7	1.5

There is a statistical difference in the number of males and females that drown by region, $p < 0.001$. Thirty five percent of drownings among females were in the Intermountain Region, however, only 19.0% of drownings among males were in this same region (Table 16). On the other hand, 32.9% of all male drownings occur in the Pacific West Region, whereas only 9.3% of female drownings occur in this same region (Table 16).

Table 16. Percent of Males and Female Drownings by Region within the National Park Service July 21, 2006 through October 20, 2010.

Region	Female	Male
AKR	2.3	0.0
IMR	34.9	19.0
MWR	9.3	8.1
NCR	9.3	0.6
NER	16.3	16.8
PWR	9.3	32.9
SER	18.6	21.7

*18 missing

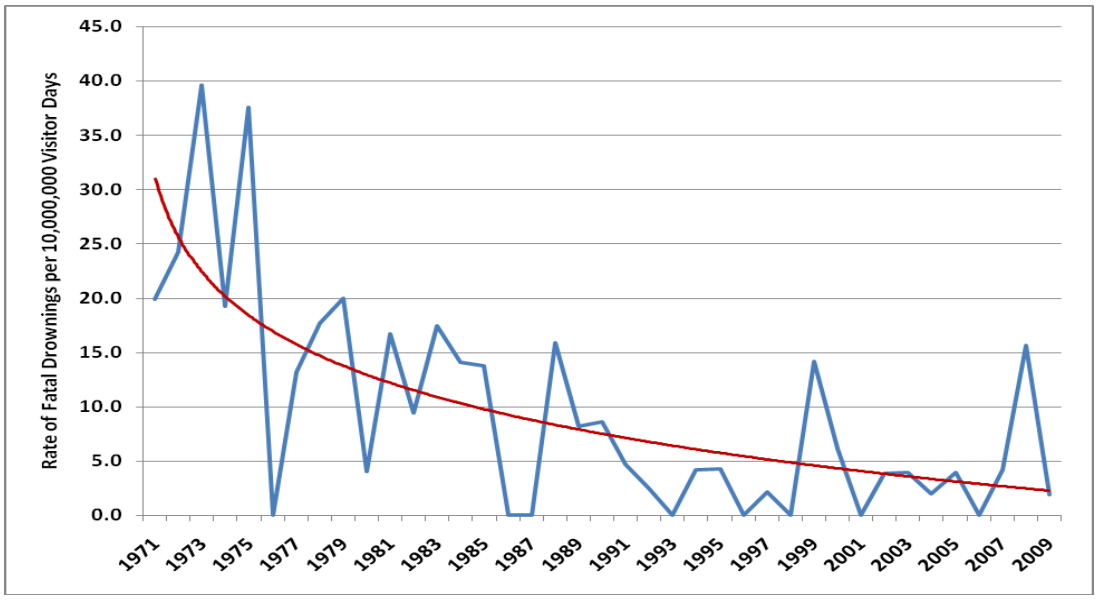
Delaware Water Gap National Recreational Area

Delaware Water Gap National Recreational Area is a park that encompasses three states, New York, New Jersey and Pennsylvania as well as a portion of the Delaware River. This park was examined because of its data dating back from 1971, the detail of the data, and the fairly regular occurrence of drowning (on average 2 per year). Overall, between January 1, 1971 and October 20, 2010 there were 81 fatal drownings . The rate of fatal drownings was 6.1 per 10,000,000 visitor days. The year with the greatest rate of fatal drowning was 1973 at 39.6 per 10,000,000 visitor days followed by 1975 at 37.5 per 10,000,000 visitor days whereas the lowest was in 1976, 1986, 1996, 1998, and 2001 where no visitors drowned (Table 17). See Appendix E for a full list of rates and number of drownings at the Delaware Water Gap National Recreational Area. There appears to be a downward trend in the rates of fatal drownings by year (Figure 7).

Table 17. Top Five Rates Fatal Drownings by Year in Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

Year	Rate per 10,000,000 Visitor Days
1973	39.6
1975	37.5
1972	24.2
1979	20.0
1971	19.8

Figure 7. Rate of Drowning by Year in Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.



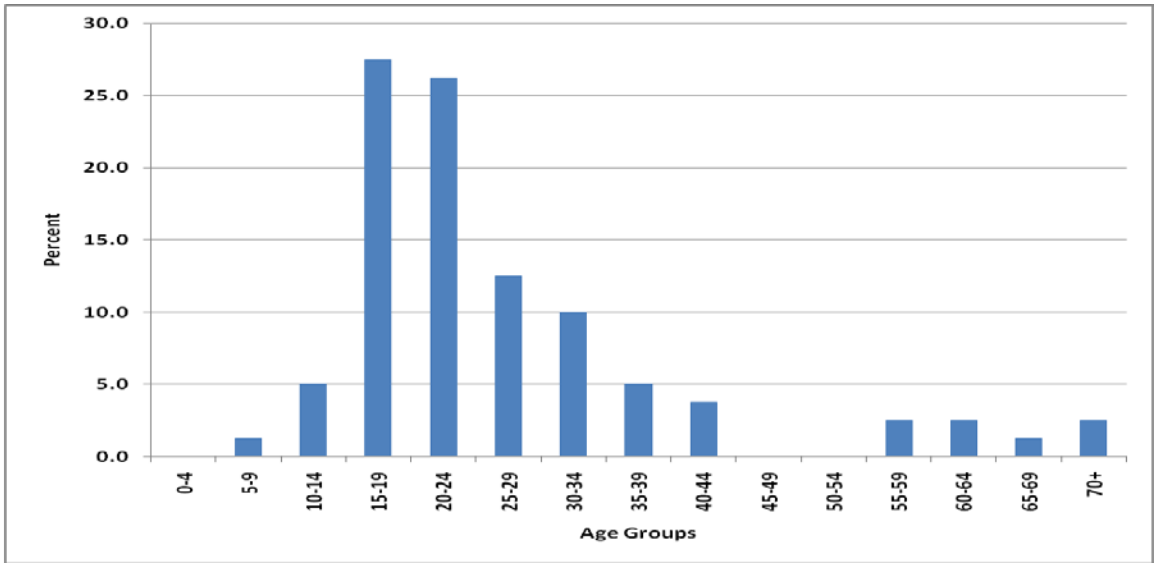
Age and Gender Characteristics and Distribution of Fatal Drowning Victims at Delaware Water Gap National Recreational Area

The average age of drowning victims was 27 years old, with a median age of 22 years old. Almost thirty six percent of drownings occurred in individuals 18 to 21 years old. The youngest victim was 5 years old and the oldest was 78 years old. The five year age group that experienced the greatest percentage of drownings within the Delaware Water Gap was 15 to 19 year, 27.5%, followed by 20 to 24 year, 26.3% (Table 18 and Figure 8). Overall, 92.9% of those who drowned were male.

Table 18. Age of Fatal Drownings in Five Year Age Categories at Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

Age (years)	Frequency	Percent
Under 5	0	0.0
5-9	1	1.2
10-14	4	4.9
15-19	22	27.2
20-24	21	25.9
25-29	10	12.3
30-34	8	9.9
35-39	4	4.9
40-44	3	3.7
45-49	0	0.0
50-54	0	0.0
55-59	2	2.5
60-64	2	2.5
65-69	1	1.2
70+	2	2.5
Missing	1	1.2
Total	81	100

Figure 8. Age of Fatal Drownings in Five Year Age Categories at Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

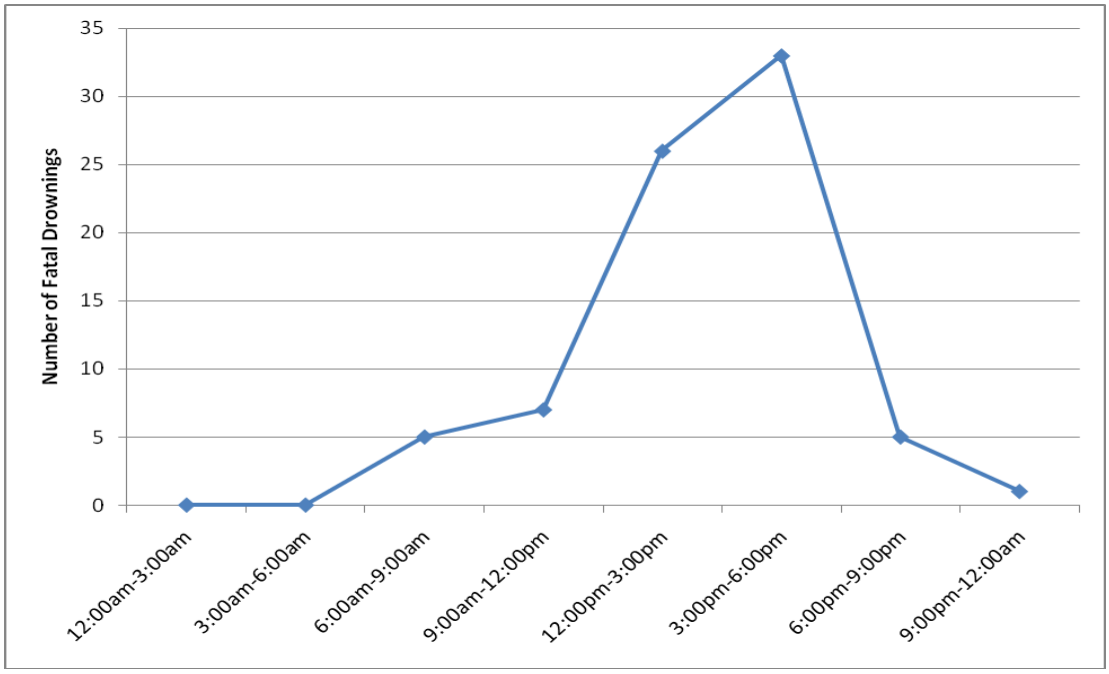


Timing of Drownings within Delaware Water Gap National Recreational Area

Hour of Drownings

The majority, 74%, of the drownings within Delaware Water Gap occurred between 12:00pm and 6:00 pm (Figure 9). On the other hand, no drownings occurred between 12:00am and 6:00am, and only one drowning occurred between 9:00pm and 12:00am (Figure 9). The time when most drownings occur tends to be in daylight hours.

Figure 9. Time of Drowning at Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

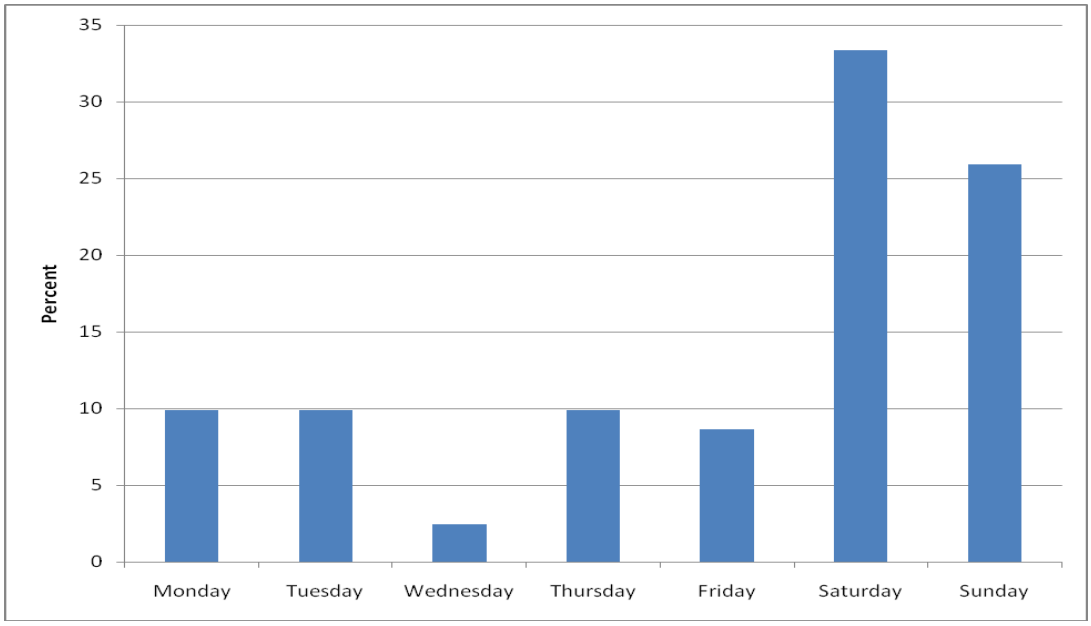


*6 missing

Weekday

The majority of drownings occurred on the weekend, 33.3% occurred on Saturday and 25.9% occurred on Sunday (Figure 10). The day with the fewest drownings was Wednesday, 2.5% (Figure 10).

Figure 10. Number of Drownings at Delaware Water Gap by Day of the Week National Recreational Area from January 1, 1971 through October 20, 2010.



Month

The greatest number of drownings occurred in the summer months, June, July and August (Table 19) comprising 75.4%. The months with the highest rates of drownings per 10,000,000 visitor days were July and August. No drownings occurred in December, January or February (Table 19).

Table 19. Month of Fatal Drowning at Delaware Water Gap National Recreational Area from January 1, 1979 through October 20, 2010.

Month	Number of Drownings	Rate per 10,000,000 Visitor Days
January	0	0.0
February	0	0.0
March	1	1.7
April	4	4.9
May	7	6.5
June	6	5.2
July	25	18.3
August	18	12.5
September	4	3.9
October	1	1.5
November	0	0.0
December	0	0.0

There is a statistical difference between age and the month that the drowning occurred, p=0.0018. The average age of drowning in June is 27.1 years compared to April at 62.0 years Table 20).

Table 20. Average age of Drowning by Month in Delaware Water Gap from January 1, 1971 through October 20, 2010.

Month	Number of Drownings	Age (years)	
		Mean	SD
January	0	N/A	N/A
February	0	N/A	N/A
March	3	33.7	24.6
April	3	62.0	3.0
May	7	28.7	14.1
June	10	27.1	19.3
July	32	23.6	12.2
August	19	25.1	7.2
September	4	25.8	9.7
October	1	19.0	0.0
November	1	43.0	0.0
December	0	N/A	N/A
Total	80	27	14.3
Missing	1		

Activity Prior to Drowning Event at Delaware Water Gap National Recreational Area

The majority of drowning happened when exposed to water, such as swimming, wading and boating (Table 21). However, close to ten percent occurred when the victim fell, was walking, hiking or backpacking (Table 21).

Table 21. Activity Prior to Drowning at Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

	Frequency	Percent
Swimming/wading	52	60.5
Boating (kayak, canoe, motor, etc.)	18	20.9
Fall	7	8.1
Camping	2	2.3
Rafting	2	2.3
Tubing	2	2.3
Walking/Hiking/Backpacking	2	2.3
Fishing	1	1.2

There is a significant difference in the activity prior to drowning and the age of the victim, p=<0.001. The average age of those individuals whose activity prior to drowning while boating is 42.1 years old, compared to those whose activity was swimming or wading which had a mean age of 22.1 years old (Table 22).

Table 22. Average age of Drowning by Activity Prior to Drowning in Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

Activity	Number of Drownings	Age (years)	
		Mean	SD
Boating (kayak, canoe, motor, etc.)	18	42.1	20.8
Camping	2	18.5	0.7
Rafting	2	24.5	13.4
Swimming/wading	52	22.1	7.0
Tubing	2	41.5	3.5
Hiking/walking	2	20.5	0.7
Fall	2	19.0	2.8

Chapter 5: Discussion

Among all National Park Service parks there were a total of 221 fatal drownings from July 21, 2006 to October 20, 2010. The rates of drownings held fairly constant (2.2 per 10,000,000 visitor days in 2006, 2.2 per 10,000,000 visitor days in 2007, 2.3 per 10,000,000 visitor days in 2008 and 2.4 per 10,000,000 visitor days in 2009) except for 2010 with a rate of 3.0 per 10,000,000 visitor days, although there is not a statistically significant difference from 2009 to 2010. This may be due to the improved reporting system of injuries put into place, which may have captured more drownings than previously or this may be a result of an actual increase in drownings within the park system.

Analysis of the Delaware Water Gap National Recreational Area allowed for a longer period to be examined. The rates of drowning within this park have a decreasing trend. The overall rate of drowning within the Delaware Water Gap was 6.1 per 10,000,000 visitor days which was higher than the average for all the parks, 2.4 per 10,000,000 visitor days. However, with all National Park Service parks some parks may have little water within them or frozen reducing exposure. Many visitors enter Delaware Water Gap do so to participate in water activites. Also, the analysis with all the National Park Service Parks only covered July 21, 2006 through October 20, 2010 where the drowning rates were low within Delaware Water Gap as well.

The average age of drowning was 34 years within all the parks. The age group with the greatest percentage of drowning was 20 to 24 year olds. However, it is unclear if there are more visitors entering the park or exposed to water within this age group and thus influencing the drowning percentages. It also could be that this age group is more likely to participate in behavior increasing the risk of drowning.

The average age of drowning within the Delaware Water Gap was 27 years. The average age of drowning for those parks whose primary source of water were rivers was 29.6 years which is similar to that of Delaware Water Gap. Since the main source of water within the Delaware Water Gap is a river this seems to support the average age of drowning for this type of water.

Males were at a greater risk of drowning than females in both the Delaware Water Gap and all the parks. Although not statistically significant the average age for drowning among males is 35 years compared to females at 29 years within the National Park Service. Due to the small numbers of females that drowned, 33, compared to males, 132, the average age for females may be less precise than males. Males may be at more risk for drowning because of greater participation in risky behaviors (2).

The greatest number of drownings occurred between 9:00 am and 3:00 pm in all National Park Service parks and 12:00pm to 6:00 pm within the Delaware Water Gap National Recreational Area. This may also be the time when there is greater exposure to water activities due to warmer temperatures, more people visiting the park, hours of operation of the parks and park activities available. A better proxy would have been rates of drowning by hour however this level of detail of the data was not available. There were also 175 incidents where the time of the incident was missing within all the parks thus this may not be representative of the drownings within all the National Park Service.

A similar phenomenon was seen for weekday, 37% of drownings occurred on the weekend within all parks and over 50% occurred on the weekend within the Delaware Water Gap. This could be due to greater number of visitors going to national parks on the weekend since many individuals may not have to work or attend school. There was

also a significant difference between the age of the drowning victim and the day of the week within the National Park Service. Those that drowned during the middle of the week tended to be older (Tuesday 39.1 years, Wednesday 44.5 years) than those that drowned on the weekend (Saturday 37.0 years, Sunday 27.3 years). This may be indicative of older individuals being able to take off work or enjoy retirement during the week and not solely on the weekend.

There was also a difference between the rates of drowning by month. The greatest rate within all the National Park Service parks was seen in June, 3.9 per 10,000,000 visitor days followed by July 3.0 per 10,000,000 visitor days. Within Delaware Water Gap from January 1, 1979 through October 20, 2010 the months with the greatest rate of drowning were July, 18.3 per 10,000,000 visitor days, and August, 12.5 per 10,000,000 visitor days. The reason that these data were not presented from 1971 was because there was not monthly visitor day data available until 1979. The rates may differ due to warmer weather increasing the number of individuals that partake in water activities. April, however, had a high rate of drowning, 3.2 per 10,000,000 visitor days within all the parks. This may be caused by the weather just beginning to warm and individuals eagerly engaging in water activities. Maybe individuals are more prone to risky behavior because of not being able to participate in water activities during the winter months. The water may still be cold and create a greater chance of hypothermia or difficulty controlling extremities while swimming and thus drowning. As expected, the winter months were also the months with lower rates of drowning.

The age of the drowning victim and the month of drowning varied. January, February, March, September, November and December all had average ages over 40

years within all the parks. This may again be due to the ease for older individuals to travel in these months as opposed to families who have children in school or those in college. Within the Delaware Water Gap only two months had average ages over 40 years, April and November. There were no drownings in January, February, or December.

Both within all the parks and the Delaware Water Gap National Recreational Area swimming and wading were responsible for the most drownings followed by boating. A difference between the age of victim who drowned and the activity they were participating in prior to drowning was observed. Those who drowned while boating within all the parks had an average age of 47.0 years and within Delaware Water Gap the average age was 42.1 years. The average age for those who were swimming or wading was 28.7 years within all parks and 22.1 within the Delaware Water Gap. This may be because older individuals are more likely to boat. It may cost more money to rent or bring a boat which older individuals would be more likely to have than younger individuals. Older individuals may be less likely to wear life jackets while boating compared to younger individuals thus making them more likely to experience a drowning event while boating. The average age for swimming may be younger because older individuals may not be engaging in swimming or wading activities. Older individuals may be better able to estimate their swimming ability compared to younger individuals. Also young children may be more prone to drowning while swimming or wading as opposed to boating thus bringing the average down.

The activity prior to drowning also differed by gender within all the parks. Nineteen percent of women were hiking, backpacking or walking prior to drowning

where as only 2.5% of males were. It is possible that more females participate in this activity compared to males or that way that women hiking puts them at greater risk. On the other had a greater percentage of males participated in swimming and wading just prior to drowning, 46.9%, compared to females, 34.9%. This could because women are better swimmers than males or are less likely to participate in risky behaviors while swimming compared to males.

Lakes and ponds have the highest rate of drowning among all parks, 3.7 per 10,000,000 visitor days. There may be more activities available associated with water at these parks such as swimming, canoeing and boating thus increasing exposure to water within these parks. Reservoir, bayous and marshes had the second highest rate of drowning at 3.0 per 10,000,000. This may be due to an increase in boating activities and also more vegetation within these areas making it easier to become entangled underwater. However, there are only 6 parks within this category containing three different types of water, making it difficult to come to any conclusions.

Rivers had the next highest rate of drowning, 2.5 per 10,000,000 visitor days followed by oceans, bays and sounds with a drowning rate of 2.2 per 10,000,000 visitor days. The currents or tides as well as activities associated with these areas such as tubing, swimming and boating may make these locations a greater risk factor to drowning. Creeks had the lowest rate of drowning at 0.3 per 10,000,000 visitor days. This is probably because few water activities are undertaken in a creeks and often times the amount of water and current are minimal making it more difficult to drown.

A difference was observed between water type and the age of the drowning victim. The average age of drowning in oceans, bays and sounds was 41.8 years, where

as in rivers it was 29.6 years. This could simply be that younger individuals frequent parks with rivers and older individuals tend to visit oceans, bays and sounds. In parks with rivers more swimming and wading may be occurring, putting younger individuals at risk. Younger individuals may attempt to cross the river while swimming not realizing the dangers. Oceans may have an older age because older individuals living closer by. The ease of accessing oceans, which may not require hiking to get to water may increase exposure to water among older individuals.

The Northeast Region had the highest rate of drowning 4.0 per 10,000,000 visitor days followed by the Intermountain Region, 3.2 per 10,000,000 visitor days. This may be due to the cooler temperature of the water. Individuals may misjudge the temperature and experience a loss of ability to control extremities. There also may be more parks with greater visitor exposure to water. The Alaska Region experienced the lowest rate of drowning, 0.9 per 10,000,000 visitor days. This is probably due to the large number of days that the water is frozen or less participation in water activities because of the cold temperatures. There is also seasonal variation of rates of drownings within these regions. In the Alaska, Midwest, Northeast, Pacific West and South East Regions summer was the leading season of drowning. Both the water and weather are warmer leading to, most likely, a greater exposure to water and water activities thus increasing the chances of drowning. Spring in the Intermountain Region had the highest rate of drownings. This may be due to greater run off of snow from the mountains increasing the swiftness currents and creating cooler temperatures of water. It may also be due to the novelty of warm weather days after the winter thus making water activities more desirable even though the water may still be cold.

It is interesting to note that there is a difference between the percentage of males and females that drown by region. Thirty five percent of females drown in the Intermountain Region and only 10% of males do. However, within the Pacific West Region 9.3% of females drown where as 32.9% of males do. It could be because more males or females visit certain regions. However, further study is needed to determine the cause

In general, the timing seems to play a role in drowning. Summer months, middle of the day and weekends are periods where more individuals drown. This is probably due to the warmer temperature and/or the greater exposure to water at the parks. The activities that individuals participate in also influence the risk of drowning. More people drown while boating and swimming compared to most other activities. The ability for individuals to participate in these activities, either through knowledge or access to areas influence who is at risk. Each park has different characteristics that influence these risk factors and thus should be examined individually. Although this thesis looks at all the parks and discusses trends and risk factors overall, these may differ on a park to park basis.

Some limitations of this study are the classification of parks into the major type of water in the park. This was based on maps to determine which type seemed to be most prominent. The water may not be accessible to visitors, either by natural barriers preventing access or park rules prohibiting the use bodies of water to visitors. Also if the park had water it was classified as a water park. Many parks had multiple water types, however each type which may not be were all the drownings took place. In some parks, especially in Alaska, it is unlikely that individuals are exposed to water year round due to

the water being frozen or parks restricting access. Also, in other parks there may be a small pond or creek which was included in the study even if water activities and exposure are limited.

Visitor days within parks were an integral part of calculating drowning prevalence rates for parks. Using visitor days as the denominator for rates also may not be representative of the actual exposure of individuals to water. Not all individuals who visit a park may come into contact with water. Thus, using visitor days as the denominator dilutes the actual rates of drownings. Parks with greater rates of drowning, such as Big Thicket, may actually have greater exposure to water than other parks, thus increasing the rates. If there was an accurate denominator the rates would differ from what is being reported.

The way in which visitor days are determined by each park also differs and is not a direct reflection of the number of individuals entering the park; instead a method is used to extrapolate this number. Thus, the actual number of visitor days may differ slightly from the visitor days reported.

Another issue with using visitor days as the denominator is that July 2006 and October 2010 did not include full months of drowning data. In order to calculate the visitor days for these months the total number of visitor days in each month were divided by the days in the month and then multiplied by the number of days data were available. This assumes that each day the same number of visitors entered the park, which is likely not true. What is more likely is that weekends experience greater numbers of visitors compared to weekdays.

There is also no way to capture the demographic of people entering the park and being exposed to water. It may be more common for males to be exposed to water than females, thus logically there should be a greater number of males that drown than females. If this information could be attained a better understanding of drownings within parks could be achieved.

The data used for all National Park Service Parks was from July 21, 2006 to October 20, 2010. This period of time may not be representative of what has happening since the National Park Service began. The quality of the data collected differs by year and has been improving each year. As the data quality continues to improve an additional analysis may be done to gain an even greater understanding of fatal drownings within the National Park Service. The Delaware Water Gap National Recreational Area had data from 1971. Some of this data, such as sex and time of the drowning, were aggregated and thus could not be analyzed in as much detail.

This analysis, however does allow for a better understanding of the National Park Service parks and Delaware Water Gap National Recreational area fatal drownings. It supports the continuation of improved surveillance of drownings within parks so that more information can be gathered about drowning incidents allowing for a better understanding of drownings. This may allow visitors to gain a better understanding of the risk factors associated with drowning and better prepare themselves for their visit to the national parks. It will also allow the National Park Service to have a better grasp about the drowning issue among its parks and potentially identify different prevention techniques to reduce this problem for certain risk factors. However, each park is different making it difficult to develop one prevention strategy for all parks. The water

type, activities that lead to water exposure and vast areas that parks can cover make each park unique and poses different risk factors for drowning. Thus, each park should be examined individually to determine the best prevention methods for drowning. By reducing drownings among parks, visitors will be able to participate in a safer environment thus leading to better enjoyment of the natural beauty within.

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Appendices:

Appendix A:

Drowning Rates by Park per 10,000,000 within the National Park Service from July 21, 2006 to October 20, 2010:

Park Name	Type of Unit	State	2006	2007	2008	2009	2010	Overall
Big Thicket	National Preserve	TX	387.7	9.5	50.6	22.8	434.6	181.1
Upper Delaware	Scenic & Recreational River	NY,PA	93.9	80.6	105.5	77.4	270.0	125.5
Gauley River	National Recreation Area	WV	0.0	84.6	89.1	0.0	310.7	96.9
Redwood	National and State Parks	CA	99.7	51.9	25.2	0.0	134.9	62.3
Little River Canyon	National Preserve	AL	0.0	0.0	101.2	0.0	121.3	44.5
Dry Tortugas	National Park	FL	0.0	0.0	0.0	0.0	219.2	43.8
Channel Islands	National Park	CA	0.0	164.2	0.0	0.0	41.8	41.2
Dinosaur	National Monument	CO,UT	0.0	0.0	49.6	49.1	106.4	41.0
Glen Canyon	National Recreation Area	AZ,UT	25.2	10.6	30.8	35.7	85.5	37.6
Cape Hatteras	National Seashore	NC	29.9	26.8	1.3	7.8	91.9	31.5
Amistad	National Recreation Area	TX	0.0	0.0	122.8	0.0	21.6	28.9
New River Gorge	National River	WV	36.5	0.0	16.5	17.5	67.3	27.6
Virgin Islands	National Park	VI	0.0	17.5	21.3	24.0	71.4	26.9
Buffalo	National River	AR	0.0	10.4	60.2	0.0	42.3	22.6
Chickasaw	National Recreation Area	OK	0.0	43.3	0.0	28.7	17.7	17.9
Apostle Islands	National Lakeshore	WI	0.0	19.3	0.0	0.0	66.9	17.2

Cape Lookout	National Seashore	NC	27.2	3.3	0.0	0.0	45.3	15.2
Saint Croix	National Scenic River	WI	0.0	0.0	0.0	17.7	54.1	14.4
Big South Fork	National River & Recreation Area	KY,TN	0.0	3.6	8.1	0.0	54.1	13.2
Fire Island	National Seashore	NY	27.6	0.0	0.0	0.0	34.8	12.5
Indiana Dunes	National Lakeshore	IN	12.9	0.0	16.4	0.0	25.2	10.9
Lake Roosevelt	National Recreation Area	WA	0.0	13.8	0.0	7.2	32.5	10.7
Lake Mead	National Recreation Area	AZ,NV	6.2	5.2	10.5	11.7	11.5	9.3
Point Reyes	National Seashore	CA	0.0	9.1	0.0	0.0	35.1	8.8
Bighorn Canyon	National Recreation Area	MT,WY	0.0	0.0	0.0	0.0	41.4	8.3
Mount Rainier	National Park	WA	0.0	19.1	0.0	0.0	18.0	7.4
Delaware Water Gap	National Recreation Area	PA	0.0	4.1	9.8	1.9	20.1	7.2
Yellowstone	National Park	ID,MT,WY	0.0	6.3	0.0	6.1	17.0	5.9
Curecanti	National Recreation Area	CO	0.0	0.0	16.5	0.0	11.2	5.5
Denali	National Park & Preserve	AK	0.0	0.0	0.0	0.0	26.4	5.3
Acadia	National Park	ME	0.0	5.8	0.0	7.8	12.7	5.3
Biscayne	National Park	FL	0.0	0.0	0.0	0.0	24.5	4.9
Grand Canyon	National Park	AZ	0.0	2.3	2.3	6.9	12.9	4.9
Ozark	National Scenic	MO	0.0	0.0	0.0	0.0	23.4	4.7

	Riverways							
Gulf Islands	National Seashore	FL,MS	0.0	0.0	4.9	7.3	11.1	4.7
Lake Meredith	National Recreation Area	TX	0.0	10.2	0.0	0.0	12.8	4.6
Sequoia & Kings Canyon	National Parks	CA	0.0	0.0	0.0	6.4	13.7	4.0
Colonial	National Historical Park	VA	0.0	16.2	0.0	0.0	3.3	3.9
Glacier	National Park	MT	0.0	0.0	0.0	4.9	13.9	3.8
Padre Island	National Seashore	TX	0.0	0.0	0.0	0.0	18.6	3.7
Olympic	National Park	WA	6.6	3.3	0.0	0.0	7.8	3.5
Zion	National Park	UT	0.0	0.0	0.0	0.0	16.9	3.4
Sleeping Bear Dunes	National Lakeshore	MI	0.0	0.0	0.0	8.6	8.2	3.4
Gateway	National Recreation Area	NY,NJ	5.0	1.1	0.0	1.1	9.3	3.3
Chattahoochee River	National Recreation Area	GA	0.0	0.0	3.2	0.0	11.9	3.0
Everglades	National Park	FL	0.0	0.0	0.0	0.0	13.1	2.6
Chesapeake & Ohio Canal	National Historical Park	DC,MD,WV	0.0	0.0	0.0	0.0	11.5	2.3
Golden Gate	National Recreation Area	CA	0.0	0.7	1.4	0.7	6.8	1.9
Cape Cod	National Seashore	MA	4.2	0.0	0.0	0.0	4.8	1.8
Great Smoky Mountains	National Park	TN,NC	0.0	1.1	1.1	1.1	3.7	1.4
Yosemite	National Park	CA	0.0	2.9	0.0	0.0	2.8	1.1
Natchez Trace	Parkway	AL,MS,TN	0.0	0.0	1.7	0.0	2.1	0.8
George Washington	Memorial Parkway	DC	0.0	1.5	0.0	0.0	1.7	0.6

Appendix B

Number of Fatal Drownings Among Parks within the National Park Service from July 21, 2006 to October 20, 2010:

Park Name	Type of Unit	State	2006	2007	2008	2009	2010	Total
Lake Mead	National Recreation Area	AZ,NV	2	4	8	9	7	30
Cape Hatteras	National Seashore	NC	3	6	1	6	2	18
Glen Canyon	National Recreation Area	AZ,UT	2	2	6	7	0	17
Delaware Water Gap	National Recreation Area	PA	0	2	5	1	1	9
Upper Delaware	Scenic & Recreational River	NY,PA	1	2	3	2	0	8
Golden Gate	National Recreation Area	CA	0	1	2	1	4	8
Gateway	National Recreation Area	NY,NJ	2	1	0	1	3	7
New River Gorge	National River	WV	2	0	2	2	1	7
Yellowstone	National Park	ID,MT,WY	0	2	0	2	2	6
Point Reyes	National Seashore	CA	0	2	0	0	4	6
Buffalo	National River	AR	0	1	2	0	3	6
Redwood	National and State Parks	CA	2	2	1	0	0	5
Big Thicket	National Preserve	TX	2	1	1	1	0	5
Indiana Dunes	National Lakeshore	IN	1	0	3	0	1	5
Grand Canyon	National Park	AZ	0	1	1	3	0	5

Lake Roosevelt	National Recreation Area	WA	0	2	0	1	1	4
Gulf Islands	National Seashore	FL,MS	0	0	1	3	0	4
Zion	National Park	UT	0	0	0	0	4	4
Chesapeake & Ohio Canal	National Historical Park	DC,MD,WV	0	0	0	0	4	4
Virgin Islands	National Park	VI	0	1	1	1	0	3
Great Smoky Mountains	National Park	TN,NC	0	1	1	1	0	3
Gauley River	National Recreation Area	WV	0	1	1	0	1	3
Big South Fork	National River & Recreation Area	KY,TN	0	1	1	0	1	3
Acadia	National Park	ME	0	1	0	2	0	3
Amistad	National Recreation Area	TX	0	0	2	0	1	3
Chattahoochee River	National Recreation Area	GA	0	0	1	0	2	3
Glacier	National Park	MT	0	0	0	1	2	3
Ozark	National Scenic Riverways	MO	0	0	0	0	3	3
Cape Lookout	National Seashore	NC	1	1	0	0	0	2
Olympic	National Park	WA	1	1	0	0	0	2
Fire Island	National Seashore	NY	1	0	0	0	1	2
Cape Cod	National Seashore	MA	1	0	0	0	1	2
Mount Rainier	National Park	WA	0	2	0	0	0	2

Chickasaw	National Recreation Area	OK	0	1	0	1	0	2
Little River Canyon	National Preserve	AL	0	0	2	0	0	2
Dinosaur	National Monument	CO,UT	0	0	1	1	0	2
Sequoia & Kings Canyon	National Parks	CA	0	0	0	1	1	2
Channel Islands	National Park	CA	0	1	0	0	0	1
Apostle Islands	National Lakeshore	WI	0	1	0	0	0	1
Lake Meredith	National Recreation Area	TX	0	1	0	0	0	1
Colonial	National Historical Park	VA	0	1	0	0	0	1
Yosemite	National Park	CA	0	1	0	0	0	1
George Washington	Memorial Parkway	DC	0	1	0	0		1
Curecanti	National Recreation Area	CO	0	0	1	0	0	1
Natchez Trace	Parkway	AL,MS,TN	0	0	1	0	0	1
Saint Croix	National Scenic River	WI	0	0	0	1	0	1
Sleeping Bear Dunes	National Lakeshore	MI	0	0	0	1	0	1
Dry Tortugas	National Park	FL	0	0	0	0	1	1
Bighorn Canyon	National Recreation Area	MT,WY	0	0	0	0	1	1
Denali	National Park & Preserve	AK	0	0	0	0	1	1
Biscayne	National Park	FL	0	0	0	0	1	1
Padre Island	National Seashore	TX	0	0	0	0	1	1
Everglades	National Park	FL	0	0	0	0	1	1

Appendix C.
Activity Prior to Drowning within the National Park Service July 21, 2006 through October 20, 2010.

	Frequency	Percent
Swimming/Wading	90	40.7
Boating (kayak, canoe, motor, etc)	47	21.3
Unknown	22	10.0
Rafting	14	6.3
Walking/Hiking/Backpacking	12	5.4
Fishing	8	3.6
Snorkeling	4	1.8
Water Sports	4	1.8
Canyoneering	3	1.4
Other	3	1.4
Surfing	3	1.4
Kite surfing	2	0.9
Camping	1	0.5
Driving	1	0.5
Fall	1	0.5
Loitering	1	0.5
Other/Unknown	1	0.5
Paragliding	1	0.5
Plane/Helicopter	1	0.5
Scuba/Free Diving	1	0.5
Tubing	1	0.5
Total	221	100

Appendix D

Percent of Males and Females who Drowned by Activity Prior To Drowning within the National Park Service July 21, 2006 through October 20, 2010.

Activity		Female	Male
Boating (kayak, canoe, motor, etc)	Number	9	35
	Percent	20.9	21.9
Camping	Number	0	1
	Percent	0.0	0.6
Canyoneering	Number	1	1
	Percent	2.3	0.6
Driving	Number	0	1
	Percent	0	0.6
Fall	Number	1	0
	Percent	2.3	0
Fishing	Number	0	8
	Percent	0.0	5.0
Kite surfing	Number	0	2
	Percent	0	1.3
Loitering	Number	0	1
	Percent	0	0.6
Other	Number	2	1
	Percent	4.7	0.6
Paragliding	Number	0	1
	Percent	0	0.6
Plane/Helicopter	Number	0	1
	Percent	0	0.6
Rafting	Number	3	10
	Percent	7.0	6.3
Scuba/Free Diving	Number	0	1
	Percent	0	0.6
Snorkeling	Number	1	2
	Percent	2.3	1.3
Surfing	Number	0	3
	Percent	0	1.9
Swimming/Wading	Number	15	75
	Percent	34.9	46.9
Tubing	Number	0	1
	Percent	0	0.6
Unknown	Number	3	9
	Percent	7.0	5.6
Walking/Hiking/Backpacking	Number	8	4
	Percent	18.6	2.5
Water Sports	Number	0	3

	Percent	0	1.9
Total	Number	43	160
	Percent	100.0	100.0
Missing	18		

Appendix E:

Rates and Numbers of Fatal Drownings by Year in Delaware Water Gap National Recreational Area from January 1, 1971 through October 20, 2010.

Year	Fatal Drownings	Rate per 10,000,000 Visitor Days
1971	2	19.8
1972	2	24.2
1973	2	39.6
1974	1	19.2
1975	3	37.5
1976	0	0.0
1977	2	13.2
1978	3	17.7
1979	4	20.0
1980	1	4.0
1981	4	16.7
1982	2	9.4
1983	4	17.4
1984	3	14.0
1985	3	13.7
1986	0	0.0
1987	0	0.0
1988	4	15.8
1989	2	8.2
1990	2	8.6
1991	2	4.7
1992	1	2.5
1993	0	0.0
1994	2	4.2
1995	2	4.2
1996	0	0.0
1997	1	2.1
1998	0	0.0
1999	7	14.1
2000	3	6.1
2001	0	0.0
2002	2	3.9
2003	2	4.0
2004	1	2.0
2005	2	4.0
2006	0	0.0
2007	2	4.1
2008	8	15.6
2009	1	1.9

2010	1	2.2
TOTAL	81	6.1