Summary of relevant life jacket research

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January 12, 2015

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Preface

This report was written by:

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- Harry Hogan, consultant, Rolling Bay LLC, a contractor to the United States Coast Guard Boating Safety Division, Office of Auxiliary and Boating Safety (CG-BSX-21).

The report presents the personal views, findings, and conclusions of the author alone and does not necessarily represent the views of the United States Coast Guard, United States Coast Guard Auxiliary, or Rolling Bay LLC. This report is furnished to the United States Coast Guard and to members of NBSAC to provide a summary of the relevant literature as background for their consideration of policy options to increase life jacket wear rates.

Thanks are also due to several members of the United States Coast Guard and to Mr. Fred Messmann, Deputy Director, National Safe Boating Council (NSBC) and the Chair of the Strategic Planning Subcommittee of NBSAC for their review of this report in draft. The responsibility for any errors or omissions rests solely with the author, however.

Mention of any specific products or services does not constitute endorsement by any agency of the United States government.

Unless otherwise noted all hyperlinks were accessed during December 2014.

Summary

This report provides a convenient summary of studies and data relevant to recreational boating safety, drownings, the effectiveness of life jackets, life jacket wear rates, boater attitudes towards life jackets, and various interventions (both voluntary and regulatory) to increase life jacket wear. The intended audience includes the members of the National Boating Safety Advisory Council (NBSAC) as they help to craft the next iteration of the Strategic Plan of the National Boating Safety Program and the United States Coast Guard as they consider the merits and feasibility of the NBSAC recommendation to consider possible regulations to require life jacket wear for occupants of certain recreational vessels. The studies and data summarized in this report include results from various countries (Australia, Canada, France, Ireland, the United Kingdom, and the United States). Including studies and data from other countries is relevant because the outreach efforts and regulatory approaches differ among these countries and there are opportunities to learn from their experience.

Here are some of the key findings:

- Drowning accounts for the majority (70+% in the United States) of recreational boating fatalities, so efforts to increase boating safety should focus on ways to reduce drowning fatalities. Most boaters who drowned (86% in the United States) were not wearing life jackets.
- Most experts believe that greater life jacket wear (not merely carriage) rates are necessary to reduce drowning fatalities. This is because most accidents that result in drowning (falls overboard, capsizing, or flooding/swamping) are sudden and unexpected, which does not provide enough time to locate and properly don a life jacket. Wearing a life jacket is a mitigating measure—it does not reduce the likelihood of an accident, but rather reduces the likelihood of a fatality once an accident occurs. Efforts to reduce boating fatalities should also address ways to reduce accident frequency.
- The ratio of drownings to total fatalities varies with boat length and type. Drowning accounts for a greater fraction of total fatalities in smaller boats (excepting personal watercraft) and rowboats, inflatables, canoes, kayaks, and open cabin motorboats. Occupants of open motorboats account for 50% of the total drownings over the period from 2000-2013 in the United States.
- Risk factors for drowning include gender, age, and alcohol use. Environmental factors are relevant (hazardous water or weather), but the reality is that most drownings occur in relatively benign environmental conditions—making it difficult to predict with any accuracy when accidents will occur.
- Belief in the efficacy of life jackets in preventing drownings can be supported by sound statistical studies conducted in Australia, the United Kingdom, and the United States. Estimates of the reduction of drownings that would result from greater wear of life jackets vary somewhat from study to study, but all are substantial. Measured (not reported) life jacket wear rates are an important measure of effectiveness of a boating safety program.
- Studies on life jacket wear rates in several countries indicate that wear rates are highest in countries that mandate that life jackets are worn for certain types and lengths of boats. The United States has mandatory wear regulations in place for children, PWC users, and persons being towed. For these groups wear rates are high. However, adult wear rates

(excluding PWCs) have remained nearly constant; 10.1% in 2000 and 9.1% in 2013, despite substantial outreach efforts. Wear rates differ with age, gender, and (importantly) with whether or not other boat occupants elect to wear a life jacket. Survey studies on wear rates have very limited utility as survey responses consistently overstate wear rates as measured by direct observation.

- Boaters have a variety of reasons for not choosing to wear a life jacket—which are similar across countries. These include the perception that boating is not dangerous (and/or that they are good swimmers), that life jackets are uncomfortable, restrictive, or unfashionable, and that wearing a life jacket is a sign of fear. Some design advances, such as inflatable life jackets, are more comfortable and less restrictive.
- Finally, the last chapter of this report summarizes outreach and regulatory efforts in various countries to increase life jacket wear. For the United States, despite the support of voluntary initiatives by various groups and an ambitious outreach effort, national life jacket wear rates have not increased materially for those boaters who account for the majority of drownings. This chapter also includes a brief discussion on two other safety initiatives involving regulation, automobile seat belts and motorcycle helmets. In the end, both efforts were successful in saving lives, but results were mixed in the case of motorcycle helmets because public opposition to helmet requirements led to repeal of these requirements in many states.

Chapter 1. Preliminaries

Introduction

This report summarizes relevant studies on the benefits of wearing life jackets in recreational boating and voluntary and mandatory initiatives to increase wear rates. Among other uses, this report provides essential background for members of the National Boating Safety Advisory Council (NBSAC) as they help to create the next iteration of the Strategic Plan of the National Boating Safety Program. In 2011, NBSAC passed Resolution Number 2011-87-01 that recommended (among other things) that the United States Coast Guard (USCG) consider a regulatory project to require that life jackets be worn by occupants of certain types and lengths of vessels. This report also provides useful data and analyses for USCG personnel as they consider the merits and feasibility of the NBSAC recommendation.

The available literature on life jackets is voluminous and this report summarizes the key findings. Extensive references and footnotes are included for those wishing to consult original source materials. A common data bank containing copies of all the references cited in this report has been compiled and is available upon request from the Coast Guard's Office of Auxiliary & Boating Safety (CG-BSX).

Report organization

- Chapter 1 explains the organization of the report, provides data showing that drownings account for the majority of recreational boating fatalities, and presents relevant statistics on the ratio of drownings to total fatalities by boat length and type.
- Chapter 2 summarizes what we know about drownings with recreational and other vessels, the role of alcohol in boating fatalities, and reasons why some boaters survive water immersion without wearing life jackets while others may drown despite wearing life jackets.
- Chapter 3 presents the key statistical evidence from various studies (in the United States and other countries) to show that wearing life jackets will reduce boating fatalities and explains various models proposed to estimate the life-saving benefits of increased life jacket wear.
- Chapter 4 summarizes available data on actual life jacket wear rates in various countries and how these wear rates vary with such factors as the gender and age of the wearer, observed behavior of other vessel occupants, and vessel type.
- Chapter 5 attempts to answer the question, in view of the demonstrated benefits of life jackets why don't more boaters choose to wear life jackets?
- Chapter 6 details the efforts in several countries, including both voluntary and regulatory initiatives, to increase life jacket wear rates. This chapter also examines possible analogies with other safety related initiatives, such as promoting use of helmets among motorcycle riders and seat belts among occupants of automobiles.
- Relevant statistical tables and other supporting information are presented in the Appendix.

Widespread belief in the benefits of life jackets

Devices intended to prevent drowning reportedly date back as far as 870 BC, when inflated animal skins were first used for this purpose.[1] Over the years, buoyancy devices have taken the form of sealed gourds, wood blocks, and clothing made out of various materials including cork, as well as natural and synthetic fibers. Originally, buoyancy aids were designed to keep the user's head above the water, but often times the head was pitched forward in the water. There have been substantial advances in the design of life jackets in an effort to keep user heads above the water and pitched back.[2] Groff and Ghadiali, (2003) offered the following comments on some of the advances in the design of life jackets:

> "Thus, life jackets were designed to have the capability to not only keep a person afloat, but also turn the wearer (whether conscious or unconscious) onto his or her back, with the head supported and the mouth out of the water[3] in order to protect the airway. Because of the S-shaped curvature of the spine, the body more easily bends forwards rather than backwards, and this results in a face-down position in the water for an unconscious, injured, exhausted or incapacitated individual. According to the pathology reports, drowning victims consistently have abrasions on the forehead, and the backs of the hands and toes consistent with a face down position on the water. As a result life jackets were designed specifically to counteract the forward face down position with a buoyant cell on the front of the upper chest to life the chest out of the water and turn the body in a supine position to reach buoyant equilibrium. Life jackets also contain another buoyant cell behind the head in order to keep the head clear of the water."

The lifesaving benefits of life jackets have been recognized and most nations of the world now have life jacket carriage requirements for both commercial and recreational craft. In the United States, for example, Congress passed a law in 1852 requiring ships to carry life preservers, and set up a Board of Supervising Inspectors that set standards and rules. More recently, Ireland and some states in Australia have mandated life jacket wear by occupants of certain vessels.

A Google search using the search term "benefits of life jackets" yields more than 2 million possible web addresses with content ranging from state and federal government regulations, information on how to select a life jacket, life jackets for kids, life jackets for pets, the need to wear a life jacket, real life stories of persons saved by wearing life jackets,[4] life jacket loaner

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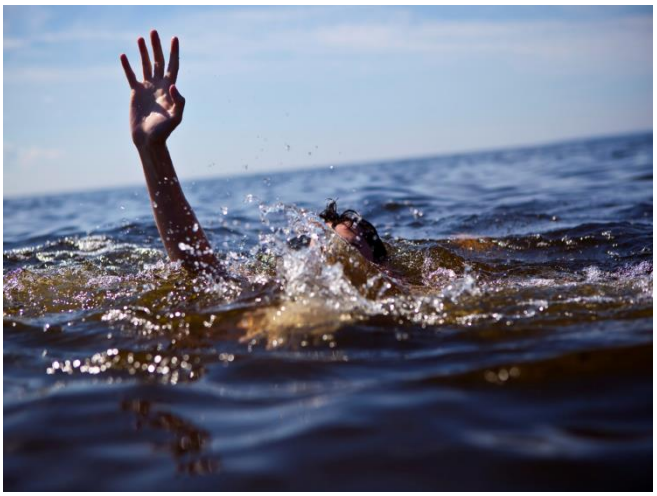
[1] See e.g., http://comingbackalive.com/life jackethistory.html, http://traveltips.usatoday.com/history-life-preservers-21951.html, and http://www.nmmc.co.uk/index.php?/collections/featured_objects/early_lifesavers_the_cork_life jacket last accessed on 26 November 2014. See also Brooks (2008).

[2] The generic term "life jackets" is used throughout this report as this nomenclature is now preferred. Not all life jackets have the same capabilities, however as discussed elsewhere in this document.

[3] Not all life jackets have this capability. There are now several types of life jackets, each with specified capabilities.

[4] See e.g., the NSBC "Saved by the Jacket" stories available in hardcover and online (http://www.boatingsidekicks.com/sbjacket/sbtjmain.htm).

programs,[5] miscellaneous outreach information, and advertisements from life jacket vendors and manufacturers.



Life jackets are intended to keep persons floating safely in the event of accidental water immersion following a boating mishap (e.g., falls overboard, capsizing, or flooding/swamping, see Chapter 2) until they can be rescued (self-rescue, rescue by Good Samaritans or search and rescue forces). Thus, in terms of the hierarchy of error management approaches (avoid, trap, mitigate), life jackets are properly termed a *mitigation measure* intended to minimize the adverse consequences of persons immersed in the water in the event of a marine accident. Life jackets do not prevent accidents, they are intended to prevent (or reduce the likelihood of) drowning fatalities resulting from accidents.[6]

Most authorities conclude that wearing a life jacket materially increases the likelihood of surviving an accidental immersion.

For example, a recent report by the State of New South Wales in Australia[7] (NSW Maritime, 2010) contains the following statement:

> "Whilst many factors contribute to a boating fatality you can never say with certainty that wearing a life jacket would save your life. But if you do end up in the water *your chances of survival increase dramatically if you're wearing a life jacket.*" [Emphasis added.]

The word "dramatically" is often used to describe the benefit of wearing a life jacket. For example, the Centers for Disease Control and Prevention (CDC) release *Stay Safe While Boating*[8] contains the following text:

> "*Wearing a life jacket can dramatically decrease your chances of drowning while boating*. 'Wear It! every time you're on the water." [Emphasis added.]

A Safety Alert (NTSB, 2013) on recreational boating issued by the National Transportation Safety Board (NTSB) notes:

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[5] Many states offer such a program. For example, http://boat.wa.gov/life-jackets.asp, details the program offered by the State of Washington.

[6] Although wearing a life jacket does not *prevent* a marine mishap it is possible that boats operated by persons who are sufficiently safety conscious to wear a life jacket may also have a lower likelihood of an accident.

[7] This same report also contains the statement: "Wearing a life jacket does not always prevent a fatality, but even when it doesn't it can help with the recovery operation and reduce risk for emergency services. An early recovery also reduces distress for the family and friends of a missing person."

[8] Available at http://www.cdc.gov/features/boatingsafety/ last accessed on 26 November 2014.

> "Use a life jacket when aboard a recreational boat and be sure that children always wear life jackets. Life jackets are effective. Boating accident data shows that when mandatory life jacket requirements are adopted, drowning fatalities go down."

A British Study (Turner et al., 2009) concluded:

> "The evidence on life jacket effectiveness indicates that *they greatly reduce the probability that someone will die from drowning when immersed in water*." [Emphasis added.]

The Pleasure Boat Safety Advisory Group (PBSAG) of the Maritime Safety Authority of New Zealand (Maritime Safety Authority, 1999) examined the available data and concluded that the benefits of wearing life jackets were substantial:

> "With potentially 75 percent of all fatalities being preventable through the simple act of wearing a life jacket in certain circumstance, the Group is convinced that the case for making the carriage of PFDs compulsory is compelling."

An earlier analysis by NTSB on a sample of boating fatalities (NTSB, 1993) suggested that the benefits of wearing a life jacket could be even higher:

> "Therefore, as many as 85% of these persons may have survived had they been wearing a PFD [life jacket]." [Material in square brackets inserted for clarity.]

Steensberg (1998) analyzed boating fatalities in Denmark from 1989 to 1993 and concluded that at least half of drowning fatalities in Denmark over this period could have been prevented had the victim been wearing a life jacket.

Lunetta et al. (1998, 2004) analyzed data from Finland and concluded that failure to wear a life jacket was a cause of drownings.

A background research paper prepared for the Canadian Safe Boating Council (Groff and Ghadiali, 2003), contains the following text:

> "Most in the boating community (including the Canadian Red Cross, the Canadian Lifesaving Society, The Canadian Coast Guard, the United States Coast Guard, and the National Association of State Boating Law Administrators [NASBLA]) promote the use of flotation devices for recreational boaters as they are believed to be effective in saving lives."

As a final example, a researcher (Bugeja L., 2003) from Marine Safety Victoria (Australia) offered the following conclusion:

> "What is clear from this investigation is that deaths resulting from recreational vessel incidents are preventable. *More specifically, in most cases a securely fitted and appropriately designed PFD and means of indicating distress within a timely manner would have meant a large number of these deaths may not have occurred*." [Emphasis added.]

As the above statements indicate, researchers and policy makers in several countries (Australia, Denmark, Finland, New Zealand, the United Kingdom, and the United States) believe that life jackets (if worn) are effective in preventing drownings. (As discussed in Chapter 2 many researchers [e.g., Brown et al., 2003; Bugeja, 2003; Bugeja et al. 2014; Cassell and Congiu 2007; Driscoll et al., 2004; Germeni et al., 2008; Groff and Ghadiali, 2003; Howland et al., 1996; Lincoln et al., 1996; Lindholm and Steensberg, 2000; Lunetta et al., 1998, 2004; Matheson, 2014; NTSB, 1993; O'Connor , 2004; O'Connor and O'Connor, 2005; Pleasure Boat Safety Advisory Group, 1999; Quan et al., 1998; Quistberg et al., 2014 a, b; Smith et al., 2001; Steensberg, 1998; Stempski et al., 2014; Strayer et al., 2010; Transport Canada, 2011; Turner et al., 2009; University of South Florida, 2009] have concluded that alcohol is also a significant contributing factor in drownings.)

The most compelling statistical evidence for the effectiveness of life jackets is presented in Chapter 3. Suffice it to say that there is now strong statistical evidence to support the widely held belief that wearing life jackets will reduce drowning deaths.

Drowning is the major cause of recreational boating fatalities

The available data from several countries indicate that drownings account for the majority of recreational boating fatalities, which justifies a focus on measures to reduce the incidence of drowning through increased life jacket wear.

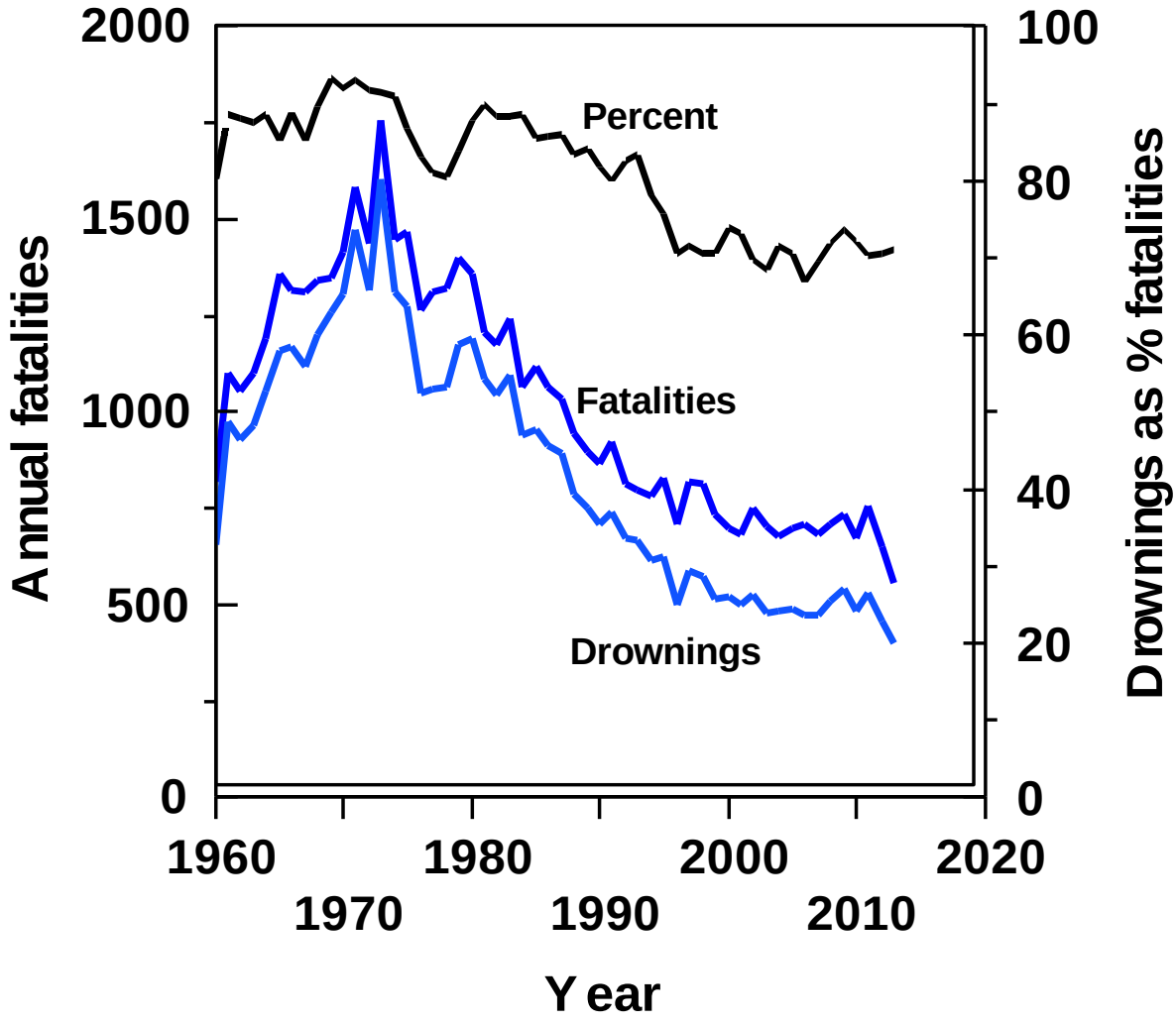
-U.S. Data

Since 1960, the United States Coast Guard has prepared an annual statistical summary of boating accidents, fatalities, injuries, and property damage titled (in various years) *Boating Statistics* or *Recreational Boating Statistics*. Among other statistics, this publication provides year-by-year data on the number of recreational boating fatalities from all causes (e.g., blunt force trauma, cardiac arrest, hypothermia, carbon monoxide, and drowning). As shown in the Appendix (Table A-1), over the 54-year period from 1960 through 2013, a total of 55,249 boating fatalities were reported of which a large majority, 45,877 (83%), resulted from drowning. This fraction has declined slightly in recent years (perhaps as a result of mandatory life jacket wear requirements in some states for certain seasons (fall, winter) or

Over the years from 2000 through 2013 drownings accounted for 71% of recreational boating fatalities in the United States and approximately 86% of drowning victims were not wearing a life jacket.

groups, such as youth or occupants of personal watercraft). Nonetheless, even for the period from the year 2000 through 2013 approximately 71% of all boating fatalities occurred as a result of drowning. Figure 1 provides a time series of recreational boating fatalities, drownings, and drownings as a percentage of total fatalities. The data for Figure 1 are presented in Table A-1 (see the Appendix).

Figure 1. *U.S. recreational boating fatalities, drownings, and drownings as a percentage of fatalities from 1960 through 2013.*



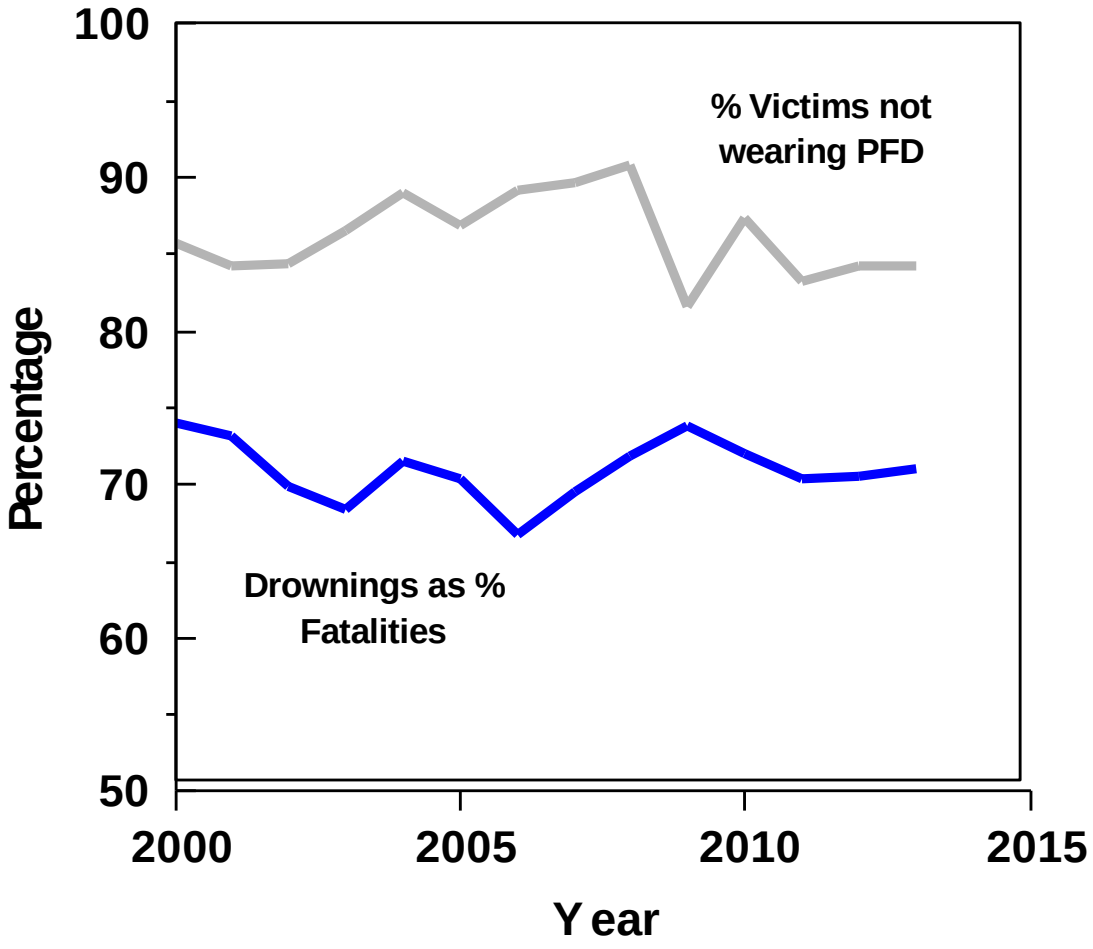
Source: Data from Boating Statistics, various years.

Boating Statistics has also recorded whether or not a life jacket was worn by those who drowned since 1995. The data indicate that life jackets are worn by only a small percentage of those who drowned. For example, for victims whose life jacket use was known over the period from 2000 to 2013, life jackets were worn by only about 13.7% of those who drown. Thus, the vast

majority of drowning victims, 86.3%, were not wearing a life jacket. This statistic is used by many policy makers as an indication of both the benefits of wearing life jackets and the need to find means (either voluntary or through regulation) to increase life jacket wear among recreational boaters if drownings are to be reduced.

Figure 2 provides a time series of drownings as a percentage of total fatalities and the percentage of drowning victims not wearing a life jacket from 2000 through 2013.

Figure 2. *Time series of drownings as a percentage of total fatalities and the percentage of drowning victims not wearing a life jacket from 2000 through 2013.*



Drownings by Boat Length and Type

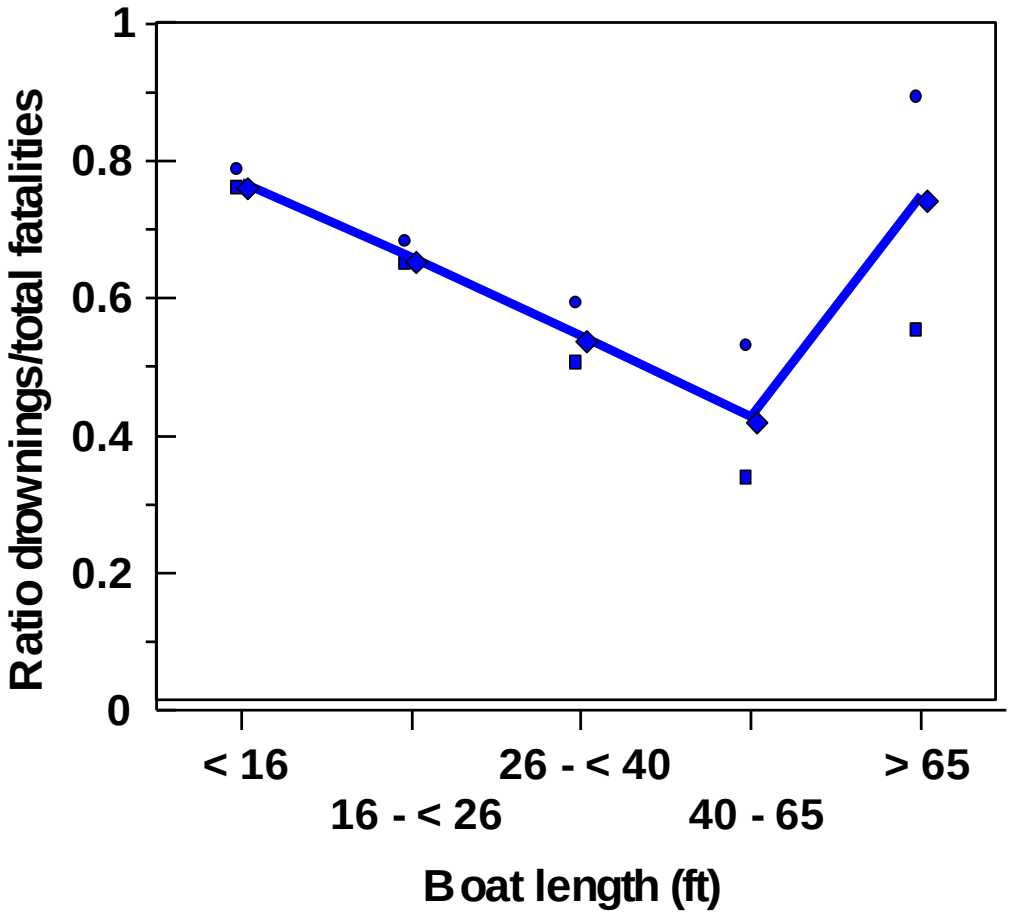
Available U.S. data indicate that the relative frequency of drownings as a fraction of total fatalities associated with recreational boating varies with both boat length and type.

-Drownings by boat length

Because many drowning deaths occur following falls overboard, capsizing, and flooding/swamping, it is plausible that the relative frequency of drownings compared to all

fatalities would be related to boat length—smaller vessels are probably more prone to capsizing or flooding/swamping and it is likely that the frequency of falls overboard would also be related to length. Table A-2 (Appendix) shows data on drownings, all fatalities, and drownings as a percentage of all fatalities from 2000 through 2013 for vessels of various lengths from *Boating Statistics.* Table A-3 (Appendix) provides the statistical analysis that shows the differences in the ratio of drownings to total fatalities by boat length are statistically highly significant (χ^2 = 218, degrees of freedom (df) = 4, $p<0.0001$). Table A-3 also provides the lower and upper 95% confidence limits on the proportions by boat length. Figure 3 shows the proportion of drownings to total fatalities for vessels in various size ranges over the years from 2000 through 2013.

Figure 3. *Proportion of drownings to total fatalities for vessels in various size ranges over the years from 2000 through 2013. Points shown as squares and circles are the lower and upper 95% confidence limits on the calculated proportions.*



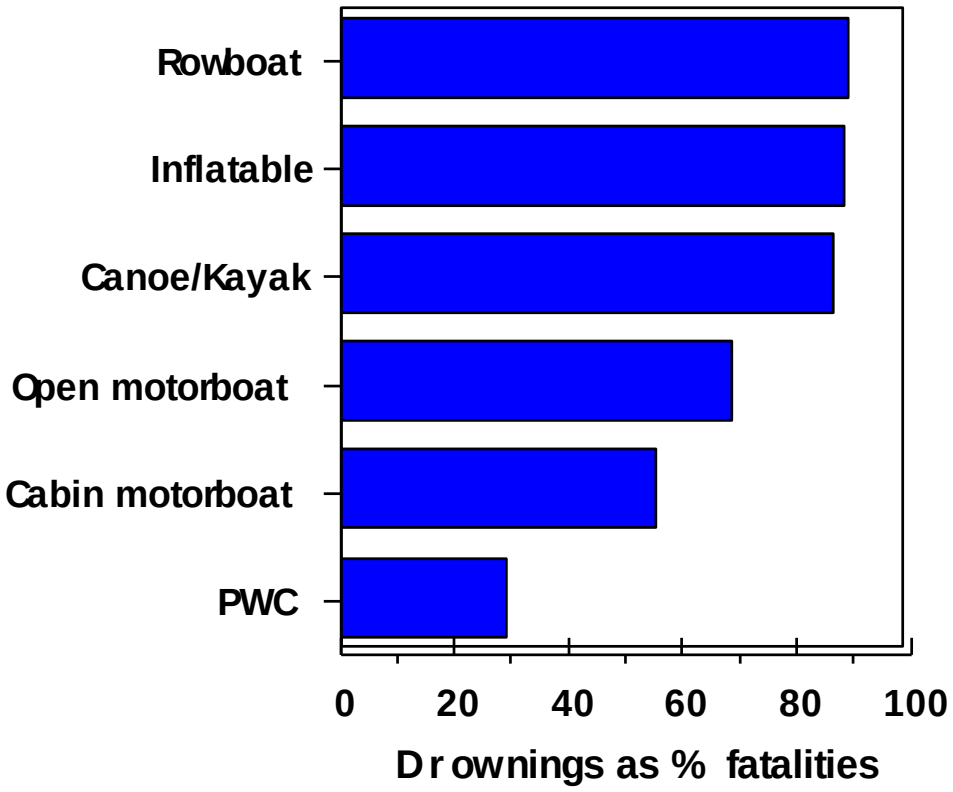
As can be seen from Fig. 3, with the exception of vessels > 65 ft. in length, drownings as a fraction of total fatalities decrease with boat length, in accord with expectation. The numbers of drownings for recreational vessels longer than 65 ft. are much smaller than those for the other boat lengths, as reflected in the width of the confidence bounds shown in Fig. 3. Note that the data presented in Fig. 3 should not necessarily be interpreted as the relative risk of drownings or fatalities—risk calculations should be based on either drownings or fatalities relative to exposure

hours. Rather these data show the proportion of drownings to fatalities for occupants of vessels involved in fatal accidents.

-Drownings by boat type

There are considerable differences among the various boat types used by recreational boaters. Rowboats, canoes, kayaks, and inflatables are small craft that are less stable and more likely to capsize resulting in accidental water immersion—although life jacket wear rates (see Chapter 4) also differ among these boat types. Accidental water immersion is also likely for operators and other users of personal water craft (PWC), but these craft are subject to state mandatory life jacket wear requirements. Table A-4 (Appendix) shows data on drownings, all fatalities, and drownings as a percentage of all fatalities from 2000 through 2013 for vessels of various types (rowboats, canoes/kayaks, PWC, open motorboats, cabin motorboats, and inflatables[9]) taken from *Boating Statistics*. Table A-5 (Appendix) provides the statistical analysis that shows the differences in the ratio of drownings to total fatalities by boat length range are statistically highly significant (χ^2 = 1,030, df = 5, $p<0.0001$). Table A-5 also provides the lower and upper 95% confidence limits on the proportions by boat type. Figure 4 shows the proportion of drownings to total fatalities for various types of boats over the years from 2000 through 2013.

Figure 4. *Proportion of drowning to total fatalities for various types of boats over the years from 2000 through 2013.*



[9] Boating Statistics also gives data for other types of boats, such as airboats and houseboats, but these were omitted in Fig. 4 because of small sample sizes.

The fact that drownings as a fraction of total fatalities are lower for PWC users than other boat types should lead the reader to conclude that PWCs are "safer" than other boats—such a conclusion requires additional analysis. Rather it indicates that other fatality causes (i.e. trauma) are proportionally more likely (perhaps arising from high speed collisions) for PWCs. It is also likely that drownings are less likely among PWC users because life jackets are required (by state regulation) to be worn. This conjecture is supported by other analyses. For example, Jones (1999) analyzed deaths and injuries to PWC users on Arkansas waterways over the years from 1994-1997. He wrote:

> "Drowning is a primary cause of mortality in boat-related injury. A major risk factor for boat-related drowning is the lack of drowning-prevention measures, especially PFDs [life jackets]. However, PWC passengers have a lower percentage of drowning deaths when compared with other boat types. One reason points to the higher usage of PFDs [life jackets]. This study provides limited data drowning among PWC passengers." [Material on square brackets inserted for clarity.]

-Drownings by boat type (another perspective)

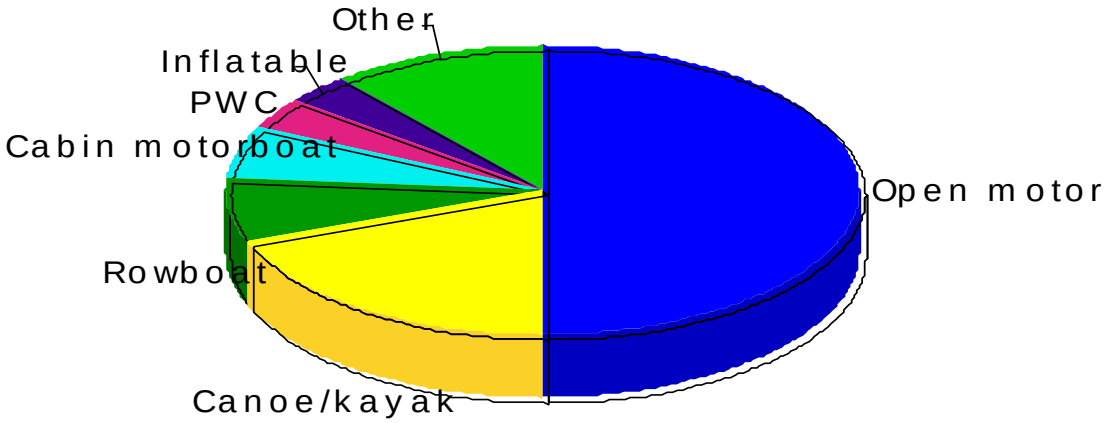
Figure 4 shows drowning as a percentage of the total fatalities *for each boat type* from 2000 through 2013. For example, for PWCs drowning accounted for approximately 31% of total PWC fatalities over the period from 2000 to 2013. The picture is quite different if drowning deaths for PWCs are compared to drowning deaths for all boats. In fact, PWCs accounted for only 3.43% of the total drowning deaths among all boat types over this period.

It is also relevant to consider the distribution of total drowning deaths among all boat types. These percentages are shown in Fig. 5 for the period from 2000 to 2013. Over this time period six boat type/groups; open motorboats, canoes/kayaks, rowboats, cabin motorboats, PWCs, and inflatables accounted for approximately 89% of all recreational boating drownings. The remaining types, including airboats, auxiliary sailboats, sail only, houseboats, pontoon boats, and other/unknown accounted for only 11% of this total.

Considering the types of boats that account for the majority of drownings over the period from 2000 to 2013, open motorboats accounted for 50%, followed by canoes/kayaks (19.1%), rowboats (7.5%), cabin motorboats (5.7%), PWCs (3.4%), and inflatables (3.3%). In purely statistical terms, attempts to reduce drowning deaths should logically be focused on measures to increase the safety (e.g., by increasing life jacket use) of open motorboats and human powered craft (canoes, kayaks, and rowboats) which collectively account for over three-quarters of all drowning deaths. This is one of the reasons why a specific numerical target for life jacket use on open motorboats[10] was set as a target in the 2012-2016 Strategic Plan of the National Recreational Boating Safety Program (USCG, 2012 b). Figure 5 shows the distribution of drowning fatalities among boat types over the period from 2000 through 2013.

[10] Observed life jacket wear rates for open motorboats are among the lowest of all boat types as discussed in Chapter 4.

Figure 5. *Percentage of all drowning deaths by boat type over the period 2000-2013. Open motorboats account for 50% of the total.*



Summary

To summarize, this chapter shows that drowning is a major cause of fatal injuries for recreational boaters and that the vast majority of drowning victims were not wearing life jackets. Both facts have prompted researchers and policy makers in many countries to focus on ways to increase life jacket wear rates as one key strategy to reduce boating fatalities. To be sure, wearing life jackets does not (itself) reduce the frequency of potentially fatal accidents—which should also be a goal of boating safety efforts—but wearing life jackets reduces the consequences of such accidents.

The data presented in this chapter also show that the proportion of drowning deaths to all boating fatalities varies with boat length and type. Drowning deaths occur with proportionally higher frequency (i.e., compared to total fatalities for this boat type) among occupants of smaller boats and also among human powered craft (rowboats, canoes, and kayaks) compared to occupants of open motorboats, cabin motorboats, and PWCs.

Mandatory life jacket wear requirements for PWC users may be one reason why drownings are proportionally less likely. When calculated as a proportion of total drowning deaths, open motorboats and human powered craft accounted for more than three-quarters of all drowning deaths, which has prompted policy makers to focus on ways to reduce drowning deaths among occupants of these craft.

Chapter 2. What we know about drowning

Introduction

This chapter summarizes what we know about drowning with recreational and other vessels, the role of alcohol in boating fatalities, and reasons why some boaters survive water immersion without wearing life jackets while others may drown despite wearing life jackets.

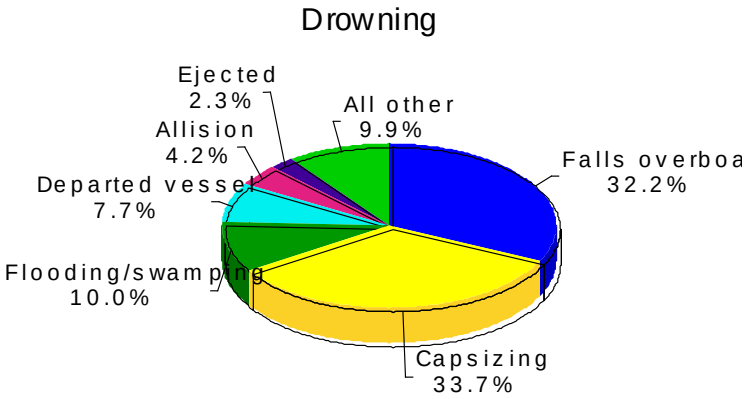
Drowning risk factors

This section identifies several relevant risk factors in drowning, including accident type, gender and age of drowning victims, environmental factors, and alcohol involvement. Wearing a life jacket is obviously a key determinant of survival, data on life jacket use in presented in Chapter 4 of this report.

-Accident type

Persons drown following water immersion,[11] so it is appropriate to consider the circumstances that lead to vessel occupants entering the water. *Boating Statistics* provides annual data on accident types, drownings, and total fatalities. Table A-6 (Appendix) presents data on the fraction of total drownings by accident type for the years from 2000 through 2013. Six accident types; falls overboard, capsizing, flooding/swamping, departed vessel, collision with fixed object (allision), and ejections from vessels accounted for 90.1% of the total number of drownings over this time period. Figure 6 contains a pie chart of the distribution of drownings by accident type from 2000 through 2013.

Figure 6. *Pie chart of the distribution of drownings by accident type from 2000 through 2013*



[11] It may be surprising, but studies show (see Brooks, 2008) that it only takes the inhalation of 150 mls of sea water to drown.

These same six accident types also account for the majority of total fatalities, albeit a slightly smaller percentage (82%) of total fatalities.

-Gender

Boating Statistics does not provide data on the gender of drowning victims. But numerous studies show that the majority (often as high as 90+%) of drowning victims resulting from boating accidents are males in such countries as Australia (Bugeja et al., 2014; O'Connor, 2004; O'Connor and O'Connor, 2005); Canada (Groff and Ghadiali, 2003); Denmark (Lindholm and Steensberg, 2000); Finland (Lunetta et al., 1998, 2004); New Zealand (Matheson, 2014); the United Kingdom (Turner et al., 2009), and the United States (Browne et al, 2003; Howland et al., 1996; Quan et al., 1998, 2012; Lincoln et al., 1996; Strayer et al., 2010). Suggestions for the preponderance of male (compared to female) drowning victims include relative exposure, alcohol use, and different attitudes towards risk (Howland et al., 1996).

-Age of victims

Figure 7 shows the age distribution of the average number of drowning (light bars) and other fatalities (dark bars) for the years 2000 - 2013 according to data given in *Boating Statistics*.

Figure 7. *Age distribution of average annual drownings and other boating fatalities for 2000 - 2013.*

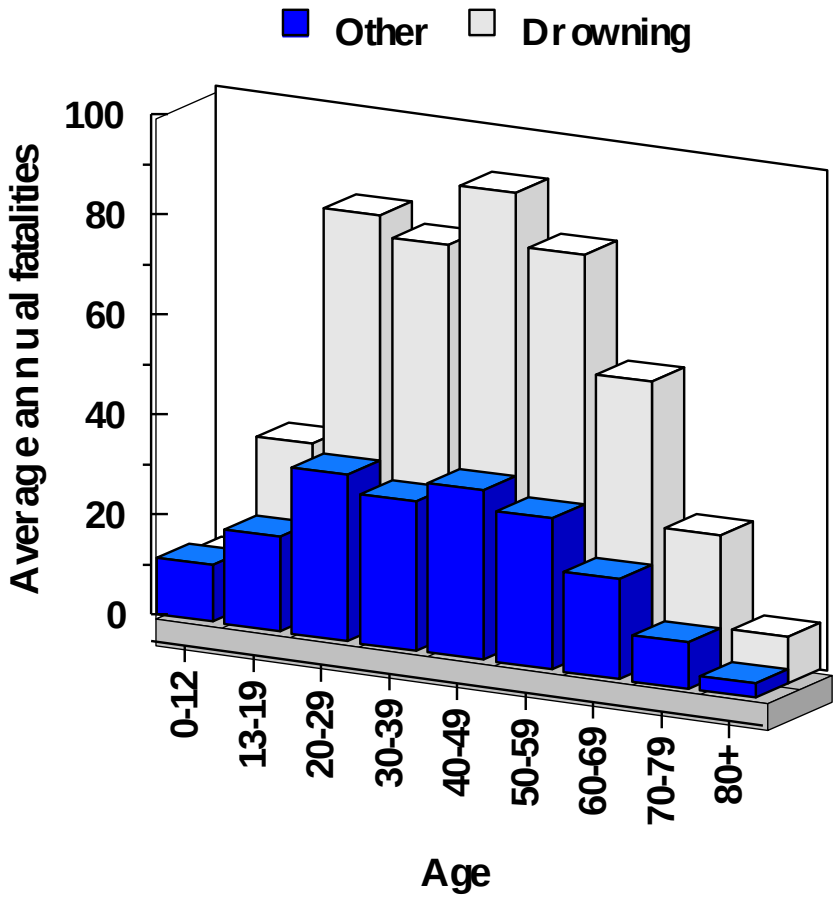


Figure 7 also exhibits the relative proportions of drowning and other recreational boating fatalities discussed in Chapter 1. The age distributions of both drownings and other fatalities are both quite broad. However, the data exhibit a deficit of drownings in the 0 to 12 age range, which may reflect the fact that youths in this age range are required to wear life jackets.

-Environmental conditions

Books and movies that include shipwrecks generally contain vivid descriptions of severe environmental conditions (think *Perfect Storm*). It is tempting to believe that drownings or other fatalities on recreational boats typically occur during adverse environmental conditions—and indeed those who advocate selective use of life jackets implicitly make the assumption that these conditions can be identified and forecast. The reality, however, is far different. Although hazardous water and adverse weather figure into some accidents (see below), most recreational boating fatalities occur in relatively benign environmental conditions. Table A-7 (Appendix) shows the distribution of boating drownings and fatalities among various environmental conditions for various years as reported in the publication *Boating Statistics*.

With respect to drownings:

- Over the years from 2008 – 2013 nearly 50% of drownings occurred on lakes, ponds, reservoirs, dams, and gravel pits—only 8 % occur on the gulf, Great Lakes, or oceans,
- Over the years from 2000 – 2013 (when water conditions were known) 75% of drownings occurred on waters with wave heights less than 2 feet—50% with wave heights less than 6 inches,
- Over the years from 2000 – 2013 (when winds were known) 58% of drownings occurred with wind conditions described as none or light (< 6 mph).
- Over the years from 2000 – 2013 (when visibilities were known) 82% of drownings occurred under conditions described as good visibility, and
- Over the years from 2000 – 2013 (when water temperatures were known) 61% of drownings occurred at water temperatures > 60 degrees Fahrenheit and 45% when the temperature was 70 degrees or more; only 2.7% when water temperatures were less than 39 degrees.

Regarding the last point on temperatures, colder water presents challenges for those immersed. For example, Groff and Ghadiali (2003) note:

> "It is well documented that immersion in cold water can cause various physiological responses, each of which can lead to drowning…In brief, the cold shock in the first few minutes of immersion can cause severe hyperventilation, muscle spasms, and even lead to heart failure due to a substantial increase in heart rate and blood pressure. The cold water may also cause limbs and hands to become numb and impede swimming ability as well as any self-rescue attempts requiring manual dexterity or handgrip strength. As well, within the first few minutes, it may become increasingly difficult to control breathing, and breathing may even stop due to 'diving response.' After being immersed for 30 minutes or

> more, body temperature will fall to hypothermic levels, resulting in a loss of consciousness."

Tipton and Brooks, (2008) provide a very useful tutorial on the dangers of sudden immersion in cold water (see also Brooks, 2001). Falls overboard or other sudden immersion can have severe consequences for those without a life jacket in colder water. This is a significant issue for those who boat in Canada and northern states of the United States, one of the reasons why some northern states have mandated life jacket use during certain months of the year.

-Alcohol involvement

As noted in Chapter 1, alcohol is known to be a major risk factor for boating fatalities (e.g., Brown et al., 2003; Bugeja, 2003; Bugeja et al. 2014; Cassell and Congiu 2007; Driscoll et al., 2004; Germeni et al., 2008; Groff and Ghadiali, 2003; Howland et al., 1996; Lincoln et al., 1996; Lindholm and Steensberg, 2000; Lunetta et al., 1998, 2004; Matheson, 2014; NTSB, 1993; O'Connor , 2004; O'Connor and O'Connor, 2005; Pleasure Boat Safety Advisory Group, 1999; Quan et al., 1998, 2012; Quistberg et al., 2014 a, b; Smith et al., 2001; Steensberg, 1998; Stempski et al., 2014; Strayer et al., 2010; Transport Canada, 2011; Turner et al., 2009; University of South Florida, 2009). One useful study on the topic was performed by Smith and colleagues (2001). They describe the effects of alcohol as follows:

> "Alcohol use while boating affects the probability not only of ending up in the water but also of survival once that happens. Because of the apparent double jeopardy, alcohol use may actually be more hazardous on a boat than in other settings, with even low BACs [Blood Alcohol Concentrations] greatly increasing relative risk (RR)." [Material in square brackets added for clarity.]

Smith et al. (2001) completed a case control study of recreational boating deaths among persons aged 18 years and older from 1990-1998 in Maryland and North Carolina (n = 221), compared with control interviews obtained from a multistage probability sample of boaters in each state from 1997-1999 (n = 3943). Their results included:

> "Compared with the referent of a BAC of 0, the estimated RR of death increased even with a BAC of 10mg/dL (odds ratio [OR], 1.3; 95% confidence interval [CI], 1.2 – 1.4). The OR was 52.4 (95% CI, 25.9 – 106.1) at a BAC of 250 mg/dL. The estimated RR associated with alcohol use was similar for passengers and operators and did not vary by boat type or whether the boat was moving or stationary."

These results are not surprising. As noted by Groff and Ghadiali, (2003):

> "Alcohol consumption impairs judgment, the ability to focus and process information, as well as reaction time. At the same time, peripheral vision, night vision and depth perception deteriorate after consuming alcohol."

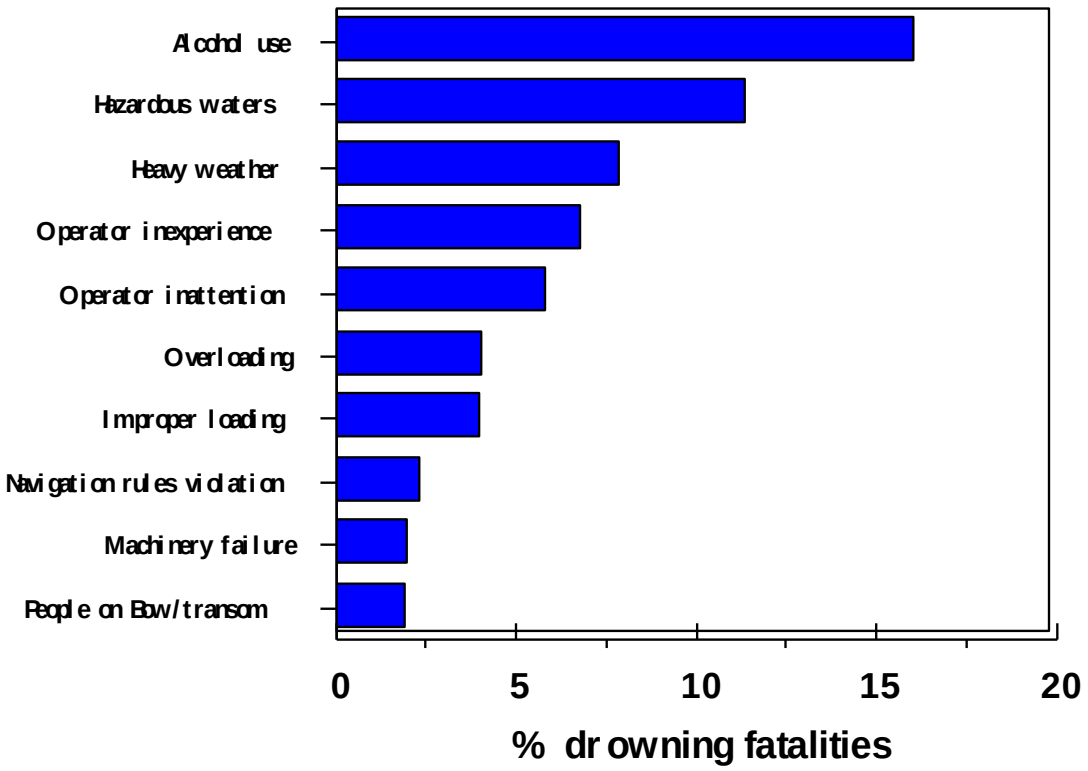
It is plausible that those who consume alcohol are less likely to use life jackets—and there is weak but significant statistical evidence that this is the case (Howland et al., 1996; Quistberg et al., 2014b). For example, Quistberg et al. (2014b) report:

> "Any reported level of alcohol use while boating was also significantly associated with no/low life jacket use (RRs ranging from 1.09 to 1.13)."

It is known in studies of automobile drivers that seat belt use is lower among those impaired (see e.g., Foss et al., 1994; Tison et al., 2010) by alcohol use.

One of the difficulties with the study of alcohol involvement in boating fatalities is that objective measures of alcohol use or impairment are difficult to come by—it may not be possible to test victims for BAC and, as the Smith et al. (2001) study indicates, risk ratios are elevated even for those not legally intoxicated. These limitations acknowledged the available data show that alcohol involvement is the leading single cause/contributing factor in boating related fatalities. Figure 8, for example, shows U.S. recreational boating drowning data from *Boating Statistics* for the years 2000 - 2013 ranked in descending order of causes/contributing factors for cases where the cause was known. Alcohol involvement leads all other factors considered.

Figure 8. *Causes/contributing factors to recreational boating drownings in the United States 2000- 2013.*



Note that heavy weather is listed in the accident reports as the third largest cause/contributing factor in drowning fatalities, even so this accounts for a minority of the 28 causes/contributing factors considered in writing boating accident reports.

Are life jackets always effective?

The composite statistical evidence for the effectiveness of life jacket wear is summarized in Chapter 3. But it is useful to provide some perspective here. The key points are:

- Persons who wear a life jacket and are immersed in water do not always survive, and
- Persons who fail to wear a life jacket do not always drown, but
- Those who wear a life jacket have a greater probability of surviving long enough to be rescued or to rescue themselves.

Table 1 provides more detail to explain the first point.

Table 1. *Possible reasons why wearing a life jacket might fail to prevent drowning.*

Reasons why persons might drown even if wearing a life jacket
1. The life jacket worn was not the right size (e.g., adult life jacket used by child), not the right type for the sea conditions (e.g., inadequate mouth freeboard or not self-righting), was old, worn out, broken (e.g., malfunction of CO_2 system or otherwise defective), improperly maintained, torn, or worn improperly (e.g., the person slipped out of the life jacket).
2. An inflatable life jacket was worn, the inflation mechanism failed to work, and the boater did not know how to manually inflate the life jacket.
3. The vessel capsized and the wearer was trapped inside because egress was impossible (e.g., SEWOL ferry sinking) or the life jacket actually prevented egress.
4. Donning a life jacket inside a rapidly flooding enclosed deckhouse resulted in the buoyant safety device carrying a wearer upward when most people had to swim downward to escape.
5. Entrapment occurred when the vessel or the boater became snagged on rocks or debris at some hazardous point, then went under due to the severe hydraulics of the water, and the boater was either unable to escape the craft or unable to escape the hydraulic pressures.
6. The victim drowned from wave splash (mouth immersions) before rescue could be effected and/or the life jacket did not offer sufficient splash protection.
7. The boater received an injury or impairment that did not kill the boater, but was severe enough to prevent the boater from doing those things necessary to keep the boater's face out of the water or prevent what are termed "mouth immersions" from restricting the victim's airway over time.
8. The victim was stuck on the head, became unconscious, and was wearing a type of life jacket that did not turn an unconscious person upright.
9. "Drowning" incorrectly reported as cause of death when hypothermia was involved.
10. The alarm was not raised immediately due to unavailability or non-use of available distress signaling, which led to delays in activating search and rescue authorities.
11. No rescue service available because of remote location of accident.

Sources: Bugeja et al., 2014; CNN SEWOL report at http://wtvr.com/2014/04/25/south-korea-ferry/; Groff and Ghadiali, 2003; HSE, 1994; NTSB, 1993; Pickens, undated.

Table 2 provides more detail to explain the second point—some who fall into the water without a life jacket still manage to survive.

Table 2. *Possible reasons why persons not wearing life jackets might not drown in the event of a potentially fatal accident*

Reasons why those not wearing life jackets might not drown
1. The person was able to find some other object (e.g., stayed with the boat, found a life ring) that was able to be used for floatation.
2. The potentially fatal mishap occurred in an area sufficiently close to the shore that the person was able to swim[12] to safety.
3. The potentially fatal mishap occurred in sufficiently close proximity to one or more other vessels that were able to rescue the potential victim.

A complete discussion of relative likelihood of survival with and without wearing life jackets is presented in the next chapter. However, two examples are instructive. First, Lincoln et al. (1996) provided the following data on relative survival rates for commercial fishermen in Alaska:

> "Strategies are currently being developed to reduce commercial fishing fatalities in Alaska by correcting instability problems, such as overloading, that cause vessels to sink or capsize and by using PFDs and "man overboard" alarms to prevent workers from drowning when falling overboard. It has been previously demonstrated that when fishers who drowned or were presumed to have drowned were compared with those who survived incidents in which at least one other fisher drowned, 63% of those wearing PFDs survived but only 12% of those not wearing PFDs survived."

Second, Australian data reported by O'Connor (2004) (see also O'Connor and O'Connor, 2005) indicated that 68% of those boaters wearing a life jacket did not drown, compared to 50% among those who did not wear a life jacket. Obviously the relative proportions surviving might differ as a result of other risk factors, but both examples indicate that survival rates are higher with a life jacket.

[12] It is reasonable to believe that persons with moderate or good swimming ability would have a higher probability of survival in the event of involuntary immersion. No doubt, swimming ability is a valuable skill. This said, being able to swim is no guarantee that drowning can be avoided, particularly in cold water. The Groff and Ghadiali (2003) report contains the following text: "Interestingly, an examination of Canadian recreational boating fatalities in 1999 shows that only 14% of those who drowned were identified as non-swimmers or weak swimmers. However, the swimming ability of a large percentage of victims was not known, and when only those drowning victims whose swimming ability are factored in, a larger proportion of the drowning victims in Canada in 1999 (59%) were swimmers than non-swimmers (41%)…There is considerable evidence that even those who are good swimmers can experience great difficulty in cold water, so swimming ability in warm water is not necessarily a good indicator of survival in cold water. Clearly, increasing boaters' experience in the water, and level of swimming ability are not the only or necessarily best ways to reduce the incidence of recreational boating-related drowning."

Why is it necessary to *wear* a life jacket?

Some believe that it is sufficient to have a life jacket on board, rather than to wear a life jacket to increase safety. The basis for this belief is the assumption that the boater would have either sufficient time in the event of an emergency to locate and don a life jacket before entering the water or, alternatively, that this could be done once in the water. One cogent response to this belief was articulated by Jeff Johnson of the Alaska Office of Boating Safety as follows:

> "Putting a life jacket on during a boating accident is like putting a seatbelt on during a car accident."

Groff and Ghadiali, (2003) offered the following rationale for wearing, rather than carrying life jackets:

> "One problem with the theory that simply having a floatation device close at hand is sufficient, is the assumption that there will be time in an emergency to actually locate it and put it on….the majority of recreational boating drownings stem either from the vessel capsizing or the victim falling overboard. Clearly such drowning and near-drowning incidents typically occur with little or no warning, and consequently, there is little or no opportunity to don a floatation device, particularly if they are stowed in a cabin or enclosed space. One expert in cold-water drownings summarizes the situation as follows:
>
> > 'A drowning accident occurs very suddenly, often within very close reach of land or assistance. The whole tragic event from start to finish typically occurs in under six minutes because very few people taken by surprise can remain afloat for much longer without a life jacket; In nearly three-quarters of the accidents, the victims are dead within 15 minutes.'
>
> …Thus, although many boaters seem to feel that there is sufficient time to locate, put on, and fasten a personal floatation device of the appropriate size in an emergency situation, this is not typically true in most drowning incidents. And, in fact, this misperception is dangerous, as this may provide boaters with a false sense of security."

Groff and Ghadiali, (2003) also offered the following comments regarding the possibility of donning a life jacket while in the water:

> "Other boaters have the impression that it is unnecessary to wear a PFD at all times when on the water since they believe that they could

> locate and put on a PFD if they suddenly and unexpectedly found themselves in the water. However, this notion that a person who is not already wearing a floatation device when he or she goes into the water can locate and put one on in the water is also flawed for several reasons. For instance adverse wind and wave conditions and darkness would certainly impede a person's ability to locate and put on a floatation device while staying afloat and keeping their airway clear of the water…As well, in some drowning cases, it is apparent that a lone boater unexpectedly fell overboard and either there was no engine kill mechanism, or it was not activated, and therefore the boat either continued on without the operator or drove around in circles. Thus, it the boater was stowing floatation devices on board but not wearing one, there is no possibility of putting one on once in the water."

The outreach literature published by Transport Canada now includes the following:[13]

> "In order to work, proper lifesaving equipment must be worn at all times. Believing that you can locate, don and fasten a PFD in the water is dangerous for many reasons; adverse wind and wave conditions can make this extremely difficult, if not impossible; you could unexpectedly fall into water and the vessel (with the PFD aboard) could be unreachable; and, cold water can severely impede your ability to don and fasten a PFD in the water."

Summary

This chapter identifies additional risk factors for drowning, including the age and gender of the victims and role of alcohol. Data are presented on various accident types that indicate falls overboard, capsizing, and flooding/swamping are the three leading accident types associated with drowning. *Most of these accident types are difficult to predict in advance with any certainty, so the option of selectively donning a life jacket in anticipation of a period of higher risk is unlikely to be fully successful*. Moreover, contrary to what might be expected, most accidents that involve drowning occur in relatively benign environmental conditions. Wearing a life jacket is not guaranteed to ensure survival, but does offer a higher probability compared to not wearing one. Finally, there are strong reasons to wear, rather than merely carry a life jacket onboard.

[13] See e.g., https://www.tc.gc.ca/eng/marinesafety/debs-obs-equipment-lifejackets-information-1324.htm.

Chapter 3. Statistical evidence

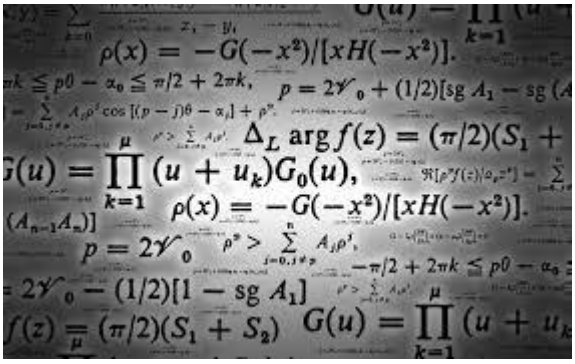
Introduction

This chapter provides a summary of the available studies that provide statistical evidence of the benefits of life jacket wear in the United States and other countries. Collectively these studies indicate that intuition is correct; these benefits are real and substantial. As noted in Chapter 2, wearing a life jacket does not confer immunity from drowning, but it does increase the chances of survival in a boating accident.

Studies in the United States

Aside from calculation of individual drowning probabilities with and without a life jacket (some of which were referred to in Chapter 2) there are three main studies of note.

-Cummings et al. (2010)



These investigators performed a matched cohort study analysis of Coast Guard data on recreational boaters during the period from 2000 to 2006. The main outcome measure was the estimated risk ratio (RR) for drowning death comparing boaters wearing a life jacket with boaters not wearing a life jacket. The matched cohort design compared the outcomes of persons from the same boat who were involved in incidents such as capsizing or sinking, which resulted in being in the water and at risk of drowning. This design has the advantage of comparing people at the same time of day, in the same water temperature, in the same water conditions, with the same distance to shore, and with the same proximity to help. These investigators considered approximately 4915 boater records from 1809 vessels but because of missing records and other problems, the analysis was restricted to 1597 boaters in 625 vessels with 878 drowning deaths. The adjusted RR was 0.51 (95% CI 0.35 to 0.74). Simply put, the authors estimated that wearing a life jacket reduced the risk of drowning by 49% (95% CI 26% to 65%). The design was appropriate, but the authors were cautious in their conclusions including possible selection bias, missing data, and a possible confounding bias. Although there were some deficiencies resulting from data issues, this analysis is basically sound.

Cummings et al. (2010) did not make any projection of lives saved if life jacket wear rates were to increase, but the relative risk ratios derived by these investigators makes such projections possible. For example, if it is assumed that about 20% of all boat occupants wear a life jacket in the base case (see the next chapter for actual U.S. data) and this wear rate could be increased to 70%--a gain of 50%, approximately half of those wearing life jackets would survive, reducing the fatality rate by 0.5 x 0.5 = 0.25 as a fraction.

-Maxim (2010)

Maxim (2010) reported an unpublished, but peer-reviewed study on the potential lives saved if life jacket wear rates were to increase. The approach differed from that used by Cummins et al. (2010). It used Coast Guard data on drowning fatalities, segmented by boat type, and measured life jacket wear rates for each type of boat derived from a study conducted by JSI (see Mangione et al., 2012) over several years (2004 – 2008). The basic model used by Maxim (2010) segmented the boater population (by vessel type) into those who wore a life jacket (with probability u_i where i is the boat type) and those who did not (with probability $1 - u_i$). In turn the model employed two probabilities; γ (gamma) the fraction of boaters who wear life jackets, encounter a situation where drowning is possible, and do not drown, and κ (kappa) the fraction of boaters who do not wear a life jacket, encounter a potentially fatal mishap and yet failed to drown. The logical possibilities are diagrammed in Fig.9. Maxim (2010) used Coast Guard data for the year 2008 and later the period 2004 through 2009 on the number of drownings among those in each boat type reportedly wearing or not wearing a life jacket to estimate the unknown parameters and calculated the potential lives saved if the life jacket wear rate were increased from the base case (actual wear rates, which differed among boat types) to 70%. For open motorboats, canoes, kayaks, and rowboats the incremental lives saved if wear rates could be increased to 70% were estimated to be approximately 125 annually, a 34% reduction. The benefits would be higher if wear rates could be raised even further. Lives saved based on this analysis are broadly similar to those of Cummins et al (2010).

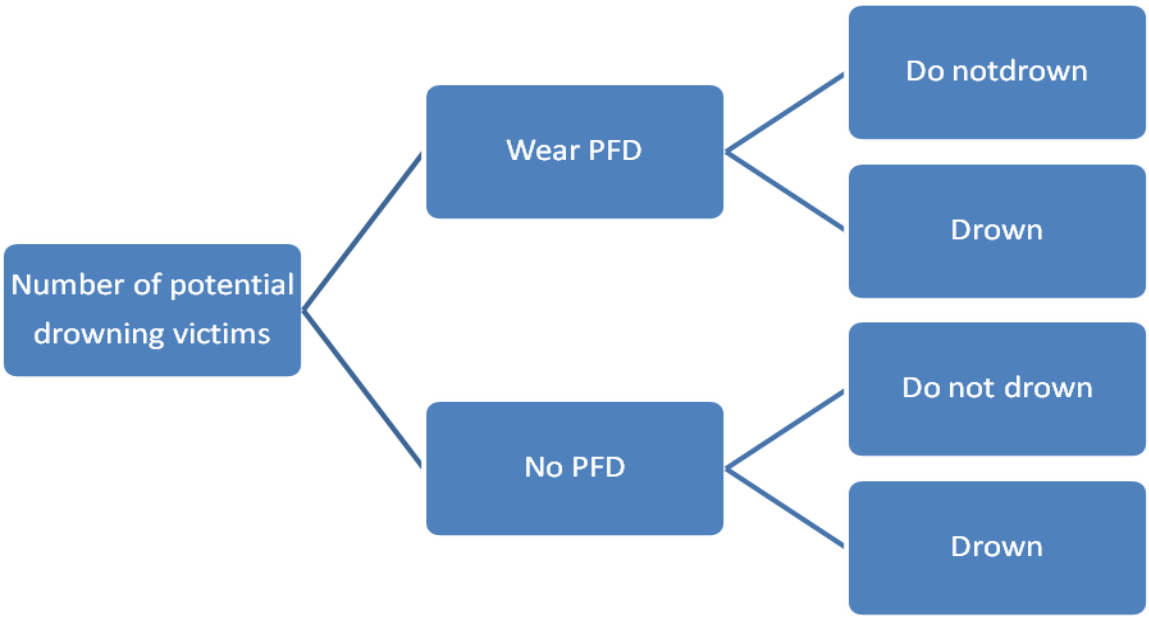


Fig. 9. *Diagram illustrating the logical possibilities associated with wearing or not lifejackets and drowning or not drowning.*

-Gungor and Viauroux (2014)

These investigators reported results (as yet unpublished, but available as submitted to a journal) of an alternative analysis of United States accident data. They used the US Coast Guard's

Boating Accident Report Database (BARD) to fit a Poisson regression of number of fatalities on many different factors interacting at the time of the accident. These investigators found that life jacket wear is one of the most influential determinants of the number of fatalities on a vessel, together with the number of vessels involved, the type and engine of the vessel. They estimated that the expected number of deceased per vessel would decrease by about 80% if the operator wears his/her life jacket. So if as many as an additional 50% of boaters were to wear life jackets the fatality rate would be reduced by 0.8 x 0.5 = 0.40. This potential benefit is somewhat higher than reported/estimated by either Maxim (2010) or Cummins et al. (2010).

-Stempski et al., 2014

These investigators performed a case–control study using the Washington Boat Accident Investigation Report Database for 2003–2010. Cases were fatally injured boat occupants, and controls were non-fatally injured boat occupants involved in a boating incident. The authors evaluated the association between victim, boat and incident factors, and risk of death using Poisson regression to estimate RRs and 95% confidence intervals. The key results reported by the investigators were:

> "Of 968 injured boaters, 26% died. Fatalities were 2.6 times more likely to not be wearing a personal flotation device (PFD) and 2.2 times more likely to not have any safety features on their boat compared with those who survived. Boating fatalities were more likely to be in a non-motorized boat, to have alcohol involved in the incident, to be in an incident that involved capsizing, sinking, flooding or swamping, and to involve a person leaving the boat voluntarily, being ejected or falling than those who survived."

This study is consistent with the results of others with respect to the benefits of life jacket wear.

Although these three analyses differed in methodology and results in detail, all point to material (and statistically significant) benefits if life jacket use could be increased.

-USACE

The United States Army Corps of Engineers (USACE, 2012) conducted a pilot program in three Districts; Pittsburgh, Sacramento, and Vicksburg. This pilot program (discussed at greater length in the next chapter) mandated life jacket wear on selected test lakes while leaving present policies in place for "control" lakes. This program included measurements of life jacket wear rates for both test and control lakes. Fatality data were also collected. The life jacket wear rate study demonstrated significant increases in wear rates for the test lakes (see Chapter 4). However, the numbers of drownings on both test and control lakes were too small to draw conclusions regarding possible lives saved.

-Opportunities for future study

NBSAC has recommended to the United States Coast Guard that it consider mandatory life jacket wear regulations—at least for certain types or lengths of boats. Whether or not such regulations are actually proposed or implemented remains to be seen. However, there are some opportunities for an empirical test of the lifesaving benefits of such a policy:

- Many states have required that children wear life jackets. The age limits for these regulations vary by state, but it would be interesting to see if there are systematic differences in the number of youth who drowned before and after such regulations were put in place.
- Winter boating is seen as inherently more hazardous than boating in the summer and several states (e.g., Connecticut, Maine, Massachusetts, New York, and Pennsylvania) have required that life jackets be worn—at least for some boaters during specified dates. The sample sizes are likely to be small, because there is less recreational boating activity during winter months and fewer fatalities, but this presents an opportunity for study.

Australian studies

Australian studies of life jacket wear are two types—analyses of the survival/non-survival of boaters immersed in the water and "before and after" studies after mandatory life jacket wear regulations were imposed in two states. Collectively the Australian studies provide compelling statistical evidence of the benefits of life jacket wear.

-O'Connor and O'Connor (2005)

These investigators performed an assessment of the effectiveness of life jackets by comparing life jacket use among those killed and those not killed in the same incidents for Australia over the period from 1992 to 1998. For this comparison, the authors used the following criteria for selecting cases:

- Two or more people remained in the water until retrieved, whether dead or alive;
- The deceased was not killed by an impact or trapped under water.
- Incidents were also excluded where the body of the deceased was not found and the life jacket status was unknown.
- If the life jacket was not fitted properly and came off, this case was treated the same as life jacket not worn.

The authors calculated that the probability of surviving was 34/50 = 0.68 (95% confidence interval including continuity correction: 0.5317 - 0.8007)[14] if the person was wearing a life jacket compared to 128/257 = 0.50 (95% confidence interval including continuity correction: 0.4355 - 0.5607) if not. Notwithstanding the relatively small sample sizes, the difference in survival probabilities is highly significant ($p < 0.0001$ based on Fisher's exact test[15]).

-Bugeja et al., 2014

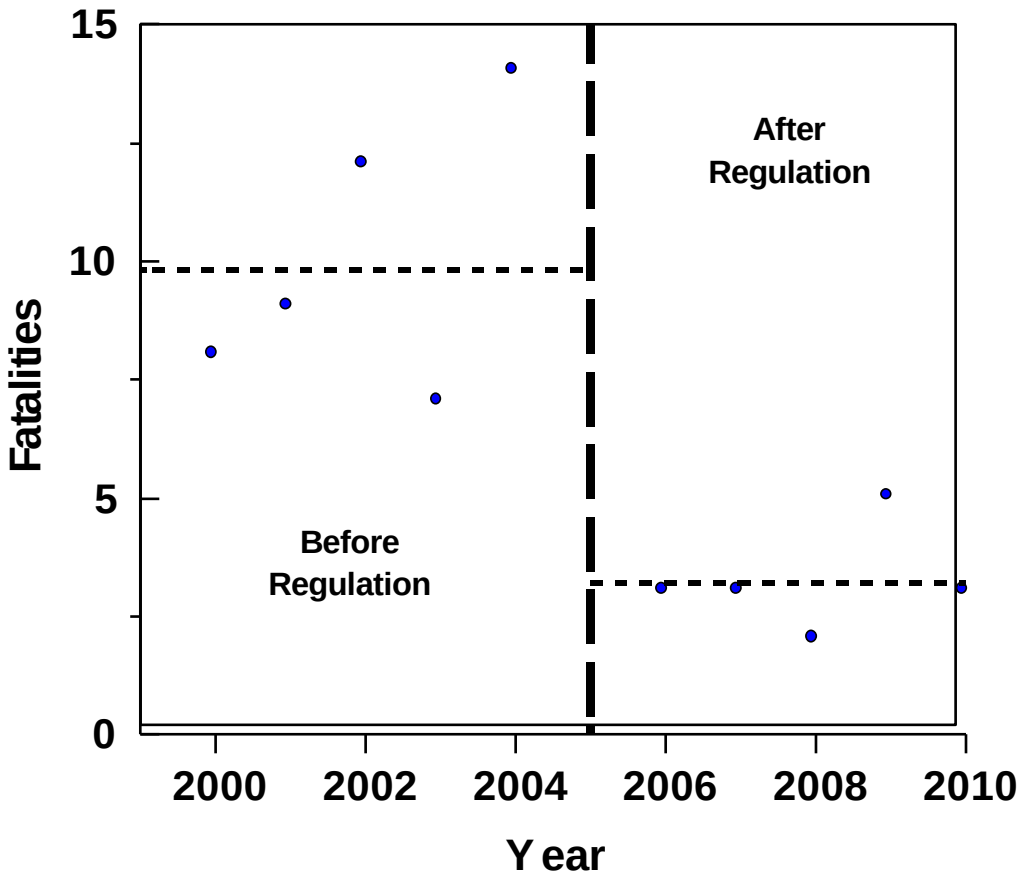
These investigators examined recreational boating fatalities in Victoria (Australia's second largest state) over the period from 1998/1999 through 2009/2010. These two time intervals are of particular interest because Victoria mandated wear of life jackets effective after 1 December 2005, thus enabling a "before and after" comparison of fatalities. The authors described the regulations as follows:

[14] These confident intervals were not calculated by the authors, but are included here. For details of this computation see http://vassarstats.net/prop1.html?.
[15] Computed using http://vassarstats.net/tab2x2.html.

"Occupants of 'small' recreational vessels were required to wear a PFD when in an open area of the vessel when the vessel was under way that is, not at anchor, made fast to the shore, aground or drifting. 'Small' vessels include power driven vessels ≤ 4.8 m *(15.7 ft)* in hull length, off-the-beach sailing yachts, personal watercraft, canoes, kayaks, rowing boats, pedal and fun boats, kite boards and sailboards.10 Occupants of 'larger' recreational vessels were required to wear a PFD at defined times of 'heightened risk' (e.g., at night, when crossing a bar and by sole operators) when the vessel was under way and the occupant was in an open area of the vessel.10 'Larger' vessels were power driven vessels >4.8–12 m *(15.7 to 39.4 ft)* in hull length and yachts, including monohull, trailerable and multihull yachts. The type of approved PFD to be worn—Type 1 (life jacket), Type 2 (buoyancy vest in high visibility colours) or Type 3 (buoyancy vest in other colours)—was specified for each vessel type and waterway classification (inland, enclosed and coastal). The Victorian water police were responsible for enforcement."

Figure 10 shows a time series of fatalities from the 1998/1999 year (plotted as 1999 in this figure) until 2010. The dashed line in the center of the plot is the effective date of the regulation and the two dashed horizontal lines are the mean annual fatalities "before" and "after."

Figure 10. *Time series of recreational vessel deaths in the State of Victoria 1999 to 2010.*

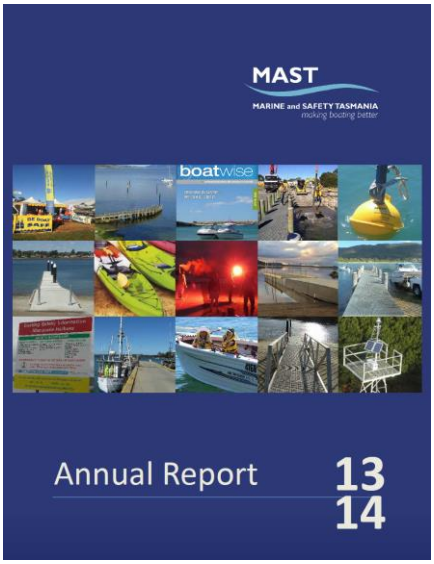


The average annual number of fatalities before the regulation went into effect was 9.83, compared to an average of 3.2 fatalities post regulation, a 67 % decrease. The authors used the Mann-Whitney non-parametric test. Before/after comparisons were statistically significant (p = 0.01). The authors also tested various subdivisions of these data showing significant differences in most cases. The authors noted that there was supporting evidence (see Cassell and Newstead, 2014) that the observed decrease in fatality rates was related to an increase in life jacket wear:

> "Strong supporting evidence for an association between these results and increased PFD wearing is provided by the before and after observation study of PFD use by recreational boaters in Victoria. The observation study, focused only on use by occupants of small (≤ 4.8 m *(15.7 ft)* in hull length) motorised vessels, found that their wearing rate increased from 22% preregulation (January to March 2005) through 54% in the transition year (January to March 2006) to 63% postregulation (January to March 2007). Regression analysis indicated there was a highly significant eightfold increase in the odds of occupants of small motorised vessels wearing PFDs during January to March 2007 compared with January to March 2005 (OR 8.17, p<0001, CI 6.6 to 10.1). PFD wearing data on occupants of large vessels at defined times of heightened risk were not collected."

Notwithstanding some acknowledged limitations, this study provides strong evidence for the benefits of wearing life jackets.

-Tasmania



The state of Tasmania also offers an interesting opportunity for a "before" and "after" comparison of recreational boat drownings as it has some of the most stringent boating regulations. Despite these stringent regulations, Tasmania has an ownership ratio of one registered boat per 17.4 residents according to data presented in the Marine and Safety Tasmania (MAST) *Annual Report* for 2013. A comparison of other states' registration and population has confirmed Tasmania has the highest ratio of registered boat ownership per person in Australia.[16]

Mandatory wearing of life jackets was required on boats < 6 meters *(19.7 ft)* in length after 1 January 2001 when under power. Regulations also required the carriage of EPIRBs for these craft in coastal waters.

A "before" and "after" study was not published in a peer-reviewed journal, but Mr. Peter Hopkins, recreational boating manager for MAST, kindly provided us data on the number of boating fatalities and the number of registered boats in Tasmania by year from 1987 through

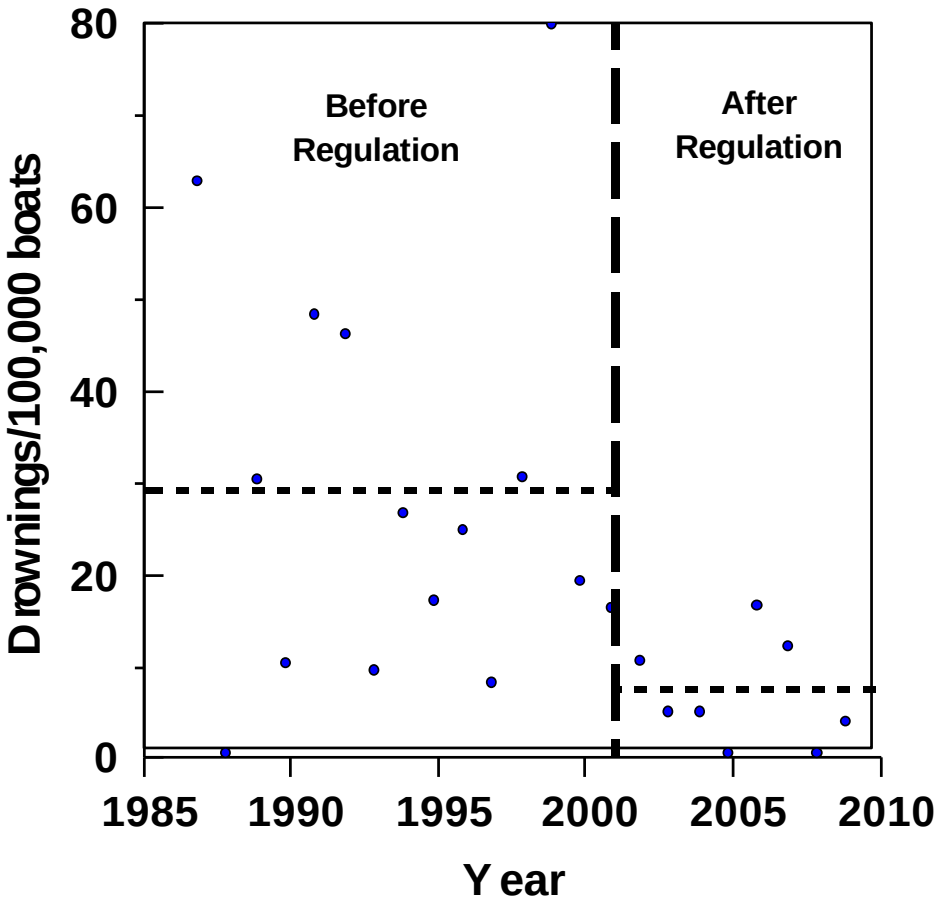
[16] See http://www.mast.tas.gov.au/wp-content/uploads/2014/05/MAST-Annual-Report-2013-2014-.pdf.

2009. These data span the years before and after the date when wearing life jackets was mandated and are analyzed below.

As shown in Table A-9 (Appendix) the Tasmanian data averaged 3.5 recreational boating fatalities annually prior to the law, compared to 1.67 after life jacket wear became mandatory, a 52% decrease. Although this decrease is material, the fatalities data were highly variable and the difference in the number of annual fatalities (pre- versus post-regulation) failed to reach statistical significance ("t" test p = 0.063 assuming separate variances or 0.104 using a pooled variance[17]).

However, during this same time period boat registrations in Tasmania increased substantially—in fact, proportionally more so than other states in Australia. Thus, a more appropriate comparison is to consider boating fatality rates normalized by the number of registered vessels. Figure 11 shows a time series of these rates (annual fatalities per 100,000 boats) over the relevant time period. The prelaw average fatality rate was 29.2/100,000 compared to 7.44/100,000 (a 75% decrease) after the law went into effect (p = 0.004 assuming separate variances or 0.011 assuming a pooled variance). Thus, the Tasmanian experience also shows both the benefits of wearing life jackets and the effectiveness of mandatory wear requirements.

Figure 11. *Annual fatality rate per 100,000 boats in Tasmania pre and post law.*



[17] Similar p values result if the Mann-Whitney test is used.

-New South Wales, Australia

The State of New South Wales (NSW) did not publish a specific study on the benefits of life jacket wear, but has mandated life jacket wear under certain conditions and notes:[18]

> "Since 2002-03, nearly 200 people have been killed in boating accidents in NSW, with more than two-thirds of those killed being presumed to have drowned. However, more than 9 out of 10 people who drowned when boating weren't wearing a lifejacket.
>
> Many factors affect the development and unfolding of vessel incidents. However, life jacket wear is clearly an over-arching factor in determining the outcome of such incidents, especially when persons end up in the water.
>
> A study done by the former National Marine Safety Committee, looking at boating incidents where one or more people were killed, found that wearing a lifejacket more than doubled the chances of surviving such an incident. *The Transport for NSW publication Boating Incidents in NSW – statistical report for the 10-year period ending 30 June 2012 also provides compelling evidence of the value of lifejackets, including evidence of a significant decline in bar crossing fatalities since the implementation of compulsory lifejacket wear requirements for all vessels crossing ocean bars.*
>
> On 1 November 2010, lifejacket laws were amended to require mandatory lifejacket wearing in a number of high risk situations, especially by people in small vessels and particularly children under 12 years. These changes came about after a very extensive consultation with the boating community which saw more than 86 per cent support for the proposed changes.
>
> Remember:
> 9 out of 10 people who drowned when boating in NSW were not wearing a lifejacket,
> Lifejackets must be worn in vessels under 4.8m *(15.7 ft)* at night, offshore, when alone, and by children under 12 years of age." [Emphasis added.]

Other states in Australia have requirements to wear life jackets for certain vessels or under certain conditions. The rules of Maritime Safety Queensland, for example, require life jacket wear when crossing a designated coastal bar in an open boat that is less than 4.8m *(15.7 ft)* in length and for children under 12 years old (from 12 months old and up to, but not including, 12

[18] See http://www.lifejacketwearit.com.au/why-do-i-need-wear-it/.

years old) in an open boat that is less than 4.8m *(15.7 ft)* in length and underway.[19] And there have been calls for mandatory life jacket wear policies in South Australia.[20]

New Zealand

There are no published studies on the effectiveness of life jackets although the claim is made that wearing a life jacket can decrease the probability of drowning by 75% (Maritime Safety Authority of New Zealand, 1999). Certain regional councils have established mandatory life jacket wear policies[21] and the country is reportedly considering some form of national regulation.

Canada

Whether or not to establish mandatory life jacket wear requirements in Canada has been (and presumably continues to be) considered in Canada. Groff and Ghadiali (2003) prepared a very detailed report on the topic. This said there are no published statistical analyses using Canadian data that demonstrate the effectiveness of life jacket wear.

United Kingdom

Turner et al. (2009) provide a comprehensive report on various aspects of life jacket wear. They summarize a study by the Maritime and Coast Guard Agency (MCA) and the Royal National Lifeboat Institution (RNLI) on the effectiveness of life jackets for the years 2007 and 2008. A panel of experts reviewed the data and judged whether wearing a life jacket would have avoided a fatality. Their conclusions reported by Turner et al. (2009) were:

> "29 casualties of the 49 reviewed cases in 2007 were judged as probably or possibly avoidable if the casualty had been wearing a life jacket. Of these, angling (eight incidents, 16.3%) and motorboating (seven incidents, 14.3%) appear to have the highest avoidable rates of fatality had lifejackets been worn. It was judged appropriate for people to wear a lifejacket in 42 of these 49 cases. 26 cases of the 48 cases reviewed in 2008 were judged as probably or possibly avoidable if the casualty had been wearing a lifejacket."

Although the results are interesting and arguably plausible, the conclusions rely on the subjective (though undoubtedly informed) views of experts and thus fall short of the statistical evidence available from other countries.

[19] See http://www.msq.qld.gov.au/safety/life-jackets.aspx.
[20] See http://www.news.com.au/national/breaking-news/sa-call-for-mandatory-life-jackets/story-e6frfku9-1226722955485.
[21] See e.g., http://www.waikatoregion.govt.nz/Services/Regional-services/Navigation-safety/Rules-and-Safety/Lifejackets/.

Ireland

Ireland established regulations in 2004 that life jackets must be worn in the following situations:[22]

- By anyone on board an open craft that is less than 7 meters *(22.9 ft)* in length;
- By anyone on deck on a craft that is under 7 meters *(22.9 ft)* length;
- By anyone under the age of 16 on board an open craft or on deck of any other type of craft;
- By anyone being towed in another craft or on any other device (skis, donuts etc.);
- By anyone on a personal watercraft (jet ski).

This law has certain exceptions including when:

- Tied up alongside or made fast to an anchor, marina, pier or mooring;
- Immediately prior to, during and after swimming from a craft that is not moving through the water;
- Putting on, wearing or taking off diving equipment on a craft that is not moving through the water.

Presumably this policy was based on findings that recreational craft have the largest number of fatalities, 66 out of a total of 134 maritime fatalities over the period from 2002 through 2012.[23] However, we could find no specific statistical study on which the mandatory wear regulations were based. Fatality data are available, so it might be possible to perform an analysis similar to that for Victoria or Tasmania.

Summary

This chapter summarizes the available studies on the potentially lifesaving benefits of wearing life jackets. Each study has strengths and limitations, but collectively these studies show that there is solid statistical evidence that wearing a life jacket will save lives. As noted by NTSB (2013):

> "Life jackets are effective. Boating accident data shows that when mandatory life jacket requirements are adopted, drowning fatalities go down."

[22] See e.g., http://www.howthcoastguard.com/lifejacket-compliance.html and http://www.waterwaysireland.org/SiteAssets/documents/Code%20of%20Practice%20for%20the%20Safe%20Operation%20of%20Recreational%20Craft.pdf.

[23] See http://www.dttas.ie/sites/default/files/publications/maritime/english/maritime-safety-strategy/maritime-safety-strategy-english-draft.pdf.

Chapter 4. Studies on life jacket wear rates

Introduction

The overall objective of a recreational boating safety program is to reduce casualties—particularly fatal casualties.[24] And, because drowning accounts for such a large proportion of fatalities (see Chapter 1), it is appropriate to focus on ways to reduce the likelihood of drowning. The results shown in Chapter 3 indicate that increased life jacket wear (not merely carriage) is the key to reduce drowning casualties.[25] Therefore, one important measure of the success of a boating safety program is the proportion of recreational boaters who wear life jackets. This is why it is important to find ways (either through effective outreach programs or the imposition of life jacket wear requirements) to increase wear rates. The oft told adage "what gets measured, gets done" underscores the importance of measuring and reporting wear rates. This chapter summarizes various studies on life jacket wear rates conducted in the United States and other countries, including Australia, Canada, France, and the United Kingdom.

Wear rate studies include four major types:

- Longitudinal studies to measure time trends—often conducted on a national basis,
- Cross sectional studies to measure differences in life jacket wear rate as a function of other variables, such as boat type, boat length, age, gender, or other relevant demographic variables,
- Campaign studies to measure the influence/effectiveness of various initiatives (campaigns) to increase wear rates. "Before and after" studies (similar to those discussed in Chapter 3 used to evaluate the success of regulatory initiatives) also fall into this category.
- Research studies seek to identify and examine the determinants of life jacket wear.

Some studies, such as the JSI studies (see below) in the United States include both longitudinal and cross-sectional components. Other studies evaluate campaigns, but may also include a research component.

Wear rate studies can be further subdivided into (i) those that actually measure wear rates based on observations and (ii) those that are based on surveys—asking respondents if or under what circumstances they wear life jackets. Surveys have their uses, but measure what respondents claim to do rather than their actual behavior. Wear rate studies based on observations measure behavior and thus are particularly relevant.

Studies to measure awareness of outreach campaigns or attitudes towards life jacket wear are also potentially relevant and are discussed later in this report.

[24] Non-fatal casualties are also important. And for some casualties, such as near-drowning, may impose very high social costs. However, fatalities are measured more accurately, so it is appropriate to focus on fatal casualties.

[25] Indeed, with the possible exception of measures to reduce alcohol impairment, successful drowning prevention measures are the most important determinant of success in increasing boating safety.

United States

All of the above types of studies have been conducted in the United States.

-Longitudinal (JSI studies)

Through annual grants from the Sport Fish Restoration and Boating Trust Fund administered by the USCG a series of annual studies on life jacket wear rates has been conducted on a nationwide basis since 1999. Results of these studies are reported to USCG annually[26] and results for the period 1999-2010 were summarized in a peer-reviewed journal article (Mangione et al., 2012). The JSI study (still ongoing as of this writing) uses a stratified random sample of sites in 30 states (typically four sites in each state). Trained observers are stationed at fixed shore-side observation points[27] in each of the states and observations are made using image-stabilized binoculars on each recreational boat observed during a scheduled period on a weekend in the middle of the summer (4 July through Labor Day). Data collected include whether or not each person seen on each vessel was wearing a life jacket, the type of life jacket, type and length of boat, number, gender, and apparent age of the boat occupants and some additional data (e.g., weather conditions). This study was carefully designed and is among the most noteworthy of the life jacket studies.

Mangione et al. (2012) analyzed data separately for youth and adults. Over the period from 1999 to 2010 they reported the following results for youth (aged 0 – 17 years):

> "We found significant increasing trends on most types of boats – all powerboats combined ($p < 0.0001$) as well as for each individual boat type. For speedboats/runabouts–on which almost two-thirds of youth in this study were observed–there was a significant increasing trend ($p < 0.0001$). For skiff/utility boats, the second most common type of boat used by these youths, the trend was also significantly increasing ($p < 0.0001$).For all paddleboats combined, we observed no significant trend; however, paddled inflatables showed a significant decreasing trend ($p < 0.0066$). For canoes and kayaks, there were no significant trends, but wear rates were high for youth on these boats (ranging from 59.9 per cent to 81.3 per cent on canoes and from 83.6 per cent to 91.9 per cent on kayaks). For all types of sailboats combined, there was a significant increasing trend ($p < 0.0001$)." [Z scores omitted in above quotation.]

The authors suggested that the reason for increasing trends for youth (at least among the younger members of this age group) was accounted for by regulations mandating life jacket wear.

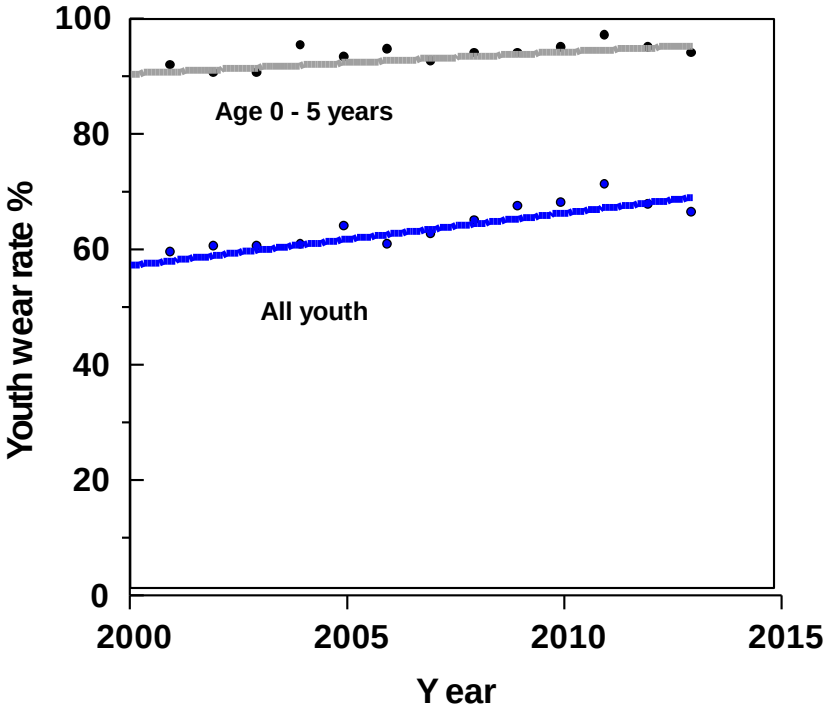
Figure 12 shows the time series of life jacket wear rates for all youth and for those aged 0 – 5 years (excluding PWCs, for which wear rates are much higher). There is a statistically significant increasing trend in the data for all youth ($R^2 = 0.82$ for a linear model)—evidence of some progress to be sure. However, the improvement in wear rates is certainly not dramatic. The measured wear rate among youth only increased from 55.6% in the year 2000 to 66.0% in

[26] Past reports are available electronically and are posted on the Boating Safety resource Center web site at http://www.uscgboating.org/statistics/pfd.aspx.

[27] A parallel study replicated the results when the observers were stationed on boats rather than fixed locations ashore with equivalent results.

2013. For those youth aged 0 – 5 years wear rates are consistently high, exceeding 90% in all but one year.

Figure 12. *Measured life jacket wear rates among all youth (aged 0 -17 years) and for the youngest members of this group (aged 0 – 5 years) , excluding PWCs, from 2000 to 2013 and fitted linear trends. (Data taken from the 2013 JSI report.)*



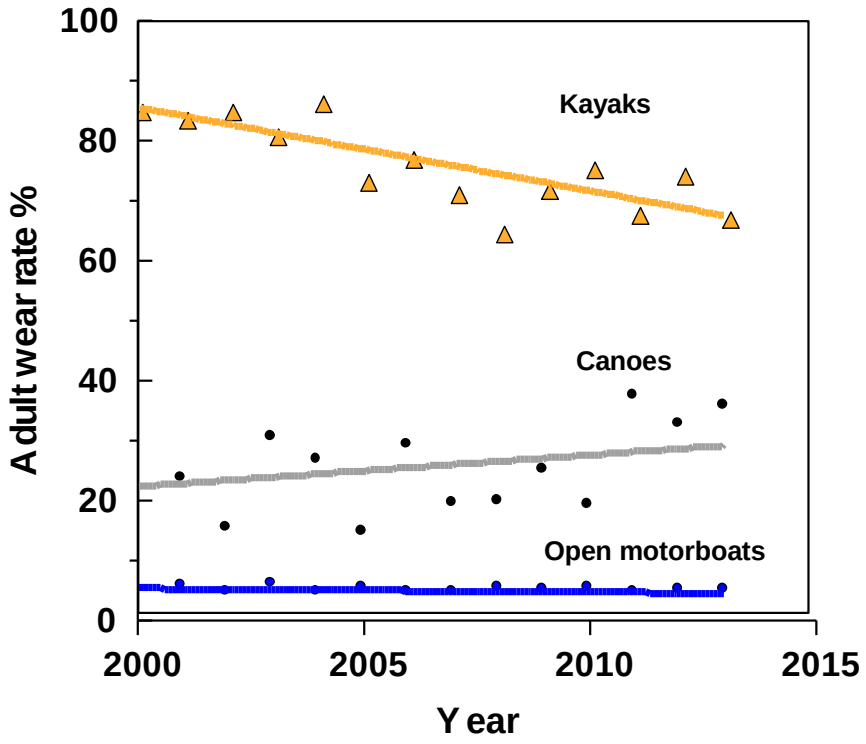
Mangione et al. (2012) reported results of wear rate measurements for adults (aged 18+ years) as:

> "For all powerboats combined (excluding PWCs), we observed a significant decreasing trend among adults over this 12-year period ($p < 0.0001$). Interestingly, PWCs were the only power boat type with a significant increasing trend ($p < 0.0001$). Runabouts/speedboats ($p < 0.0001$) and pontoon boats ($p < 0.0001$) showed significant decreasing trends. There were non-significant decreasing trends for skiffs and powered inflatables. For adults on all paddled boats, there was a significant decreasing trend ($p < 0.0001$). Paddled inflatables, canoes, and kayaks all showed significant declining trends. In contrast, trends for adults on sailboats were significantly positive. For all sailboats combined, there was a significant increasing trend ($p < 0.0001$). Day sailors (small sailboats without sleeping accommodations) showed a significant increasing trend ($p < 0.0001$). Rates were lowest in 1999 at 30.7 per cent and have steadily increased, peaking in 2009 at 61.8 per cent. Bigger cabin sailboats (those with sleeping

quarters) also showed significant positive trends ($p < 0.0001$)." [Z scores omitted in quotation.]

Thus, the trends for adults can technically be described as 'mixed' but, from the perspective of saving lives, discouraging on balance. Perhaps the most discouraging results are for open motorboats. Recall from data presented in Chapter 1 that open motorboats have accounted for 50% of drowning deaths and there has been no improvement in wear rates for this group. Although wear rates for both canoes and kayaks are significantly higher than for open motorboats, there is not much trend in the canoe data and the trend for kayaks is decreasing. Figure 13 shows the wear rate trends for open motorboats, canoes, and kayaks.

Figure 13. *Measured life jacket wear rates among all adults (aged 18+ years) for occupants of canoes, kayaks, and open motorboats, from 2000 to 2013 and fitted linear trends. (Data taken from the 2013 JSI report.)*



Because the craft depicted in Fig. 13 account for such a high proportion of drowning deaths these results are disappointing—particularly in view of the substantial resources devoted to outreach efforts aimed to increase wear rates. (Policy perspectives are discussed later in this document.)

. The National Water Safety Congress provided useful data validity checks on JSI measurements (see http://www.watersafetycongress.org/mats/pastjournals/2010/Journal_Feb2010.pdf and http://c.ymcdn.com/sites/www.americancanoe.org/resource/resmgr/spp-documents/usace_pfd_study_&_test.pdf) on four lakes included in the USACE pilot program as

part of a grant effort. These life jacket wear rate measurements were in agreement with JSI estimates. Independent checks by Coast Guard Auxiliary personnel taking observations at the same sites have resulted in comparable wear rates.

The JSI study is both a longitudinal and cross-sectional study. There is no study of comparable scope and power on wear rates conducted in any country. Although the study has certain limitations it can fairly be characterized as a 'gold standard.'

-Quan et al., (1998)

These investigators conducted an observational study to measure life jacket wear rates in the states of Oregon and Washington in 1995 (a successor effort to one conducted earlier by Treser et al., 1997). This was a small cross-sectional study; variables of interest were the effects of age, gender, boat type on life jacket wear rates. Results were believed to be representative of the boating activities conducted in the region. The results and conclusions reported by the authors were:

> "**Results:** Among 4181 boaters, 25% wore a PFD. Use was highest in <5 year olds (91%) and lowest in those over 14 years (13%). Those in kayaks were most likely (78%) and those in motor boats (19%) were least likely to wear a PFD. Females were more likely to wear a PFD than males (relative prevalence 1.5, 95% confidence interval 1.3 to 1.6). When a child less than 15 years was in a boat with an adult, PFD use was 65% if no adult wore a PFD and 95% if at least one accompanying adult wore a PFD (p=0.001).
> **Conclusions:** Generally, PFD use by boaters was low in the Northwestern US. Efforts to increase PFD use should target adolescents, adults and specific boating populations, especially those in motor boats."

These results are broadly consistent with those reported in the later JSI studies. The finding that life jacket use by children was significantly higher if the adult occupant of the boat also wore a life jacket is interesting, though not surprising. The finding that life jacket use is higher among females than males has been observed in several studies.

-Bennett et al., (1999)

These investigators conducted a 'campaign study' to evaluate the effectiveness of a three-year drowning prevention. The air of the campaign was to increase the use of life vests among children 1–14 years old in King County, Washington. The study was conducted to determine campaign awareness, change in ownership and use of life vests by children, and predictors of life vest use. The study used four telephone surveys conducted with parents before, during, and after the campaign. The results and conclusions reported by the authors included:

> "**Results:** The campaign was recalled by 50% of families surveyed. From before to after the campaign, reported life vest use by children on docks, beaches, or at pools increased from 20% to 29% ($p<0.01$) and life vest ownership for children increased from 69% to 75% ($p=0.06$). Among parents aware of the campaign, reported child life vest use increased from 20% to 34% ($p<0.001$) and ownership increased from 69% to 80% ($p<0.01$). Among families unaware of the campaign,

neither life vest use nor ownership changed significantly. Children were more often reported to wear life vests if a parent knew of the campaign, was confident fitting the vest, was younger than 40 years, felt the child could not swim well, and owned a life vest for the child.
Conclusions: A community-wide drowning prevention campaign resulted in a significant, although modest, increase in reported life vest use and ownership among children."

Although the results are interesting (particularly in terms of the outreach material employed), this study has limitations, including a limited follow-up period and, perhaps most important, relying on telephone surveys to attempt to measure behavioral change.

-USACE (2012)

As noted earlier in this report, USACE conducted a pilot program to test the effectiveness of mandating life jacket wear on some of the lakes they manage. USACE identified 'control' and 'test' (intervention) lakes and implemented the mandatory wear policy on the test lakes. The initiative was well publicized and included 'life jacket loaner' stations to ease the burden of compliance. The collection and analysis of the wear rate data were conducted by JSI (reported in Appendix I of USACE, 2012) using the same observation protocol as employed on the national study. Results of the campaign analysis differed among the lakes, but overall the pilot program was judged a success. For example, here is an extract from the JSI summary for the lakes in the Vicksburg District (measurements reported for years 2008, 2009, 2010, and 2011):

"Life jacket wear rates in the Mississippi intervention lakes have shown substantial increases comparing pre-regulation data to post-regulation data available to date, whereas the control lakes essentially have stayed level. Unless otherwise indicated, all numbers exclude non-regulated boats, PWCs, and towed watersports participants.

a. Adults increased from 13.8% to 75.6% to 69.8% and then to 69.9%.
b. Both adult males and adult females showed similar substantial increases.
c. Teenagers increased from 47.8% to 88.2% to 87.0% and then to 91.3%.
d. Children under the age of 13 showed small increases from already high levels (94.3% to96.4% to 97.8 and then to 95.2%).
e. All four intervention lakes showed substantial increases…
f. Substantial increases were seen in all three major types of boats that are used on the lakes--skiffs, yearly averages from 27.0% to 83.7% to 79.2% and then to 81.9%; speedboat/runabouts, yearly averages from 4.3% to 71.7% to 66.3% and then to 68.4%; pontoons, 5.1% to 68.4% to 60.6% and then to 59.2%.
g. Substantial yearly increases were seen for power boats of different sizes--under 16 feet, 21.7% to 72.2% to 62.7% and then to 63.3%; 16 to 21 feet, 14.6% to 79.0% to 75.9% and then to 75.6%; and 21 to 26 feet 6.5% to 72.8% to 62.7% and then to 64.1%.
h. Boaters who were fishing or intending to fish showed substantial yearly increases from 27.6% to 84.4% to 78.6% and then to 80.2%.

> i. Boaters participating in other activities (predominately pleasure boating) showed substantial yearly increases from 8.3% to 70.7% to 65.5% and then to 66.4%."

Although the number of fatalities on any given lake in a year is small, the results for the test lakes were encouraging--fatalities were reduced by 75% (from four in the baseline year to only one in each of the test years).

Results for the California pilot program were less dramatic (in part because of some public opposition to mandating life jacket wear), but still successful. For example, adult wear rates on the test lake increased from 8.4% to 40.2%.

-Quistberg et al. (2014 a)

These investigators conducted a cross-sectional in-person survey of boaters at nine public boat ramps in Washington State. The intent of this study was on finding the determinants of 'intent to wear' life jackets rather than the actual measurement of wear rates. For this reason the study is covered in Chapter 5.

-Chung et el., (2014)

Chung et al (2014) reported on the results of an observational study of life jacket use among Washington State boaters conducted in 2010. The authors summarized their results and conclusions as follows:

> "**Results:** Among 5157 boaters, 30.7% wore life jackets. Life jacket use was highest among groups required by state law: personal watercraft users (96.8%), people being towed (e.g., water-skiers) (95.3%) and children 0–12 years old (81.7%). Children and youth were more likely to use a life jacket if any adult in the boat wore a life jacket: 100% versus 87.2% for 0–5 years, 92.8% versus 76.7% for 6–12 years and 81.4% versus 36.1% for 13–17 years. Adult role modeling was particularly beneficial for adolescents aged 13–17 years, who were not covered by a life jacket law. *In multivariable analysis, the presence of at least one adult wearing a life jacket was associated with a 20-fold increased likelihood that adolescents were also wearing a life jacket.*
> **Conclusions:** Highest life jacket use was strongly associated with laws requiring use and with adult role modeling. Legislation requiring life jackets for ages 13–17 years and social marketing encouraging adult life jacket wear in the company of children and youth are promising strategies to increase life jacket use in Washington State." [Emphasis added.]

Results of this study are consistent with the findings of the national study—life jacket use is relatively low except in situations (e.g., young boaters, boaters on PWCs, boaters being towed, etc.) where life jacket use is mandated. The finding that life jacket use among younger occupants is higher if one or more adults chose to wear a life jacket has been reported in other studies.

Australia

Two relevant life jacket wear rate studies have been conducted in Australia.

-National Marine Safety Committee (2007)

The National Marine Safety Committee completed a benchmark survey of PFD wear in four States: Queensland, New South Wales, South Australia and Western Australia. Their key findings are summarized in the following excerpts (shown as the bullet points) from the summary of this report:

- The highest overall level of PFD wearing occurred in South Australia (SA) where 22% of boaters wore PFDs. This was followed by Queensland (QLD) with 16%; New South Wales (NSW) with 9% and Western Australia (WA) which achieved a baseline rate of 6%. In comparison, the overall wear rate in Victoria at baseline in 2005 was 17%.
- The wearing of PFDs in small vessels (i.e., those less than 4.8 meters *(15.7 ft)*) was slightly higher in all four States. The rate in SA was 28% followed by QLD (20%), WA (9%) and NSW (8%). The baseline rate in Victoria was 22%.
- In all four States the female PFD wear rate was consistently higher than the male rate. Overall the rate was 3-6% higher, with the rate for small vessels being 4-9% higher and for larger vessels the rate was 1-5% higher. Similarly, the female wear rates were higher than the male rates in Victoria but the gender difference in PFD wear was much larger than in the other States at baseline. In Victoria the PFD wear rates for females were 10% higher overall with smaller vessels being 16% higher and larger vessels being 9% higher.
- The PFD wear rates for children (aged 0-17 years) were consistently higher than adults in all four States (20-64%). The highest overall wear rate for children (64%) was achieved in South Australia. PFD wear rates were also consistently higher in younger children (aged less than 10 years) than older children/adolescents (aged 10–17 years). The rate for children aged less than 10 years varied between 33% and 78% and for children aged 10-17 years the rate was between 11% and 57%.
- The PFD wear rate was influenced by the type of vessel being operated. Very low to low wear rates were observed by boaters on open boats (tinnies) across all four States. Similarly, boaters of cuddy/half cabin cruisers, as well as full cabin cruisers achieved very low to low wear rates across all four States.
- The PFD wear rate on ski boats (including person being towed) varied from state to state. Generally low rates were recorded for WA, NSW and QLD. In South Australia a moderate rate of 50% was achieved. Likewise, PFD wear rates on yachts (motor and trailer sailor) were generally low in QLD, SA and WA. The wear rate in NSW was 55% but the number of observations was small (n=11) so data were unreliable. Personal water craft (PWC) riders achieved the highest PFD wear rates across all four States. The wearing of PFDs is compulsory for PWC in all States.

In semi-quantitative terms, results are generally similar to those in the United States. However, the State of Victoria imposed mandatory life jacket wear in 2005.

-Cassell and Newstead, (2014)

These investigators estimated the effect of the 2005 Victorian mandatory life jacket wear regulations on wear rates by occupants of small (hull length ≤ 4.8 m *(15.7 ft)*) powerboats. Recall from the results presented in Chapter 3, that this regulation, introduced in December

2005, resulted in a statistically significant reduction in drowning deaths. The Cassell and Newstead (2014) study measured wear rates before and after the regulations were introduced compared with the probability of use by occupants of larger powerboats (hull length > 4.8 - 12 m *(15.7 to 39.4 ft)*) who were not required to wear life jackets before or after the regulations were introduced. The methods, results, and conclusions of the study are excerpted from the study abstract:

> "**Methods:** Statewide observation surveys of boaters were conducted in peak boating periods between January and March 2005 (prelegislation) and 2007 (postlegislation). Data collection included size of vessel, age and sex of boaters, life jacket use, boat type, activity of boaters, type of waterway and weather and water conditions. Logistic regression modeling tested whether there were statistically significant differences in the change in the relative odds of occupants wearing PFDs from the preintervention to the postintervention period in small compared with large power recreational vessels.
> **Results:** The probability of PFD use increased from 22% to 63% on small power vessels compared with 12% to 13% on large vessels. Regression analysis showed a high statistically significant increase in the odds of PFD use on small vessels relative to large vessels (OR 6.2, 95% CI 4.2 to 9.3, $p < 0.001$). No statistically significant effect on use on large vessels was associated with the regulation (OR 1.27, 95% CI 0.94 to 1.70, $p = 0.15$). Relative to large vessels, on small vessels the odds of PFD use increased significantly in both sexes, all age groups, all vessel types and activity groupings except for towed water sports where the increase was only marginally statistically significant.
> **Conclusions:** The legislative intervention was successful in increasing PFD wearing in small vessels. However, visible enforcement and tougher penalties are needed to optimise compliance."

Although the measured 63% compliance rate falls far short of the ideal of 100%, it was sufficient to reduce drowning deaths significantly.

Canada

There are limited data on life jacket wear rates from Canada.

-Groff and Ghadiali, (2003)

These authors prepared background research paper for the Canadian Safe Boating Council (CSBC) on various aspects of mandatory life jacket wear applicable to Canada including a short summary of wear rate data (The Starr Group, 2001). Groff and Ghadiali (2003) refer to two studies:

- A survey study of 15-25 year old males in Western Canada conducted in 200 reported that 47% of respondents claimed to have worn a life jacket while they were on the water during their last outing. Another 16% claimed for some of the time during their last outing, but took it off for comfort or other reasons. The remaining 37% admitted they did not wear a life jacket.

- The second study, sponsored by the Canadian Coast Guard in 2002 was more rigorous and based on actual observations. This study concluded that only 21% of Canadian boaters wore a life jacket. Canadian data also showed that life jacket wear rates decrease with age: 85% of children age 5 or younger; 70% of children age 6–9; 37% of teenagers; compared to 21 per cent for adults. Overall rates also differed by boat type: 95% on kayaks; 92% on PWCs; 63% on canoes; 58% on non-motorized fishing boats; and 42% on utility boats/skiffs.

The results of the observational study are similar to those reported in the JSI study in the United States. The 2002 study has not yet been updated, but this has been urged by the Canadian Safe Boating Council and is reportedly under consideration.

New Zealand

A report commissioned by Maritime New Zealand (MNZ) and conducted by Research New Zealand[28] in 2013 summarizes results of a survey claims that 70% of New Zealand boaters (termed "boaties" in the press release) report that they wear a life jacket at all times. The wear rate figure was higher (86%) for those in canoes/kayaks, and lower (58%) for other powered and non-powered vessels. Life jacket carriage is mandated in New Zealand, but life jacket wear is not a national requirement at present (though apparently under consideration for boats under 6 meters *(19.7 ft)* in length, see Matheson, 2014). Some Regional Councils do require wearing of life jackets.[29] Matheson (2014) comments on a small regional observation study as follows:

> "Last year's small Waikato study (Waikato Regional Council, 2013) referred to above, found that lifejackets were worn by all of those on board for 40% of the vessels that were approached (another 23% of vessels had some people wearing PFDs)."

As might be expected, these wear rate numbers are significantly lower than those derived from a boater survey; an earlier boat ramp study (Parker, 2011) reported that 8.3% of boats either carried no life jackets or fewer than required.

United Kingdom

At present the United Kingdom does not have mandatory life jacket wear regulations,[30] although as in other countries, life jacket wear is strongly encouraged. There are two available studies for the United Kingdom.

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[28] See http://www.boatingeducation.org.nz/279/safety/.

[29] According to Matheson (2014) these include Greater Wellington, Hawkes Bay, Horizons, Northland, Waikato, Canterbury and Southland Regional Councils, and Nelson City Council.

[30] For that matter, many recreational craft are not required to carry life jackets on board (see http://www.rya.org.uk/infoadvice/regssafety/pleasurecraftregs/Pages/PleasureCraftRegulations.aspx) although this practice is strongly encouraged. This makes their higher voluntary wear rates even more impressive.

-Turner et al., 2009

Turner and colleagues (2009) report (under the heading of "local research") both observational data and survey data. The sample size for the observational data were limited (n = 247) and the date is unspecified. The overall wear rate was 27%, which ranged from 17% for motorboats to 80% for a category labeled "other." Values for sailboats were 21% and for RIB were 56%. The survey results (n = 65) indicated that only 23% of survey respondents reported either "never" or "only under certain conditions," meaning that the overall wear rate should be closer to 77%. This study underscores the possible bias in survey studies. The overall wear rate from the observational study is closer to that reported in the U. S. studies.

-Chennell (2013)

Chennell (2013) reported results of an ongoing observational study of coastal boaters conducted by the Royal National Lifeboat Institution (RNLI). Data on observed life jacket wear rates are shown in Table 3 for the years 2008 through 2012.

Table 3. *Observed life jacket (LJ) wear rates for the United Kingdom.*

Year	Adults on board	Adults wearing LJ	% adults wearing LJ	Children on board	Children wearing LJ	% Children wearing LJ	Total on board	Total wearing LJ	Total %
2008	2571	972	37.8%	195	139	71.3%	2766	1111	**40.2%**
2009	7538	3617	48.0%	830	651	78.4%	8368	4268	**51.0%**
2010	12174	5086	41.8%	1211	829	68.5%	13385	5915	**44.2%**
2011	49711	17637	35.5%	4333	2531	58.4%	54044	20168	**37.3%**
2012	13423	5668	42.2%	1269	947	74.6%	14692	6615	**45.0%**

The reported wear rates for adults are slightly higher than observed in the United States, perhaps because these were coastal or open sea vessels (power and sail), operating in what might be perceived as more hazardous waters.

France

Wear rate data are available for France for 2013 and 2014 from studies conducted by the Société Nationale de Sauvetage en Mer (abbreviated SNSM and translated as the National Society For Sea Rescue, http://www.snsm.org/), headquartered in Paris.[31] Wear rate data were determined from an observational study at 33 (28 in 2013)

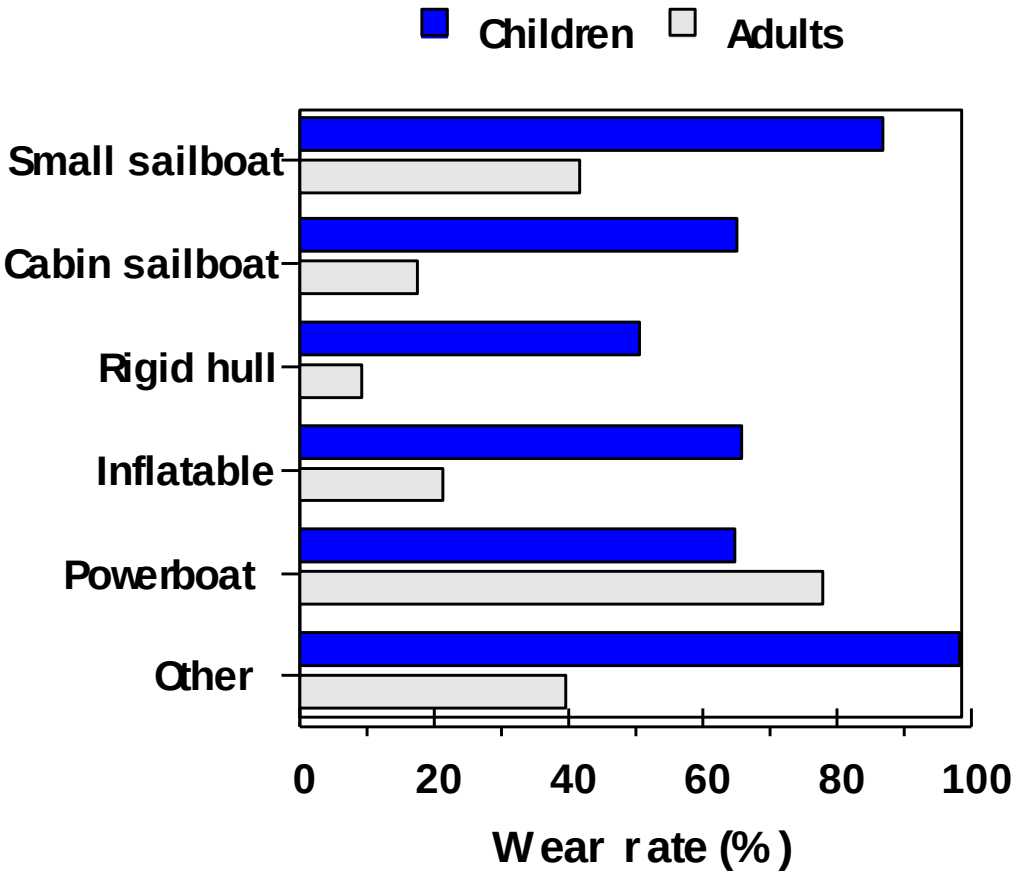
[31] The Société Nationale de Sauvetage en Mer (SNSM) is a French voluntary organisation founded in 1967 by merging the Société Centrale de Sauvetage des Naufragés (founded in 1865) and the Hospitaliers Sauveteurs Bretons (1873). SNSM's mission (similar to that of RNLI in the United Kingdom) is saving lives at sea around the French coast, including the overseas départments and territories.

stations (principally ports, such as Le Havre) in France and overseas territories (Nouméa).

- For 2014 a total of approximately 5,500 boat occupants were observed of whom 17.89% of adults and 59.85% of children were wearing life jackets.
- Comparable wear rates observed in 2013 were 11.57% and 52.89%, respectively, so the wear rate trend is apparently increasing.
- Observed wear rates differed among observing stations and among both boat types and boat lengths.
    - For example, wear rates in 2014 were 25.23% and 64.58% (adults and children) for boats < 5 meters *(16.4 ft)* in length compared to 15.45% and 59.69% for boats between 5 and 10 meters *(16.4 and 32.8 ft)* in length, and 12.99% and 44.19% for boats longer than 10 meters *(32.8 feet)*.

Figure 14 shows the measured wear rates in 2014 for adults and children by boat type from the SNSM study.

Figure 14. *Observed life jacket wear rates for adults and children in France 2014 (SNSM data).*



The category labeled "other" in Fig. 14 includes principally canoes and kayaks.

Overall the measured wear rates in France are broadly consistent with results from the United States, and slightly lower than those measured in New Zealand or the UK. (The unusual pattern of measured wear rates for adults and children in powerboats shown in Fig. 14 may be an artifact of small sample sizes and/or a difference in the sizes of boats observed.)

Summary

Wear rate studies have been conducted in several countries. Aside from survey studies (asking respondents if they wear a life jacket), which are likely to give optimistically biased results, the observational studies provide generally consistent results. That is, wear rates are generally low unless there is a specific legal wear requirement. In the United States, for example, life jacket wear is mandated for youth and PWC users—and corresponding life jacket wear rates for these groups are high. In certain states of Australia (Tasmania and Victoria) life jacket wear is mandated for certain classes of vessels and corresponding wear rates are higher than in years before these regulations went into effect. Rates in Canada and France are comparable to those in the United States and rates in the UK are somewhat higher. Several studies show that life jacket wear rates vary with the boat type, length, age, and gender of the occupants.

Chapter 5. Boater Attitudes towards Life Jacket Wear

Introduction

The preceding chapters in this report have summarized relevant facts about recreational boating fatalities (drowning in particular), the effectiveness of life jackets in preventing drowning, and available studies on life jacket wear rates. This chapter summarizes studies on consumer attitudes towards life jacket wear. It is arguably surprising that life jacket wear rates (at least those in the United States) are so low given the demonstrated capability of life jackets to reduce drowning deaths. Clearly cost is not the dominant concern as boaters are now required to carry life jackets aboard their boats in any event. The available studies indicate that there are other reasons why so many boaters fail to wear life jackets. This chapter summarizes studies on boater attitudes towards life jackets.

One probable determinant of the decision to wear a life jacket is the estimated risk of a drowning. The USCG sponsored the National Recreational Boating Survey (USCG 2012 a), a study that (among other things) measured the annual exposure hours for various types of boats in 2012. In concert with fatality data for the same year, this enables calculations of the likelihood of a fatality or drowning fatality per boat exposure hour.

Across all boats, the calculated fatality rates in 2012 were approximately 0.44 and 0.31 fatalities per million boat hours for all fatalities and drowning fatalities, respectively, as shown in Table A-10 (Appendix). To place these rates in perspective, these are approximately the same as the calculated average annual fatality rate (2003 to 2012) per exposure hour[32] for all motor vehicles in the United States and very much lower than the average rate for motorcycles (8.57 per million motorcycle hours) over this same period. So it is likely that most boaters have the impression that boating is a relatively safe activity—comparable to driving a car on an exposure hour basis.

United States

Several studies of boater attitudes towards wearing life jackets have addressed possible reasons for failure to wear life jackets (see e.g., Center for Social Marketing, 2009; Isaacs and Lavergne, 2010; Mangione and Chow, 2014; Quan et al., 2006; Quistberg et al., 2014 a, b; and Responsive Management, 2001). Perhaps the most detailed of these studies are those of Quistberg and colleagues, discussed below.

-University of South Florida (USF) Center for Social Marketing, 2009

The USF Center for Social Marketing performed a study for the Lee County Department of Natural Resources-Marine Program that was funded by the Florida Fish and Wildlife Conservation Commission's Florida Boating Improvement Program. This study summarized

[32] Vehicle fatality rates are typically calculated in terms of vehicle miles traveled rather than exposure hour. However, since vehicle miles traveled is not an appropriate rate measure for boats, Table A-10 converts vehicle rates to fatalities per exposure hour.

relevant literature on (among other things) boater/hunter/angler attitudes towards life jacket wear. Their summary on attitudes towards life jackets is given below:

> "Although studies have shown that boaters understand the importance of having PFDs on board and agree that wearing one is a good idea, the perception of availability and ease of putting them on outweighs actual continuous wear in boaters. To make the point, Rhode Island law enforcement offered boaters a certificate if the operator and passenger could all don their PFDs within 30 seconds or less. Almost all boaters were unable to accomplish this task. Although most boaters feel they could don a PFD in a sufficient amount of time, this is not true with most drowning accidents.
>
> In four focus groups of hunters and anglers [Responsive Management, 2001], PFDs were viewed as being a symbol of inexperience and creating a child-like appearance. The primary motivator for voluntary use of a PFD was an emotional, tragic event of losing a fellow boater. Recommendations that evolved from the focus groups to increase PFD use include having television fishing professionals and other water activity personalities model PFD use by wearing them, messages that carry an emotional tone and are family oriented (such as using a child to talk about missing their dad because he drowned from not wearing a PFD), and recommendations to PFD manufacturers to make PFDs more utilitarian and more comfortable." [Material in square brackets added for clarity.]

-Isaacs and Lavergne, 2010

This study reported results of a survey of Louisiana boaters. The survey asked questions about life jacket wear rates and, as observed in other survey studies, the self-reported use of life jackets was much higher (60.7% claimed to use life jackets all or most of the time) than determined by observational studies. The survey also addressed reasons why boaters were reluctant to wear life jackets. The authors report a long list of responses to this question which can be summarized in a few key groups (i) the risk is low (e.g., travel at low speeds or only for short distances), (ii) life jackets are uncomfortable and unattractive, (iii) interferes with their activities, and (iv) "I should not have to wear one" (presumably a reaction to the possibility of mandatory wear).

-Quistberg et al., 2014 a

The first study by these authors attempted to identify barriers to life jacket use. The authors employed a cross-sectional study of boaters (> 18 years old) launching or retrieving motorboats (< 26 ft. in length) at nine public boat ramps in King, Pierce, and Snohomish counties in Washington State during August to December 2008. The investigators asked boaters "What percent of the time do you think you'll wear (or did wear) a life jacket/vest for this trip?" The study dichotomized responses into two groups, low use (0 – 50%) and high use (> 50%) groups. Poisson regression was used to calculate risk ratios (RR) for several variables, including respondent characteristics (e.g., age, gender, education), trip characteristics (salt/fresh water, weather, number of occupants/children onboard and purpose) and also queried attitudes (confidence that a life jacket was protective, life jacket comfort) and behavior (alcohol use while boating). Their results and conclusions are reported below:

"**Results:** Low/no life jacket use (0–50% of time) was associated with longer boat length (per foot, risk ratio [RR] 1.03, 95% CI 1.02 to 1.05), alcohol use (RR 1.11, 95% CI 1.01 to 1.20), perception of life jackets as 'uncomfortable' (RR 1.29, 95% CI 1.09 to 1.52), perceived greater level of swimming ability (RR 1.25, 95% CI 1.03 to 1.53 for 'expert swimmer') and possibly with lack of confidence that a life jacket may save one from drowning (RR 1.13, 95% CI 0.96 to 1.32). Low life jacket use was less likely when an inflatable life jacket was the primary life jacket used by a subject (RR 0.77, 95% CI 0.63 to 0.94), a child was onboard (RR 0.88, 95% CI 0.79 to 0.99) or if the respondent had taken a boating safety class (RR 0.94, 95% CI 0.87 to 1.01).
Conclusions: Life jacket use may increase with more comfortable devices, such as inflatable life jackets, and with increased awareness of their efficacy in preventing drowning. Boater education classes may be associated with increased life jacket use among adults."

The length RR may be explained by the perception that bigger boats are less likely to capsize or result in a fall overboard, a reasonable hypothesis and consistent with other studies on life jacket wear. The perception that life jackets are uncomfortable has been reported in several other studies.

The finding that life jacket use is less likely if the boater has greater confidence in his/her swimming ability is plausible. Certainly being able to swim is a desirable skill, but the accuracy of self-evaluation of swimming ability is subject to question (Croft and Button 2013; Moran et al., 2012). Moreover, there are substantial swimming difficulties associated with cold water immersion. See Ducharme and Lounsbury (2007) for a more optimistic assessment.

The finding that boaters who intended to use alcohol were less likely to use a life jacket is consistent with other findings. The finding that life jacket use was more likely with a child on board, an inflatable life jacket was at hand (more comfortable), or if the boater had taken a boating safety course is plausible, even encouraging.

-Quistberg et al., 2014 b

These authors conducted a qualitative study among boat owners attending a boat show in the Northwest and explored factors associated with life jacket use by adults and child/adolescent passengers. A total of 16 boaters participated in four focus groups. The key results and conclusions contained in their abstract are:

"Results: Most boaters reported inconsistent use of life jackets, using them only when conditions were poor. Each described episodes of unpredictable boating risk which occurred despite favorable conditions. Most required younger child passengers to wear a life jacket, but reported resistance among older children. Barriers to consistent life jacket use included discomfort and the belief that life jacket use indicated inexperience or poor swimming ability. Participants stated that laws requiring life jacket use would change behavior especially for children. The only demonstrated behavior change among group members was associated with use of inflatable life jacket devices.

> **Conclusions:** Boating risk is inherently unpredictable; therefore interventions should focus on strategies for increasing consistent use of life jackets. Passage and enforcement of life jacket legislation for older children and adults is likely a promising approach for behavior change. Designing more comfortable, better-fitting, more appealing life jackets will be paramount to encouraging consistent use."

This paper also contains key quotations from the focus groups, which are generally in alignment with other reported results.

Canada

Groff and Ghadiali (2003) prepared an extensive background paper that among other things addressed boater attitudes towards life jackets. Table 4 shows the main reasons why boaters are reluctant to wear life jackets.

Table 4. *Reasons why boaters choose not to wear life jackets—Canadian Research*

Reason	More detail
Low risk of drowning	I'm a good swimmer; Experienced boaters don't drown; I don't go far from shore; I can easily reach my life jacket
Life jackets restrict movement	PFDs are bulky and uncomfortable; you can't go swimming or get a sun tan with a PFD
Life Jackets are uncomfortable	PFDs are bulky and hot to wear
Life jackets are unattractive or unfashionable	Unfashionable, unattractive, unflattering are words used by boaters to describe PFDs
Wearing a life jacket is a sign of fear	Perception that wearing a PFD is a sign of weakness or fear as revealed in focus groups particularly among young males.

Source: Groff and Ghadiali (2003) and contained references.

These same attitudes have been reported in other studies and help to define the need for specific messages in outreach efforts. The authors offer several comments and suggestions to counter or reframe public perceptions.

United Kingdom

Turner et al. (2009) conducted a study for the UK Maritime and Coastguard Agency (MCA) and the Royal National Lifeboat Institution (RNLI) that (among other things) summarizes boater attitudes towards life jacket wear and develop the most effective and efficient ways to encourage behavioral change in the boater population. Table 5 shows the top ten reasons why boaters surveyed in the UK choose not to wear life jackets.

Table 5. *Top Ten reasons why boaters choose not to wear life jackets, UK Research*

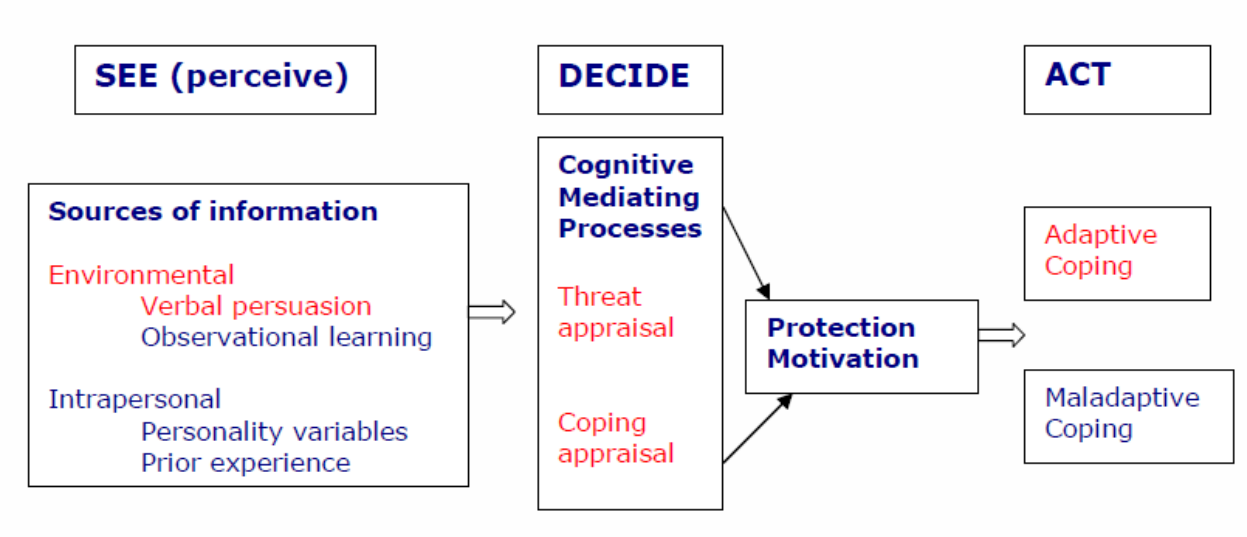
Rank	Reason
1st	Do not perceive a substantial threat
2nd	Would only go out in good conditions and would not wear a lifejacket unless conditions got rough
3rd	Lack of confidence in lifejackets to save their lives (may use harnesses instead and careful movement around the boat)
4th	Habit or laziness
5th	Because lifejackets are restrictive
6th	They would rather die quickly and have little hope of getting rescued
7th	Do not sail offshore
8th	Because lifejackets are uncomfortable, especially chaffing the neck
9th	The 'on holiday' mentality
10th tied	Because they trust the skipper to keep them safe Do not do anything on the boat that would risk falling overboard Because lifejackets are a hassle to maintain Because lifejackets prevent an even suntan Because lifejackets are a hassle when changing other clothing (as they always need to be on top)

Source: Based on survey results cited in Turner *et al*., 2009.

A consistent theme from all surveys of boater attitudes towards wearing life jackets is that the risk is not perceived as high. The data provided at the beginning of this chapter indicates that the risk of boating per exposure hour is comparable to that for driving an automobile. Automobile drivers were very reluctant to use seat belts (see next chapter), presumably for the same reason.

These authors also propose what they term a "protection motivation model in combination with the See-Decide-Act model of warning communications" illustrated in Fig. 15. The essential elements of the model are that boaters first perceive information (from various sources), then make a decision whether or not to wear a life jacket (based on the perceived threat), and finally act based on this decision. The threat appraisal included in their schematic model is properly view as an intuitive risk assessment.

Figure 15. *Protection motivation model suggested by Turner et al (2009).*



Summary

This chapter provides an overview of studies that cover attitudes towards life jacket wear. Studies included here have been conducted in the United States, Canada, and the United Kingdom. Although there are some differences among these studies, the key findings are quite similar. Boaters don't wear life jackets because (i) the perceived risk is low (either inherently or because they are good swimmers or are selective in the circumstances of the voyage), (ii) life jackets are viewed as uncomfortable, unattractive, or restrictive, (iii) wearing a life jacket is a sign of fear, and (iv) miscellaneous others.

Chapter 6. Initiatives to increase life jacket wear rates

Introduction

The foregoing chapters have established the following:

- Most recreational boating fatalities result from drowning and the fraction of drowning victims found wearing a life jacket is quite low,
- Regulatory agencies and boating safety advocates believe that wearing, rather than merely carrying, life jackets is necessary to materially reduce fatalities,
- The hypothesis that greater wear rates for life jackets will result in fewer drownings is well supported by statistical analyses of available data from both Australia and the United States,
- Therefore, the actual wear rate of life jackets is one useful measure of effectiveness (MOE) of a boating safety program.
- Studies in several countries (including the United States) indicate that wear rates are generally low, except in those countries (or states within countries) that have mandated life jacket wear for certain types/lengths of boats, and
- Boaters have several reasons for not wearing life jackets, including the perception that the risks of boating are low, that life jackets are uncomfortable, restrictive, or unattractive, and that wearing a life jacket is a sign of weakness.

The policy dilemma facing those agencies responsible for boating safety programs is to select the appropriate combination of voluntary (e.g., outreach) and regulatory initiatives in order to reduce boating fatalities. This chapter summarizes the approaches/interventions employed by several countries, including Australia, Canada, Ireland, New Zealand, the United Kingdom, and the United States. For the United States it is relevant to present a brief review of analogous safety issues, including seat belts and motorcycle helmets.

Before addressing differences in policy instruments to increase life jacket wear employed by various countries, it is appropriate to make the point that, regardless of whether or not life jacket wear is mandated, all countries maintain outreach programs (of varying scope) designed to convince/reaffirm the boating public of the necessity to wear rather than merely carry life jackets aboard their vessels. For those countries, such as Canada or the United States, which have only limited wear requirements, the outreach efforts have been the core component of the safety strategy. For countries that have opted to mandate life jacket wear, outreach efforts are still employed, in order to convince/reassure the boating public of the need for these regulations.

Countries with broadly applicable life jacket wear requirements

Many countries (or political subdivisions within countries) have some form of life jacket wear regulation. For example, in the United States (which has not opted for a broad wear requirement to date), almost all states have regulations requiring life jacket wear by children (ages differ by

state) and require that life jackets be worn by PWC users.[33] As a second example, the State of Queensland, Australia, requires that life jackets be worn by those under 12 years of age and by all boat occupants when crossing a designated coastal bar in an open boat that is less than 4.8 m *(15.7 ft)* in length.[34]

However, some countries (or political subdivisions) have adopted more stringent or more broadly applicable life jacket wear requirements. These are discussed in this section.

-Ireland

Effective in 2004, the life jacket wear requirements for Ireland (excluding PWCs) are as follows:[35]

- All persons on board any craft of less than 7 m *(22.9 ft)* in length must wear a personal floatation device (PFD) or a lifejacket while on board an open craft or while on the deck of a decked craft, other than when the craft is made fast to the shore.
- The master or owner of a craft is required to ensure that either a PFD or a lifejacket is carried on the craft for each person on board.
- The master or owner of a craft is required to take all reasonable steps to ensure that all persons under the age of sixteen must wear a personal floatation device or a lifejacket while on board an open craft or while on the deck of a decked craft, other than when it is made fast to the shore or at anchor.
- The term "open craft" refers to a craft without a cabin or below deck facilities for persons on board and where any seating is exposed or partially exposed to the elements.
- The master or owner of a craft (other than a PWC) is required to take all reasonable steps to ensure that a person wears a PFD/lifejacket while:
    - Being towed by the craft, or
    - On board a vessel or object of any kind being towed by the craft.
- The wearing of PFD/lifejacket requirements under these Regulations do not apply to a craft (other than a PWC), which is not underway, when the person (i) Is wearing, putting on, or taking off, scuba diving equipment, or (ii) Is about to engage in, or has just completed swimming (including snorkeling) from the craft.

Lifejacket Regulations on Personal Watercraft (PWC - Jet Skis)

- Every person on a personal watercraft (PWC) is required to wear a PFD/lifejacket at all times while on board, or being towed in any manner by a PWC. The master or owner of a PWC is required to take all reasonable steps to ensure that a person under 16 years of age complies with the requirement to wear a PFD/lifejacket while on board or being towed on a PWC.

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[33] The United States Coast Guard's Life Jacket Rule for Children went into effect December 23, 2002. The Coast Guard is requiring that all children under 13 years of age wear Coast Guard approved life jackets, while aboard recreational vessels underway, except when the children are below decks or in an enclosed cabin. The Rule affected only those States that had not established requirements for children to wear life jackets. For the remaining states, the rule recognized and adopted the existing state regulation, even if it was less stringent than the federal rule. The threshold age where life jacket wear is no longer required varies by state. The BoatU.S. Foundation maintains a web site that provides state by state requirements, see http://www.boatus.org/life-jacket-loaner/staterequirements.asp.

[34] See the Maritime Safety Queensland web site at http://www.msq.qld.gov.au/safety/life-jackets.aspx.

[35] See http://www.howthcoastguard.com/lifejacket-compliance.html.

The Maritime Safety Directorate Ireland published a Code of Practice that is part of the outreach effort to explain legal requirements and recommended practices.[36] Various non-governmental or quasi-governmental organizations (e.g., Irish Water Safety[37] and Rowing Ireland[38]) also provide outreach materials.

-Australia (Tasmania)

As discussed in earlier chapters, the State of Tasmania (Marine and Safety Tasmania [MAST]) established/oversees the following mandatory life jacket wear requirements:[39]

- An approved life jacket must be provided for each person on board. Occupants are required to wear a life jacket in any recreational motor boat or motor-propelled tender that is less than six meters in length when under power.
- It is also compulsory for children under the age of 12 years to wear a life jacket in a recreational motor boat or motor-propelled tender of any length while under power.
- A life jacket does not need to be worn within a deckhouse, cabin or secure enclosed space.

MAST publishes outreach materials, such as brochures on safety equipment. "Wear It Australia!" modeled on the National Safe Boating Council (NSBC) program in the United States provides outreach material in a variety of formats (e.g., Facebook, Twitter, YouTube, and print media) for Tasmania as well as other Australian states.

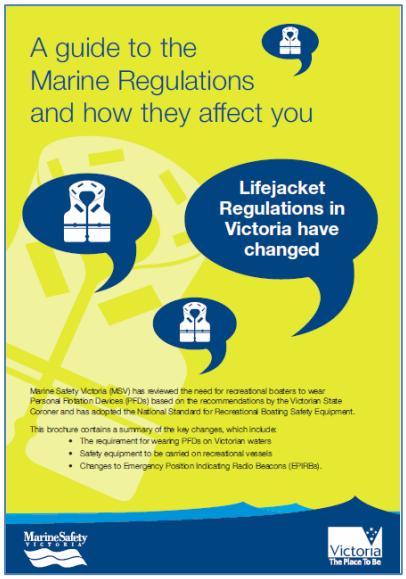
-Australia (Victoria)

As described in earlier chapters the State of Victoria (Transport Safety Victoria) has the following requirements:[40]

- All occupants of the following vessels are required to wear a specified life jacket when in an open area of the vessel that is underway:
  - Powerboat up to and including 4.8 meters *(15.7 ft)* in length,
  - Off-the-beach sailing yachts,
  - Personal watercraft,
  - Canoes, kayaks, rowing boats and rafts,
  - Pedal boats, fun boats and stand up paddle boards,
  - Kite boards and sail boards, and

[36] See http://www.waterwaysireland.org/SiteAssets/documents/Code%20of%20Practice%20for%20the%20Safe%20Operation%20of%20Recreational%20Craft.pdf.
[37] See http://www.iws.ie/about/history-of-irish-water-safery.175.html.
[38] See http://www.rowingireland.ie/life-jackets-and-buoyancy-aids/.
[39] See http://www.mast.tas.gov.au/recreational/boating/life-jackets/ and http://www.thelaw.tas.gov.au/tocview/content.w3p;doc_id=+100+2013+AT@EN+20140926000000;rec=0.
[40] See http://www.transportsafety.vic.gov.au/maritime-safety/recreational-maritime/safety-equipment/personal-flotation-devices.

    - Recreational tenders.
- All occupants of the following vessels are required to wear a specified life jacket at times of heightened risk when in an open area of the vessel that is underway:
    - Yachts (including monohull, trailerable and multihull yachts, excluding what are termed "off-the-beach" sailing yachts),
    - Powerboats greater than 4.8 m *(15.7 ft)* up to and including 12 m *(39.4 ft)* in length, and
    - When there is a sole occupant on a vessel, regardless of its type.



Two agencies of the Victoria government (Transport Safety Victoria and Parks Victoria) publish outreach materials[41] and, as noted above, "Wear It, Australia!" provides active support of the reasons behind the life jacket requirements. One Australian commercial insurer (Club Marine) has also taken an active interest in the need for wearing life jackets.[42]

Countries without broadly applicable life jacket requirements

These countries include Canada, France, the United Kingdom, and the United States. As noted above, each of the countries in this group may have some life jacket wear requirements (typically for youth, PWC users, or when being towed), but have thus far failed to establish more broadly applicable requirements. With the possible exception of the United Kingdom, as a group the adult life jacket wear rates are much lower than for those countries that have mandatory wear policies (see Chapter 4).

-Canada

Although several organizations (including the Ontario Provincial Police[43] and NGOs[44]) in Canada have urged that the country have more broadly applicable life jacket wear requirements (note the study of Groff, P. and Ghadiali, 2003 referred to in earlier chapters), to date Canada has relied on outreach efforts to increase wear rates. Canadian life jacket requirements are limited to the requirement to carry one Canadian approved life jacket of the appropriate size for each person on board.

In lieu of wear requirements, Canada has pursued a voluntary life jacket wear policy with an extensive outreach program sponsored by several NGOs, including the Cook-Rees Memorial Fund (sponsors of the wearalifejacket.com web site[45]), Canadian Safe Boating Council[46],

[41] See, e.g., http://www.boatieafloat.com.au/GuideMarineRegulations.pdf. For Parks, Victoria, see http://parkweb.vic.gov.au/__data/assets/pdf_file/0006/313566/rec_boat_guide_port_phillip.pdf.
[42] See http://www.clubmarine.com.au/internet/clubmarine.nsf/docs/MG25-5+Water+Wise.
[43] See http://www.cbc.ca/news/canada/wearing-life-jackets-should-be-mandatory-opp-1.948856.
[44] See the petition by Change.org available at https://www.change.org/p/canadian-federal-government-life-jackets-should-be-made-mandatory-for-all-boaters-and-other-personal-water-crafts-of-all-ages-at-all-times.
[45] See http://www.wearalifejacket.com/walcEn/about_us01En.html.
[46] See http://www.csbc.ca/index.php/en/pfd-wear/pfd-wear-best-practices.

Canadian Red Cross,[47] and BoatU.S.[48] Outreach material is also prepared and distributed by the government agency, Transport Canada[49] as well as various provincial governments.

Potentially valuable outreach initiatives include the life jacket loaner stations that are administered or sponsored by the Canadian Red Cross,[50] the Lifesaving Society,[51] and various provincial government agencies. [52] These stations are located throughout Canada often accompanied with the slogan "Kid's Don't Float"[53] (originally developed in Homer, Alaska).

Canada is one of the countries (along with Australia, France, and New Zealand) that subscribe to the International Life Jacket Wear Principles,[54] a voluntary agreement to declare support for the International Lifejacket Principles listed below:

- We recognize the fundamental role the wearing of lifejackets plays in the safeguarding of life for water users;
- We recognize the importance of promoting the wearing of lifejackets when boating;
- We will endeavor to ensure that any publication including brochures, DVD, video, websites, and the like will feature all people wearing contemporary style lifejackets when in an outside area of a small craft that is underway;
- We will recommend to the recreational boating industry that its publications similarly feature all people shown wearing lifejackets when in an outside area of a small craft that is underway;
- We will require our own on-water education and compliance staff to wear lifejackets whenever they are on the water;
- We will use the term "lifejacket" in public information and education; and
- We agree to engage our own boating safety networks to encourage them to become 'safety partners' by supporting the above principles.

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[47] See http://www.redcross.ca/what-we-do/swimming-and-water-safety/swimming,-boating-and-water-safety-tips/lifejackets-and-pfds.
[48] See http://www.boatus.com/boattech/casey/canadian-coast-guard.asp.
[49] See https://www.tc.gc.ca/eng/marinesafety/debs-obs-equipment-lifejackets-information-1324.htm.
[50] See http://www.redcross.ca/where-we-work/in-canada/new-brunswick/new-brunswick-specific-programs/pfd---life-jacket-loan-program.
[51] See http://www.lifesaving.org/public_education.php?page=674.
[52] See e.g., http://news.gov.mb.ca/news/index.html?item=18151.
[53] See e.g., the Royal Canadian Marine Search and Rescue organization web site http://rcmsar.com/boating-safety/kids-dont-float/ or the Canadian Coast Guard Auxiliary-Pacific web site http://ccga-pacific.org/resources/member/kdf_program_guide.pdf. The Kids Don't Float Program was initially developed in 1996 by a group in Homer, Alaska as a response to Alaska's high rate of drowning and is used in Canada as well.
[54] See http://www.lifejacketwear.com/en/.

-France

Applicable life jacket rules for recreational vessels in France are limited to carriage requirements.[55] Several organizations (such as Société Internationale de Sauvetage du Léman [SISL] and Société Nationale de Sauvetage en Mer [SNSM]) provide outreach materials on life jackets (Gilets de Sauvetage) including how to select the correct life jacket.[56]

Several organizations, (including SNSM, the Secretariat General of the Sea, the Supreme Council of the Boating the Department of Maritime Affairs, the French Federation of Marinas, the National Federation of Charter Schools, the National Federation of boaters and anglers of France, the paddler sailors group, the Yacht Club of France, the National Sailing School, Water Sports, Sailing School Glénans) agreed to launch a joint communication campaign to encourage wearing life jackets. The campaign (web based, radio, and video)[57] employs several creative copy ideas (see photo at right). A web site describing the campaign (in French) is available.[58]

-New Zealand

New Zealand has life jacket carriage requirements for recreational boats. New Zealand maritime rules provide that it is the skipper's legal responsibility to ensure that lifejackets are worn in situations of heightened risk, such as when crossing a bar, in rough water, during an emergency, and by non-swimmers. Lifejackets must be stored so that they are immediately available in case of a sudden emergency or capsize. Children should wear lifejackets at all times in boats under 6 meters.[59] Some Regional Council Bylaws are more stringent, requiring that life jackets be worn at all times.

Maritime New Zealand has an active outreach program keyed to the theme "Life Jackets for Life." Additional outreach activities are conducted by the Royal New Zealand Coastguard Inc.[60] the Kiwi Association of Sea Kayakers (KASK)[61] and the National Pleasure Boat Safety Forum,[62] Water Safety New Zealand,[63] and

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[55] See http://www.drascombe-association.org.uk/articles/frenchrules.html. See also (in French) http://www.developpement-durable.gouv.fr/Le-materiel-de-securite-et-les.html.
[56] See e.g., http://www.sisl.ch/technique/brassiere.htm, http://www.snsmdelegationvendee.com/pages/infos-gilet-sauvetage/, and http://www.sauvetage.qc.ca/contenu-splash.asp?id=224.
[57] See http://www.europe1.fr/france/nouvelle-campagne-pour-le-port-du-gilet-de-sauvetage-1146117.
[58] See http://www.snsm.org/page/campagne-gilet-de-sauvetage.
[59] See http://www.maritimenz.govt.nz/recreational-boating/Lifejackets/Lifejackets.asp.
[60] See http://www.coastguard.co.nz/boating-safely/life-jackets/.
[61] See http://kask.org.nz/wp-content/uploads/SafeSeaKayakingbrochurepdf.pdf.
[62] See http://www.maritimenz.govt.nz/Recreational-Boating/Publications/National-pleasure-boat-safety-forum.asp.
[63] See http://www.watersafety.org.nz/about-us/.

Water Safe Auckland Inc. [64]

-United Kingdom

The United Kingdom does not have mandatory life jacket wear requirements for pleasure craft. The UK Maritime and Coastguard Agency (MCA) provides a limited amount of outreach materials on life jackets.[65] Several NGOs maintain active boating safety outreach programs that, among other things, endorse the wearing of life jackets. For example:

- The National Water Safety Forum (NWSF) provides information on lifejackets and statistical data on drowning deaths.[66] They also produce a short document on selection of the appropriate life jacket.[67]
- The Royal Yachting Association (RYA) policy is to "Wear a lifejacket or buoyancy aid unless you are sure you don't need to."[68]
- The Royal National Lifeboat Institution (RNLI) publishes outreach material on life jackets.[69] RNLI volunteers offer to visit various organizations and demonstrate the proper fitting and maintenance of life jackets.[70] One of the slogans is "Useless unless worn."

-United States

As noted above, most U.S. states require that life jackets be worn by PWC users and young boaters (age depending upon the state). Each state also has regulations applicable to life jackets. As of this writing five states (Connecticut, Maine, Massachusetts, New York, and Pennsylvania) require that life jackets be worn during certain periods of the year.[71]

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[64] See http://www.watersafe.org.nz/wearit4work/.
[65] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/303234/Lifejackets_save_lives.pdf.
[66] See http://www.nationalwatersafety.org.uk/professional/faq.asp#LJ.
[67] See http://www.nationalwatersafety.org.uk/member/projects/info/wg0407_lifejackets.pdf.
[68] See http://www.rya.org.uk/coursestraining/resources/keepingcurrent/Pages/Lifejacketpolicy.aspx.
[69] See http://rnli.org/safety/respect-the-water/activities/Documents/13-618-LeisLifejacketLeaflet-LR.pdf. See also http://completeguide.rnli.org/lifejackets.html.
[70] See http://rnli.org/safety/respect-the-water/face-to-face-advice/Pages/Safety-demonstrations.aspx.
[71] See http://www.americancanoe.org/?page=Cold_Weather_PFD_Law for a summary of the requirements, which vary by state.

The option of mandating life jacket wear in the United States has been considered at various times. For example, the National Transportation Safety Board (NTSB) sponsored a public forum on this topic in 2004. The idea proved controversial. Some groups, such as the American Canoe Association [ACA] (Dillon, 2004) and the National Safe Boating Council [NSBC] (Griswold, 2004) were supportive of mandatory life jacket wear, but others, including the National Marine Manufacturers Association (Fontaine, 2004), the Marine Retailers Association of America (Innis, 2004), and the BoatU.S. Foundation (Ellis, 2004) argued that this was unwise, although they endorsed the idea of voluntary life jacket wear.

More recently, the National Boating Safety Advisory Council (NBSAC) recommended that the United States Coast Guard consider the option of issuing regulations to make wearing a life jacket compulsory for certain types/lengths of boats. This report provides relevant background to the Coast Guard in considering this option. Another recent development is the United States Army Corps of Engineers (USACE) pilot program on several lakes discussed earlier in this report (Mangione and Chow, 2014; USACE, 2012).

To date, however, the United States has relied on voluntary approaches to encourage life jacket wear. These include the production of outreach materials (see NSBC, 2000, 2013, 2014) and the establishment of life jacket loaner programs throughout the United States (Sea Tow Foundation, 2013). Outreach programs are endorsed/conducted by a large number of organizations; there were 28 signatories to the 2012 – 2016 Strategic Plan (USCG 2012, b). Additionally, all U. S. states and territories are key supporters.

Among the more noteworthy of the outreach efforts are those of NSBC and partners, including National Safe Boating Week and, more specifically, the "Wear It" annual campaign. This campaign is national in scope and surveys (NSBC, 2013, 2014) have demonstrated significant boater awareness of the campaign. Additionally, NSBC has published a short monograph, Saved by the Jacket (NSBC 2000, updated 2013) presenting testimonials from boaters who were saved by wearing life jackets. (Some of these testimonials can be found on a web site, http://www.boatingsidekicks.com/sbjacket/sbtjmain.htm). Another component of the program is the "Ready, Set, Wear It!" Life Jacket World Record Day, an annual an event dating back to 2010, designed to set the world record for the number of life jackets worn and inflatable life jackets inflated simultaneously. The event, sponsored by the National Safe Boating Council and the Canadian Safe Boating Council was designed to educate recreational boaters about the importance of life jacket wear and promote public awareness of inflatable life jackets. To date, nearly 20,000 people in eleven countries have participated in "Ready, Set, Wear It!"

Another noteworthy effort is a program to loan life jackets to boaters (particularly children) for their day on the water. Life jacket loaner stations have been established throughout the United States. According to the nationwide survey data, 44 different state agencies or boating safety organizations run a life jacket loaner program in the U.S. and, as of July 2013, there are at least

1,915 life jacket loaner locations in the U.S. (Sea Tow Foundation, 2013). Several boating organizations and states participate or sponsor this program.[72]

Altogether there is much to praise in the outreach efforts and, undoubtedly, these efforts have saved some lives. *This said, according to the 2014 JSI report on the life jacket wear rate study, observed life jacket wear rates (all boaters excluding PWCs) went from 17.6% in 2000 to 17.7% in 2013; for adults the respective wear rates were 10.1% and 9.1%, respectively.* As the life jacket wear rate is a valid measure of effectiveness, it is difficult to conclude that the outreach programs have significantly improved national life jacket wear rates. Of course, we don't know what would have happened absent these outreach programs, but (at least for most adults) it is fair to conclude that these voluntary programs have had at most a limited impact. There are no published estimates of the total cost of outreach efforts, but it is clear that this cost has been substantial.

In contrast, the available evidence with respect to mandatory programs supports the conclusion that mandatory life jacket wear programs are effective. The data from two states in Australia, the USACE pilot program results, and the nationwide mandatory requirements for youth and PWC users in the United States have materially increased life jacket wear rates.

Possible analogies: seat belts and motorcycle helmets

In the United States context there are two possible analogies to the initiatives to increase life jacket wear rates, automobile seat belts and motorcycle helmets. Both initiatives were intended to increase highway safety and both ultimately resulted in use mandates—for seat belts in all states and for motorcycle helmets in many states. For both motorcycle helmets and seat belts the initial approach was to rely on campaigns to increase voluntary use, which did not prove successful. Regulations requiring seat belt and motorcycle helmet use came only after voluntary efforts proved a failure. In the case of seat belt regulations, the benefits of such regulation have proven substantial. In the case of motorcycle helmets, 'before and after' studies have shown that these regulations saved lives, but opposition to these laws has led to several states rescinding the requirement, providing an unforeseen opportunity for 'after and before' studies, which have demonstrated an increase in fatalities after the requirements were lifted.

-Automobile seat belts

The history of automobile seat belts and associated regulation has been described in several articles and reports (Cohen and Einav, 2001; Hedland et al., 2008; Nichols and Ledingham, 2008; Ruschmann et al., 1981; Waters et al., 1998). Briefly, lap belts were included in a small number of cars beginning in the 1950s. By 1968, such devices were required to be installed in the front seats of all new passenger vehicles. However, it was not until 1984 that New York passed the first seat belt law, closely followed by other states. Beginning in 1993, states started passing more stringent laws including what is termed primary enforcement, meaning that a peace

[72] See e.g., States of Alaska(http://dhss.alaska.gov/dph/Chronic/Pages/InjuryPrevention/KidsDontFloat/kdf_loaner.aspx), California (http://www.dbw.ca.gov/BoaterInfo/LifeJacket.aspx), Indiana (http://www.in.gov/dnr/4683.htm), Washington (http://boat.wa.gov/life-jackets.asp), and NGO programs (see e.g., the BoatU.S. program http://www.boatus.org/life-jacket-loaner/).

officer can issue a ticket based solely on the observation that the person is not using a seatbelt.[73] Over the 17 year period from 1968 (when seat belts were first required to be installed in new cars) until 1984, seat belt use was voluntary.

Despite evidence of the effectiveness of seat belts, there was substantial opposition to a regulatory approach so that some researchers (see e.g., Ruschmann et al., 1981) concluded that seat belt legislation was not feasible at the time (1981). According to one source (The Fraud of Seat Belt Laws):[74]

> "The Gallup Opinion Index," report no. 146, October 1977, stated: "In the latest survey, a huge majority, 78 percent, opposes a law that would fine a person $25 for failure to use a seat belt. This represents an increase of resistance since 1973 to such a law. At that time 71 percent opposed a seat belt use law." "The Gallup Report" (formerly "The Gallup Opinion Index"), no. 205, October 1982, report showed that a still-high 75 percent queried in June of that year opposed such a law."

Some were opposed to seat belt use based on concerns that the government was overreaching and infringing on personal freedom as this excerpt from a 2004 piece by Holdorf asserts:[75]

> "Seat belt laws represent unabated tyranny on the march as each year law enforcement is expanded. Such laws infringe on a person's rights as guaranteed in the Fourth, Fifth, and the Ninth Amendments, and the Civil Rights section of the Fourteenth Amendment.
> Seat belt laws are an unwarranted intrusion by government into the personal lives of citizens; they deny through prior restraint the right to determine a person's own safety and health standards for his own body, the ultimate private property. Not using a seat belt is a victimless, state-created crime that does not hurt or threaten anyone."

A variety of outreach efforts, such as television ads, were initially employed to encourage drivers and passengers to use seat belts (Insurance Institute for Highway Safety, 1972; Robertson et al., 1972). Slogans such as "buckle up for safety," "lock it to me," "what's your excuse," and the like were used in these campaigns. One television ad (Insurance Institute for Highway Safety 1972) titled "It doesn't hurt anymore…" featured a pretty girl sitting in a rocking chair holding a stuffed toy. She says, "I could go out more, but since the car crash, I just don't." She says she goes for walks with her father after dark, "That way I don't get, you know, stared at." She turns slowly to reveal a large scar on what was the hidden side of her face and says "It doesn't hurt anymore." Meanwhile an off camera announcer says, "Car crashes kill two ways; right away and little by little. Wear your seat belts." Robertson et al (1972) studied the effectiveness of these ads and concluded:

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[73] Secondary enforcement requires that a person be observed committing another violation (e.g., speeding) in order to be issued a ticket for failure to wear a seat belt. Data on the time series of states with primary versus secondary laws can be found in Cohen and Einav, 2001.

[74] See http://fee.org/freeman/detail/the-fraud-of-seat-belt-laws.

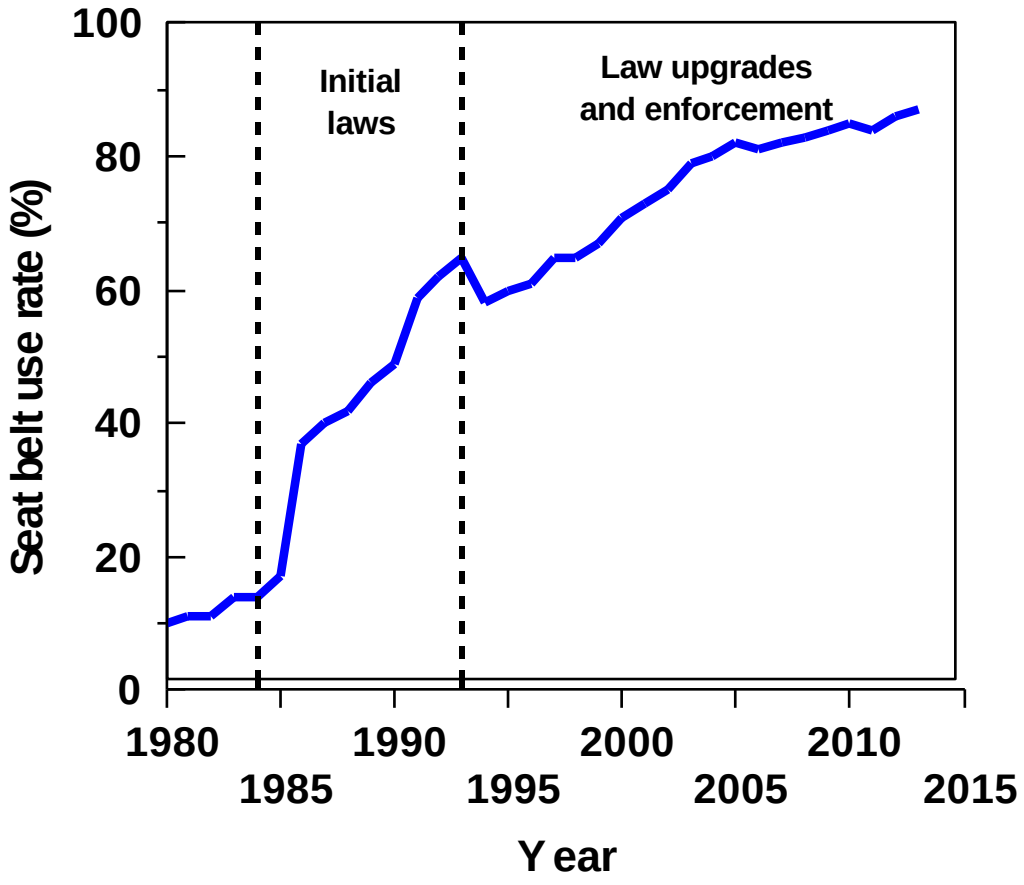
[75] See http://www.newswithviews.com/guest_opinion/guest27.htm.

> "A study shows that television campaigns do not have any effect on use of safety belts, thus supporting the argument that approaches directed toward changing behavior are inefficient and often ineffective means of reducing highway losses."

Some believed that the reason for failure of the voluntary program was just poor advertising. In 1985 a new campaign was developed using Vince and Larry, two crash test dummies with the tagline "You can learn a lot from a dummy" appeared and promptly won the advertising industry's prestigious Addy award, followed by a Cannes Film Festival Bronze Lion, and two CLIO awards in 1986 and 1987.[76]

Figure 16 shows a time series of measured front seat belt use in the United States (Nichols and Ledingham, 2008). The "voluntary period" did not result in an appreciable level of seat belt use. It was only after the states passed seat belt legislation that seat belt use increased appreciably.

Figure 16. Measured s*eat belt use rates 1980-2013 (Nichols and Ledingham, 2008 and NHTSA).*



[76] See http://americanhistory.si.edu/blog/2010/07/vince-and-larry-dummies-crash-into-the-smithsonian.html for a short history of this advertising program. See alsohttp://www.aef.com/exhibits/social_responsibility/ad_council/2434.

Estimates of the reduction in fatalities as a result of seat belt regulations differ somewhat (see Cohen and Einav, 2001), but all point to a successful program.

Seat belt use has increased over the years as shown in Fig. 16, but there are still differences in seat belt use among states and among various groups of drivers. Most modern research (see e.g., Nichols and Ledingham, 2008) is focused on finding better means (additional regulations and improved enforcement) to increase seat belt use from current relatively high levels.

As mentioned in the introduction to this chapter, selecting a regulatory, rather than a voluntary approach, does not mean that outreach efforts are no longer required. Indeed, advertising programs and other outreach efforts need to continue (along with enforcement efforts) to help avoid "backsliding." With seat belt advertisements (e.g., TV and social media) the messages have changed since regulation to those that remind motorists of the law and consequences for failure to use seat belts, such as "Click it or Ticket" (CIOT), but these continue.[77]

-Motorcycle helmets

Motorcycle helmets provide another interesting example of public health initiatives and their results. One article in the peer-reviewed literature (Jones and Bayer, 2007) provides a useful summary of this case. As with seat belts, use of motorcycle helmets is effective in reducing injuries to motorcycle riders in the event of an accident. Studies have demonstrated that helmets are about 37 percent effective in preventing motorcycle deaths and about 67 percent effective in preventing brain injuries.[78] The public health benefits of motorcycle helmets ultimately prompted inclusion of a provision in the 1966 National Highway Safety Act that withheld federal funding for highway safety programs to states that did not enact mandatory motorcycle helmet laws within a specified time frame. This provision was added after a study showed that helmet laws would significantly decrease the rate of fatal accidents. The National Highway Safety Act was passed without debate on the helmet law provision and ultimately 47 states, the District of Columbia, and Puerto Rico had passed mandatory helmet laws that applied to all riders. These laws reduced the incidence of fatal injuries (Jones and Bayer, 2007).

However, many motorcyclists felt that the helmet laws infringed on their personal rights and ultimately became sufficiently organized to oppose such legislation, which ultimately led to the repeal of the "offensive" provision of the National Highway Safety Act in 1976. Following this, several states repealed helmet laws, creating an unusual opportunity for an "after and before" study that ultimately showed an increase in fatality rates for those states that repealed helmet laws. Jones and Bayer (2007) conclude their article with the statement:

[77] See http://www.nhtsa.gov/PEAK for NHTSA's outreach materials with this theme.
[78] See http://www.iihs.org/iihs/topics/t/motorcycles/fatalityfacts/motorcycles.

> "This history of motorcycle helmet laws in the United States illustrates the profound impact of individualism on American culture and the manner in which this ideological perspective can have a crippling impact on the practice of public health. Although the opponents of motorcycle helmet laws seek to shape evidence to buttress their claims, abundant evidence makes it clear—and has done so for almost 3 decades—that in the absence of mandatory motorcycle helmet laws, preventable deaths and great suffering will continue to occur. The NHTSA estimated that 10, 838 additional lives could have been saved between 1984 and 2004 had all riders and passengers worn helmets. The success of those who oppose such statutes shows the limits of evidence in shaping policy when strongly held ideological commitments are at stake."

The motorcycle helmet example makes it clear that mandatory approaches do not always work as intended (although lives are still being saved in those states that have not repealed helmet regulations).

Summary

This chapter summarizes the various programs (voluntary and regulatory) employed by several countries to increase life jacket wear rates. Overall, the evidence supports the view that life jacket wear rates have increased in those countries with laws/regulations mandating life jacket use and that life jacket wear rates have not increased appreciably in those countries that have not chosen to regulate life jacket wear.

To date the United States has not opted for any broad requirement for boaters to wear life jackets (excepting youths and PWC users). Though wear rate studies demonstrate compliance with wear rate regulations, despite a variety of attractive outreach efforts, such as the "Wear It" and life jacket loaner programs, national life jacket wear rates among those not required to wear life jackets have not increased in the past 15 or so years that these have been measured. This conclusion suggests that regulation might be the only way to increase wear rates and reduce drowning fatalities appreciably.

The automobile seat belt and motorcycle helmet cases (as well as some of the experience with proposals for mandatory life jacket wear) show that there is likely to be some adverse public reaction to proposals for additional regulations that, however well intentioned, appear to limit personal freedom. In the case of seat belts the mandatory approach has ultimately proven to be very successful. With motorcycle helmets, regulations have undoubtedly saved lives, but opposition by some riders has led to the repeal of applicable laws in many states and, unfortunately additional fatalities in those states as a result. Overall these examples suggest that the Coast Guard should carefully consider any regulatory approach to try to develop an appropriate strategy. Outreach efforts alone have had at most limited success, but these efforts would certainly be needed if a regulatory approach is selected.

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Personal Communications

1. Chennell, P., RNLI to Jeffrey Hoedt, USCG on 31 July 2013 regarding life jacket wear rates in the UK.

Appendix

Table A-1. Fatalities, drownings, and whether or not life jacket was worn 1960 to 2013

Year	Number of fatalities	Number of drownings	Life Jacket worn	Life Jacket not worn	Unknown	Drownings as % fatalities	Life Jacket not worn as % drownings
1960	819	657				80.22	
1961	1101	976				88.65	
1962	1055	930				88.15	
1963	1104	968				87.68	
1964	1192	1057				88.67	
1965	1360	1158				85.15	
1966	1318	1172				88.92	
1967	1312	1118				85.21	
1968	1342	1203				89.64	
1969	1350	1260				93.33	
1970	1418	1305				92.03	
1971	1582	1472				93.05	
1972	1437	1318				91.72	
1973	1754	1604				91.45	
1974	1446	1314				90.87	
1975	1466	1274				86.90	
1976	1264	1052				83.23	
1977	1312	1062				80.95	
1978	1321	1065				80.62	
1979	1400	1174				83.86	
1980	1360	1193				87.72	
1981	1208	1086				89.90	
1982	1178	1042				88.46	
1983	1241	1096				88.32	
1984	1063	941				88.52	
1985	1116	954				85.48	
1986	1066	914				85.74	
1987	1036	891				86.00	
1988	946	788				83.30	
1989	896	753				84.04	
1990	865	707				81.73	
1991	924	739				79.98	
1992	816	673				82.48	
1993	800	667				83.38	

Year	Number of fatalities	Number of drownings	Life Jacket worn	Life Jacket not worn	Unknown	Drownings as % fatalities	Life Jacket not worn as % drownings
1994	784	613				78.19	
1995	829	628	68	534	26	75.75	88.7
1996	709	500	60	440	0	70.52	88.0
1997	821	588	65	523	0	71.62	88.9
1998	815	574	65	509	0	70.43	88.7
1999	734	517	64	453	0	70.44	87.6
2000	701	519	74	445	0	74.04	85.7
2001	681	498	78	420	0	73.13	84.3
2002	750	524	82	442	0	69.87	84.4
2003	703	481	65	416	0	68.42	86.5
2004	676	484	53	431	0	71.60	89.0
2005	697	491	65	426	0	70.44	86.8
2006	710	474	51	423	0	66.76	89.2
2007	685	476	49	427	0	69.49	89.7
2008	709	510	46	459	5	71.93	90.9
2009	736	543	87	385	71	73.78	81.6
2010	672	484	57	395	32	72.02	87.4
2011	758	533	84	415	34	70.32	83.2
2012	651	459	71	379	9	70.51	84.2
2013	560	398	61	328	9	71.07	84.3
Total	**55249**	**45877**	**1245**	**8250**	**186**	**83.04**	**86.9**
From 2000 through 2013	**9689**	**6874**	**923**	**5791**			**13.1**
		70.94%	**13.7%**				

Table A-2. Drownings and total fatalities by length from 2000 through 2013

Year	< 16 ft			16 - < 26 ft			26 - <40 ft		
	Drownings	Total	%	Drownings	Total	%	Drownings	Total	%
2000	267	337	79.2	164	245	66.9	24	41	58.5
2001	245	322	76.1	172	254	67.7	17	25	68.0
2002	254	331	76.7	179	290	61.7	19	37	51.4
2003	209	297	70.4	179	280	63.9	27	41	65.9
2004	193	255	75.7	186	279	66.7	8	22	36.4
2005	226	308	73.4	187	278	67.3	21	38	55.3
2006	201	282	71.3	182	279	65.2	16	39	41.0
2007	192	263	73.0	204	298	68.5	20	41	48.8
2008	236	292	80.8	185	281	65.8	29	59	49.2
2009	251	308	81.5	213	317	67.2	18	30	60.0
2010	224	289	77.5	201	295	68.1	23	37	62.2
2011	258	315	81.9	198	316	62.7	26	41	63.4
2012	214	278	77.0	178	262	67.9	22	47	46.8
2013	209	264	79.2	146	219	66.7	18	30	60.0
Total	**3179**	**4141**	**76.8**	**2574**	**3893**	**66.1**	**288**	**528**	**54.5**
Average	**227.1**	**295.8**	**76.8**	**183.9**	**278.1**	**66.1**	**20.6**	**37.7**	**54.5**

Year	40 – 65 ft			> 65 ft			Unknown		
	Drownings	Total	%	Drownings	Total	%	Drownings	Total	%
2000	6	9	66.7	3	3	100.0	55	66	83.3
2001	4	7	57.1	2	3	66.7	58	70	82.9
2002	3	6	50.0	1	4	25.0	68	82	82.9
2003	4	8	50.0	1	1	100.0	61	76	80.3
2004	2	5	40.0	1	1	100.0	94	114	82.5
2005	3	9	33.3	0	0	#N/A	54	64	84.4
2006	3	12	25.0	3	4	75.0	69	94	73.4
2007	4	7	57.1	1	2	50.0	55	74	74.3
2008	5	9	55.6	0	1	0.0	55	67	82.1
2009	2	7	28.6	0	0	#N/A	59	74	79.7
2010	3	8	37.5	0	0	#N/A	33	43	76.7
2011	2	7	28.6	2	2	100.0	47	77	61.0
2012	5	11	45.5	0	0	#N/A	40	53	75.5
2013	1	5	20.0	7	7	100.0	17	35	48.6
Total	**47**	**110**	**42.7**	**21**	**28**	**75.0**	**765**	**989**	**77.4**
Average	**3.4**	**7.9**	**42.7**	**1.5**	**2.0**	**75.0**	**54.6**	**70.6**	**76.3**

Table A-3. Statistical analysis of length data

Length Range	Drownings	Other deaths	Total	LCL	Est	UCL
< 16 ft	3179	962	4141	0.7545	0.7677	0.7804
16 - < 26 ft	2574	1319	3893	0.6461	0.6612	0.676
26 - < 40 ft	288	240	528	0.5019	0.5455	0.5884
40 – 65 ft	47	63	110	0.3346	0.4273	0.5252
> 65 ft	21	7	28	0.5478	0.75	0.8857

Chi-Square	218.34
Degrees of freedom	4
p	<0.0001

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Table A-4. Drownings and total fatalities by vessel type from 2000 through 2013

Year	Open Motorboat			Cabin Motorboat			Canoe/Kayak		
	Drownings	Total	%	Drownings	Total	%	Drownings	Total	%
2000	280	361	77.6	32	65	49.2	93	104	89.4
2001	256	352	72.7	24	41	58.5	94	101	93.1
2002	307	423	72.6	30	53	56.6	67	78	85.9
2003	244	359	68.0	42	64	65.6	74	87	85.1
2004	244	351	69.5	30	42	71.4	93	98	94.9
2005	253	351	72.1	25	54	46.3	64	78	82.1
2006	226	346	65.3	29	55	52.7	86	99	86.9
2007	230	334	68.9	33	53	62.3	97	107	90.7
2008	252	353	71.4	27	59	45.8	100	114	87.7
2009	279	393	71.0	26	45	57.8	120	131	91.6
2010	213	325	65.5	19	31	61.3	128	141	90.8
2011	253	374	67.7	24	47	51.1	118	134	88.1
2012	211	286	73.8	35	55	63.6	83	102	81.4
2013	189	272	69.5	17	25	68.0	93	109	85.3
Total	**3437**	**4880**	**70.4**	**393**	**689**	**57.0**	**1310**	**1483**	**88.3**

Year	PWC			Rowboat			Inflatable		
	Drownings	Total	%	Drownings	Total	%	Drownings	Total	%
2000	24	68	35.3	35	38	92.1	15	16	93.8
2001	11	50	22.0	47	49	95.9	14	16	87.5
2002	21	71	29.6	34	35	97.1	11	11	100.0
2003	15	57	26.3	52	58	89.7	8	12	66.7
2004	14	56	25.0	47	55	85.5	12	13	92.3
2005	21	65	32.3	37	39	94.9	21	22	95.5
2006	22	68	32.4	33	35	94.3	19	23	82.6
2007	14	67	20.9	30	33	90.9	5	6	83.3
2008	17	45	37.8	39	43	90.7	8	8	100.0
2009	14	42	33.3	40	42	95.2	28	30	93.3
2010	9	38	23.7	33	35	94.3	22	22	100.0
2011	18	44	40.9	44	52	84.6	23	25	92.0
2012	23	58	39.7	19	23	82.6	28	30	93.3
2013	13	36	36.1	26	30	86.7	10	14	71.4
Total	**236**	**765**	**30.9**	**516**	**567**	**91.0**	**224**	**248**	**90.3**

Table A-5. Statistical analysis of vessel type data

Boat Types	Drownings	Other	Total	LCL	Fractions Estimated	UCL
Rowboat	516	51	567	0.8827	0.9101	0.9317
Inflatable	224	24	248	0.8577	0.9032	0.9357
Canoe/Kayak	1310	173	1483	0.8656	0.8833	0.899
Open motorboat	3437	1443	4880	0.6912	0.7043	0.717
Cabin motorboat	393	296	689	0.5324	0.5704	0.6076
PWC	236	529	765	0.2762	0.3085	0.3428
Subtotal	6116	2516	8632	0.6988	0.7085	0.718

Chi-Square	1030
Degrees of freedom	5
p	<0.0001

Table A-6. Drownings and total fatalities by accident type, 2000-2013

	Falls overboard		Capsizing		Flooding/swamping		Departed vessel	
Year	Drownings	Fatalities	Drownings	Fatalities	Drownings	Fatalities	Drownings	Fatalities
2000	182	213	189	205	40	47	--	---
2001	156	176	193	210	34	47	14	15
2002	167	189	200	228	40	50	31	33
2003	169	201	170	206	36	41	38	39
2004	163	199	162	184	45	52	35	36
2005	185	213	164	199	31	33	39	40
2006	161	202	190	215	20	26	32	35
2007	169	208	187	204	30	35	33	33
2008	157	188	163	189	80	89	37	37
2009	152	188	180	199	82	99	48	51
2010	130	161	167	180	61	72	57	62
2011	148	205	147	163	73	89	62	75
2012	153	197	109	133	58	68	58	65
2013	120	149	93	112	58	67	44	52
Total	**2212**	**2689**	**2314**	**2627**	**688**	**815**	**528**	**573**
Percentage	**32.18**	**27.75**	**33.66**	**27.11**	**10.01**	**8.41**	**7.68**	**5.91**

	Allision		Ejected from vessel		All other		Total	
Year	Drownings	Fatalities	Drownings	Fatalities	Drownings	Fatalities	Drownings	Fatalities
2000	24	42	--	--	84	194	519	701
2001	17	49	11	17	73	167	498	681
2002	16	53	5	7	65	190	524	750
2003	19	50	3	5	46	161	481	703
2004	23	46	12	16	44	143	484	676
2005	18	41	--	--	54	171	491	697
2006	21	47	8	13	42	172	474	710
2007	11	35	13	25	33	145	476	685
2008	23	53	11	17	39	136	510	709
2009	17	41	20	24	44	134	543	736
2010	19	38	11	20	39	139	484	672
2011	22	58	35	47	46	121	533	758
2012	24	50	15	21	42	117	459	651
2013	36	56	16	22	31	102	398	560
Total	**290**	**659**	**160**	**234**	**682**	**2092**	**6874**	**9689**
Percentage	**4.22**	**6.80**	**2.33**	**2.42**	**9.92**	**21.59**	**100.00**	**100.00**
Selected 6	**90.1%**	**78.4%**						

Table A-7. Recreational boating fatalities and environmental conditions

		Drownings		Fatalities	
		Total Number	Percent	Total Number	Percent
Waterbody Years 2008 - 2013	Lakes, Ponds, Reservoirs, Dams, Gravel Pits	1457	49.8%	1957	47.9%
	Rivers, Streams, Creeks, Swamps, Bayous	920	31.4%	1220	29.9%
	Bays, Inlets, Marinas, Sounds, Harbors,	246	8.4%	394	9.6%
	Channels, Canals, Sloughs, Coves	68	2.3%	142	3.5%
	Ocean, gulf	173	5.9%	290	7.1%
	Great lakes (not tributaries)	62	2.1%	82	2.0%
	Unknown	1	0.03%	1	0.02%
	Total	2927	100%	4086	100%
Water conditions Years 2000-2013	Calm	3049	44.4%	4563	47.1%
	Choppy	1509	22.0%	2211	22.8%
	Rough	899	13.1%	1127	11.6%
	Strong Current	254	3.7%	280	2.9%
	Unknown	801	11.7%	1074	11.1%
	Very Rough	357	5.2%	429	4.4%
	Whitewater	5	0.1%	5	0.1%
	Grand Total	6874	100%	9689	100%
Wind Years 2000-2013	Light	2920	42.5%	4281	44.2%
	Moderate	1429	20.8%	2072	21.4%
	None	702	10.2%	991	10.2%
	Storm	242	3.5%	292	3.0%
	Strong	892	13.0%	1103	11.4%
	Unknown	689	10.0%	950	9.8%
	Grand Total	6874	100%	9689	100%
Visibility Years 2000-2013	Fair	638	9.3%	887	9.2%
	Good	4932	71.7%	6954	71.8%
	Poor	429	6.2%	648	6.7%
	Unknown	875	12.7%	1200	12.4%
	Grand Total	6874	100%	9689	100%
Water temperature Years 2000-2013	<39	144	*2.7%	192	*2.6%
	>60	3228	*61.2%	4825	*64.9%
	>69	2364	*44.8%	3630	*48.8%
	Unknown	1596		2256	
	Total	6874		9689	

*of “known” temperature

Table A-8. Top ten known primary contributing factors of boating accidents 2000-2013

	Drownings		
2000-2013 Primary Contributing Factor of Drownings	Total Number	Percent	
Alcohol use	1121	16.3%	
Hazardous waters	799	11.6%	
Heavy weather	561	8.2%	
Operator inexperience	487	7.1%	
Operator inattention	420	6.1%	65.0% of Total
Overloading	296	4.3%	
Improper loading	294	4.3%	
Navigation rules violation	180	2.6%	
Machinery failure	156	2.3%	
People on Bow/transom	151	2.2%	

Table A-9. Boating fatalities, registrations, and fatality rates for Tasmania

Year	Recreational boat fatalities	Boat registrations	Fatalities per 100,000 boats
1987	6	9624	62.34
1988	0	9876	0.00
1989	3	10020	29.94
1990	1	10224	9.78
1991	5	10439	47.90
1992	5	10896	45.89
1993	1	11030	9.07
1994	3	11430	26.25
1995	2	11844	16.89
1996	3	12273	24.44
1997	1	12718	7.86
1998	4	13176	30.36
1999	12	15084	79.55
2000	3	15928	18.83
2001	3	18841	15.92
2002	2	19931	10.03
2003	1	21045	4.75
2004	1	22179	4.51
2005	0	23407	0.00
2006	4	24628	16.24
2007	3	25365	11.83
2008	0	26072	0.00
2009	1	27342	3.66
Prelaw mean	**3.50**		**29.22**
Postlaw mean	**1.67**		**7.44**

Source: Mr. Peter Hopkins, MAST

Table A-10. Fatalities per vehicle hour for recreational boats (2012), motor vehicles, and motorcycles

Recreational boating, 2012

Quantity	Value	Source
Number boats (000)	21,611	Survey results
Average days/boat	11.30	Survey results
Boating days (000)	244,203	Survey results
Average use (Hrs/day)	5.70	Survey results
Mean persons aboard/day	2.40	Survey results
Person hours (millions)	3,584	Survey results
Boat hours (millions)	1,493	Calculation
Fatalities	651	Boating Statistics, 2012
Drowning deaths	459	Boating Statistics, 2012
Fatalities/million boat hours	**0.436**	Calculation
Drownings/million boat hours	**0.307**	Calculation

Some figures for comparison:

Motor vehicles Source: http://www-fars.nhtsa.dot.gov/Main/index.aspx.

Year	Total Fatalities	VMT (billions)
2003	42,884	2,890
2004	42,836	2,965
2005	43,510	2,989
2006	42,708	3,014
2007	41,259	3,031
2008	37,423	2,977
2009	33,883	2,957
2010	32,999	2,967
2011	32,367	2,946
2012	33,561	2,946
Total	**383,430**	**29,682**

Note: Includes all vehicle occupants, motorcyclists, and non-occupants (e.g., pedestrians)

Assumed average speed (MPH)	Exposure hours (millions)	Fatalities per million hours
20	1,484,107	0.258
25	1,187,285	0.323
30	989,404	0.388
32	927,567	0.413
35	848,061	0.452

Note: Average vehicle speed is approximately 30 mph, see http://nhts.ornl.gov/2009/pub/stt.pdf, Table 27 on page 48.

Thus, average fatalities per million vehicle hours is approximately **0.39**.

Motor cycles	Source: Fatalities: http://www-fars.nhtsa.dot.gov/Main/index.aspx. VMT: http://www-nrd.nhtsa.dot.gov/Pubs/811639.pdf	
Year	**Total Fatalities**	**VMT (millions)**
2003	3,714	9,576
2004	4,028	10,122
2005	4,576	10,454
2006	4,837	12,049
2007	5,174	21,396
2008	5,312	20,811
2009	4,469	20,822
2010	4,518	18,462
2011	4,630	18,500
2012	4,957	18,500
Total	**46,215**	**160,692**

Assumed average speed (MPH)	**Exposure hours (millions)**	**Fatalities per million hours**
20	8,035	5.752
25	6,428	7.190
29.8	5,392	8.571
30	5,356	8.628
35	4,591	10.066

Note: The median pre-crash speed according to one study was 29.8 mph,
see http://www.magpie.com/nycmoto/hurt.html. "Findings from the Hurt study."