Personal Watercraft (PWC) Management Guide: a Comprehensive Reference Handbook

A PUBLICATION OF THE MASSACHUSETTS OFFICE OF COASTAL ZONE MANAGEMENT AND THE EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

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Dear Friend:

Recreational boating is an important part of our culture in Massachusetts and an increasing number of residents and visitors are participating in boating and boating-related activities. In recent years, the growth and diversification of boating on Commonwealth waters has begun to challenge coastal managers by fueling an array of recreational boating issues and conflicting waterways uses.

Personal watercraft (PWC) are widely perceived as being among the most difficult recreational vessels to manage. They are frequently associated with management issues such as ecological damage, aesthetic degradation, multiple-use conflicts and public safety concerns, and they pose further concern because they can navigate in shallow water areas that are less accessible by other craft. However, few scientific studies have investigated, quantified or evaluated the environmental impacts of PWC operation and little is known about the cumulative or relative nature of PWC-related impacts.

In response to this widespread uncertainty, the Massachusetts Office of Coastal Zone Management, in partnership with the National Oceanic and Atmospheric Administration's Coastal Services Center, has collected and evaluated scientifically valid environmental, safety and management data to support the responsible development of public policy regarding the management of PWC. This document presents the findings of that work.

I hope that municipal, state, federal and non-profit coastal managers, as well as others involved in recreational boating issues will find it helpful in addressing the many difficult aspects of personal watercraft management. Thank you for your interest in keeping Massachusetts waters clean, safe and enjoyable for its many diverse user groups.

Very truly yours,

Bob Durand
Secretary of Environmental Affairs
Commonwealth of Massachusetts

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EXECUTIVE SUMMARY

Personal watercraft (PWC) are compact, powerful and agile vessels that have revolutionized the world of recreational boating. Although PWC ownership and sales have decreased in recent years, PWC use has remained high and these vessels continue to represent a modest, yet profitable sector of the recreational boating industry. However, as PWC popularity and use has increased, so has public concern regarding their impact on the physical and socio-cultural environment. Few studies specifically examine the consequences of PWC design and use, but these vessels are frequently associated with management issues such as multiple-use conflicts, noise complaints, public safety concerns and natural resource damage. The *PWC Management Guide* attempts to improve community-based management of these issues by providing updated information about PWC characteristics and the ecological and social impacts that these vessels have on coastal and marine resources.

In general, the *PWC Management Guide* serves as a reference handbook for the diverse array of individuals, agencies and communities involved in PWC management. It targets a large audience and provides instruction on assessing and managing PWC-related environmental impacts. Moreover, it offers a framework by which to evaluate individual PWC management efforts and, if used by communities sharing a given body of water, it potentially enhances the consistency and compatibility of concurrent management efforts. Although the *Guide* focuses primarily on marine and estuarine environments, most of the information it presents is also applicable to freshwater systems.

Chapter One provides insight into the history and popularity of these unique vessels and discusses some of the underlying considerations that readers should keep in mind when addressing PWC issues. Chapter Two summarizes the information that currently exists regarding the environmental impacts of recreational boating (i.e. air and water pollution, wildlife disturbance, habitat destruction, noise, aesthetic degradation and public safety threats). In doing so, it compares PWC-related impacts to those of more traditional vessels and highlights some of the scientific uncertainties that complicate PWC management. Chapter Two also delineates the data and information necessary to conduct site-specific PWC assessments. These data and information are important because the factors that determine the nature and extent of PWC impacts vary widely and it is not always possible to transfer scientific results from one site to another.

Chapter Three presents a broad range of management strategies that can be used to mitigate PWC impacts. These strategies range from rather simple, voluntary measures to complex regulatory frameworks. In between are a myriad of more moderate strategies, such as zoning, education, licensing, certification and noise abatement. Where possible, Chapter Three uses illustrative case studies to show how these strategies can be modified to meet the specific needs of different communities. Finally, since effective PWC management begins with effective policy development, Chapter Four examines both the general steps and specific considerations that pertain to PWC policy development. More specifically, it discusses the recognition, definition and refinement of emerging issues; the development and evaluation of policy alternatives; and the initiation, implementation and modification of selected policy solutions.

CHAPTER ONE: INTRODUCTION

1.1 PWC HISTORY
1.2 PWC POPULARITY
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INTRODUCTION

The environmental impacts of recreational boating are well studied and widely documented. Scientific literature abounds with studies regarding the physical damage and disturbance caused by traditional vessels such as outboard motorboats and sailboats, as well as the impacts linked to boating-related activities such as fishing and water skiing. Resource managers and municipal officials use these studies to develop comprehensive boating policies that effectively balance recreational water uses with natural resource protection; however, recent increases in the popularity and use of personal watercraft (PWC) have complicated such policy development. These controversial vessels, which are easily distinguished by their unique design and operational characteristics, create a variety of concerns for both resource managers and the public.

Few studies specifically examine the consequences of PWC use but these vessels are frequently associated with management issues such as multiple-use conflicts, noise complaints, safety concerns and natural resource damage. Efforts to alleviate these problems are complicated by debates regarding scientific uncertainty, public perception, individual biases and the feasibility of different management strategies. These debates hamper the collaborative and consensus-building processes that are necessary to develop successful management initiatives. This manual attempts to inform these debates and improve management efforts by providing updated information about PWC and how they affect coastal and marine resources.

1.1 PWC HISTORY

PWC are compact, powerful and agile vessels that have revolutionized the world of recreational boating. According to the United States Coast Guard (USCG), PWC are classified as inboard boats under 16 feet in length; however, PWC are more generically described as:

> …any vessel propelled by a water jet pump (rather than a propeller) …that is designed to be operated by a person sitting, standing or kneeling on the vessel (rather than in it).

This definition does not place size restrictions on PWC, nor does it include open-cabin vessels or non-motorized craft.

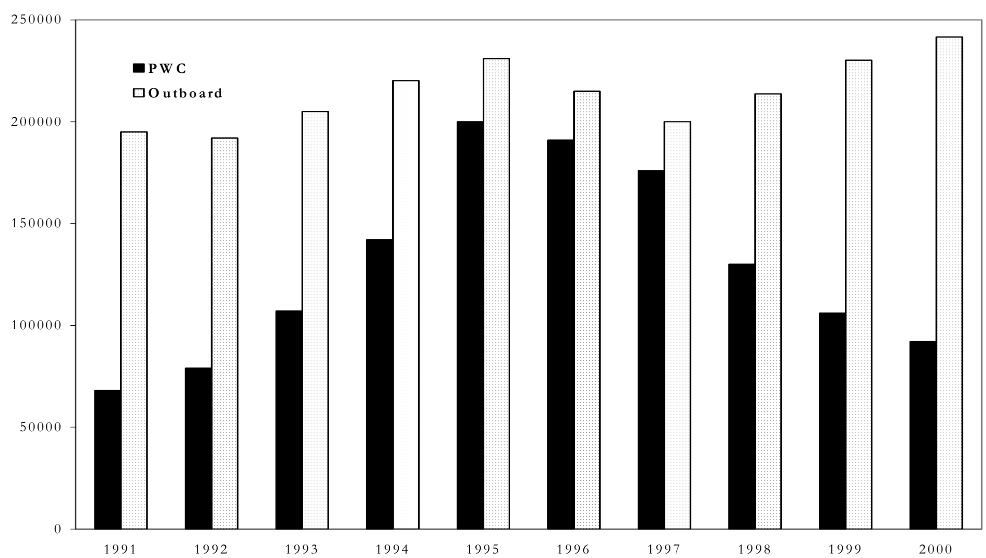
PWC were invented in the 1960s but they did not achieve commercial success until the early 1970s, when Kawasaki introduced its landmark Jet Ski®. Since then, several other marine manufacturers have also profitably marketed PWC, including Bombardier (Sea-Doo®), Honda, Polaris and Yamaha (Waverunner®) (PWIA 2000). The innovation and success of these companies has created a complete PWC-subculture that includes competitive events, membership clubs, trade associations, consumer magazines and Internet sites. PWC use, which began as a unique marketing scheme in the 1970s and exploded into a rapidly growing sport in the 1980s, has, in recent years, matured into a modest yet profitable sector of the recreational boating world.

1.2 PWC POPULARITY

PWC are appealing to some boaters for several reasons. First, compared to most other motorized vessels, the cost and maintenance involved in owning a PWC is relatively low. Second, PWC are easy to trailer, transport and launch. Their small size makes them easy to tow or store but they are large enough to accommodate up to four passengers and carry large amounts of fuel and gear. These attributes make PWC ideal for boaters who travel or are unable to moor a larger vessel. Third, PWC are simple to operate and can be used by individuals with very little instruction or training. Finally, many people think PWC are fun. These versatile vessels provide an exciting mix of speed, power and maneuverability and enable riders to participate in a wide range of activities including pleasure cruising, long-distance touring, racing and water skiing. In general, PWC have expanded the world of recreational boating to a larger, more diverse sector of the public and will most likely continue to be used throughout coastal and inland waterways.

It is widely asserted that PWC are the fasting growing sector of the boating industry and that their sales are skyrocketing. However, data from the National Marine Manufacturers Association (NMMA) suggest otherwise. As shown in Figure 1, NMMA data indicates that PWC sales exploded in the early 1990s, but that they peaked in 1995 and have been steadily decreasing ever since. Outboard motorboat sales, on the other hand, remained rather stable throughout the 1990s and have even been increasing in the past few years (NMMA 2000).

Figure 1. Annual Vessel Sales



Unfortunately, the NMMA data only accounts for the sale of new motorboats and PWC, not used ones. Since the NMMA does not track the resale of motorboats and PWC, more accurate comparisons between vessel sales cannot be made. However, national vessel registration data suggest that PWC ownership has decreased slightly in recent years, while the ownership of other motorized vessels has increased (NMMA 2000). Decreases in PWC registrations are due to declining PWC sales, as well as to their relatively short life spans, which have resulted in the scrapping of a large number of the PWC sold in the early 1990s. Regardless of decreasing ownership and sales, overall PWC use continues to be significantly high. For example, in 1999, only 1.1 million PWC were registered nationally (NMMA 2000) but about 19.5 million people participated in PWC use (Leeworthy 2001). By comparison, 51 million people participated in motorboating that year, but almost 17 million motorboats were registered. These data suggest that PWC have carved a relatively small, yet persistent niche in the world of recreational boating.

1.3 OVERARCHING PWC MANAGEMENT CONSIDERATIONS

Readers should keep a few overarching considerations in mind when reading this manual:

- Despite significant gaps in PWC-specific research, a wealth of peer-reviewed scientific literature exists regarding the environmental impacts of recreational boating. This information facilitates well-informed management initiatives by identifying assumptions and clarifying perceptions regarding PWC operation and design. It also enables managers to correctly differentiate between PWC and other vessels.

- Much of the existing information on PWC design is dated and does not account for recent technological advances that have made newer PWC models safer, more fuel-efficient and less polluting.

- Generally, the adverse impacts attributed to PWC also apply to other recreational vessels and activities, as well as various landside activities. To effectively protect natural resources and public safety, PWC impacts should be assessed and managed in a manner that considers the impacts of other recreational and aquatic uses.

- PWC management should be a site-specific process. Certain generalizations can be made about PWC design, use and impact but the factors contributing to PWC-related impacts vary widely. These factors include physical characteristics such as water depth, wildlife presence and habitat type, as well as operational characteristics such as local PWC usage levels or operator education and experience. Supplemental, site-specific data and information are necessary to identify the impacts that are occurring in a given area and to select effective management alternatives.

1.4 PURPOSE OF THE *PWC MANAGEMENT GUIDE*

In general, this manual serves as a reference handbook for the diverse array of individuals, agencies and communities involved in PWC management. It targets a large audience and provides instruction on assessing and managing PWC impacts. Moreover, it offers a framework by which to evaluate individual PWC management efforts and, if used by communities sharing a given body of water, it enhances the consistency and compatibility of concurrent management efforts.

The manual begins by summarizing the information that currently exists regarding recreational boating and PWC impacts. When possible, it compares PWC-related impacts to those of more traditional recreational vessels and attempts to clarify public perception of PWC. It also discusses the information and data needed to conduct site-specific PWC assessments and illustrates a broad range of management strategies that can be used to mitigate PWC impacts. Finally, this manual presents some general policy considerations to guide PWC management. Although it is not exhaustive, this manual is one of the most inclusive PWC references available at this time.

1.5 References

Leeworthy, V.R. 2001. Preliminary Estimates from Versions 1-6: Coastal Recreation Participation. 2000 National Survey on Recreation and the Environment. Silver Spring, MD: National Ocean Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Personal Watercraft Industry Association. 2000. The Personal Watercraft Story. Available at: http://www.pwia.org/abo_PWIA.htm.

National Marine Manufacturers Association. 2000. National Boating Statistics. Available at: http://www.nmma.org/facts/boatingstats/200stats.

CHAPTER TWO:
IMPACTS OF RECREATIONAL BOATING & PWC USE

IMPACTS OF RECREATIONAL BOATING & PWC USE

Recreational boating raises a number of issues for coastal resource managers and the public, including noise complaints, safety concerns and various environmental impacts. Although much information is available about these issues, relatively little is known about PWC-specific impacts or how they compare to those of more traditional vessels. This lack of information impairs the development of scientifically-sound resource policy and undermines the effectiveness of PWC management initiatives.

To rectify this, this section of the PWC Management Guide comprehensively reviews the scientific literature that does exist regarding PWC impacts. It discusses PWC use in the general context of recreational boating and, where appropriate, distinguishes between impacts that are unique to PWC and those that are relevant to other types of motorized vessels. This section also addresses the scientific uncertainties, data gaps and widespread misinformation that managers must contend with. Finally, it suggests important points to be considered as management alternatives are selected and strategies are developed.

2.1 NOISE

Physically speaking, noise is a measurement of sound (Box 1) and is a function of three variables: loudness, pitch and temporal variability (Komanoff and Shaw 2000).

Box 1. The Physics of Sound

Sound is a form of mechanical energy transmitted by rapid pressure (P) changes in an elastic medium, such as air or water. Acoustic pressures exhibit a huge and dynamic range, making them difficult to manage mathematically. Therefore, they are usually converted into a scale of decibels (dB) using the logarithmic equation:

dB= 20 log (P/(2x10^-5)

When using this scale, it is important to note that separate sounds cannot be directly added to calculate a cumulative sound. Rather, the dB values must be converted back into acoustic pressures, added and then converted back into dB. Therefore, relatively small changes in dB ratings correspond to significant changes in sound (Komanoff and Shaw 2000).

Sound waves travel through seawater at approximately 1480 m/s and through air at about 331 m/s. As sound travels through these media, its intensity decreases due to spreading, scattering and/or absorption. This decrease is proportional to the given power of the distance between the source of the sound and the receiver. This corresponds to a sound reduction of 5dB (over water) to 6dB (over land) for each doubling of distance between the source and receiver of the sound (Garrison 1999, Gross 1993).

Loudness, which corresponds to the amplitude of a sound wave, is the difference between atmospheric pressure (without sound) and total pressure (with sound). It is measured in decibels and is the most common variable examined in noise issues.

Pitch, measured in Hertz (Hz), corresponds to wave frequency and is the rate at which a sound vibrates. In seawater, sound absorption is proportional to the square of sound frequency; therefore, high frequency sounds are absorbed quickly and don't travel as far through the water as low frequency sounds (Garrison 1999).

Temporal variability refers to the changing nature of noise patterns and can be described as continuous, fluctuating, intermittent or impulsive (see Table 1). Regardless of their relative noise level, fluctuating noises tend to be the most annoying because they penetratingly attract the hearer's attention and are difficult to "tune out."

TABLE 1. Types of Noise

Type	Characteristics	Example
Continuous	long duration; constant noise level	*waterfall*
Fluctuating	long duration; variable noise level	*freeway traffic*
Intermittent	short duration	*ringing telephone*
Impulsive	extremely short duration; loud	*gunshot*

Noise, or "unwanted sound," threatens public health and welfare by contributing to hearing loss and stress and by interfering with human activities such as thought, communication and sleep. Noise also detracts from environmental quality by polluting peace or serenity and by disturbing sensitive wildlife (US EPA 1974).

2.1.1 PWC and Noise

Noise is a ubiquitous complaint among beach-goers, waterfront property owners and traditional boaters who express their dislike of the high-pitched whine of PWC. Environmental advocates who contend that PWC noise compromises the integrity of marine and coastal environments by degrading quality of life, destroying recreational experiences and threatening wildlife, also highlight noise issues. PWC industry officials, on the other hand, emphasize that technological innovations such as baffles, insulation and resonator-equipped mufflers have significantly reduced PWC noise and that newer models are two to eight times quieter than older ones (PWIA 2000a). Their claims are backed by studies suggesting that, under analogous operating conditions, PWC are no louder than similar motorized vessels (Noise Unlimited 1995) and that PWC comply with all existing noise regulations.

According to the National Pollution Clearinghouse (NPC), PWC compliance with decibel regulations is a moot point. The NPC maintains that PWC have unique design and use characteristics that make them more annoying than other motorized vessels. For example, by continually leaving and reentering the water, PWC create rapid cycles of variable noise that disturb humans and wildlife. The repetitive smacking of PWC hulls against the water and the tendency of PWC operators to circle about the same location for extended periods of time also exacerbate PWC noise (Komanoff and Shaw 2000). For these reasons, many environmental groups charge that PWC use in near-shore areas subjects public beaches and habitat areas to excessive noise. They argue that more stringent PWC regulations are necessary to protect sensitive wildlife species and to maintain public health and welfare (Bluewater Network 1998, Martin 1999, NPCA 1999).

The Personal Watercraft Industry Association (PWIA), on the other hand, emphasizes the need for public waterways to accommodate a variety of users. Although it sympathizes with public concerns, the PWIA advocates for management strategies that fairly address the noise impacts of PWC and other motorized vessels. Specifically, the PWIA endorses the use of shoreline sound measurement laws, the establishment of slow/no-wake zones and the development of educational programs that promote socially-responsible and environmentally-sensitive PWC use (PWIA 2000b).

2.1.2 Management Considerations

- Noise is a function of loudness (dB), pitch (Hz) and temporal variability. While most new PWC models meet or exceed existing noise regulations, the high-pitched whine and operational behaviors associated with PWC continue to make them more annoying to many people.

- Since PWC have shallow drafts and lack propellers, they can operate at much higher speeds closer to shore than other types of motorized vessels. Therefore, in certain places or given certain operational behaviors, PWC-related noise may have a greater impact on wildlife and coastal visitors than other vessels.

- Buffer zones can be used to protect sensitive wildlife species and to minimize the disturbance that PWC cause to shorefront property owners, beachgoers and other coastal resource users.

- Researchers need to address the following data gaps and scientific uncertainties:

    - How wildlife species respond to PWC noise and how these responses vary over time.

    - The effect of PWC noise on the experience and satisfaction of coastal visitors.

    - The effectiveness of setback-distances and buffer zones at mitigating noise impacts.

2.2 SAFETY

In contrast to recreational boating issues that are linked to an increasing number or diversity of vessels on the water (i.e., overcrowding and multiple-use conflicts), safety issues rarely correlate to overall boating levels. In fact, research shows that most boating-related accidents, injuries and fatalities are linked to irresponsible and inappropriate vessel use rather than to the number of vessels on the water (American Red Cross 1991; NTSB 1998). Congress addressed this issue in 1971 by passing the Safe Boating Act, which expanded the USCG's role in supervising public waterways and enhanced its ability to improve recreational boating safety. Despite this federal action, however, many local and state law enforcement agencies continue to struggle with maintaining a safe recreational boating environment.

In recent years, this struggle has been exacerbated by notable increases in PWC use. PWC have certain characteristics that may make them more difficult to control than other vessels, especially for young or inexperienced riders (Williams 1996). These characteristics, combined with the thrill-seeking behavior of some PWC riders, give rise to distinct differences in the cause and nature of PWC safety incidents (American Academy of Pediatrics 2000; Branch *et al.* 1997; Clarke 2000; Hamman 1993). Moreover, they draw negative attention from safety officials, law officers and much of the boating public and have resulted in the implementation of PWC-specific restrictions throughout the country.

Despite these safety concerns, it is difficult to ascertain whether or not PWC pose a more eminent threat than other vessels. Vessel-specific accidents and injuries cannot be quantified because of insufficient reporting and incomplete accident and injury data makes it difficult to estimate, much less compare, the relative safety of different vessel types (NTSB 1998). Nonetheless, PWC are widely perceived to be a threat to public safety and this perception continues to be a driving force behind many PWC management initiatives.

2.2.1 PWC Design Characteristics

As previously noted, many of the high-performance design characteristics that make PWC appealing to ride also make them relatively dangerous and difficult to control. For example, PWC can accelerate rapidly and can travel across the water at very high speeds. They can also turn abruptly and weave through heavily congested boat traffic. Despite this maneuverability, PWC can be difficult to slow, stop or reverse. In fact, the only way to stop most PWC is to lay off the throttle and coast, which can be precarious when operating a PWC near other vessels or obstacles (Bluewater Network 1998; NPCA 1999). Stability can also be problematic for PWC operators. Older, smaller PWC models may be less stable than other vessels and may capsize when the operator falls off, thereby putting the operator at risk of drowning or being hit by a passing vessel (NPCA 1999). Finally, many PWC lack "off-throttle steering" so the vessel can only be turned if the engine is receiving sufficient power. This power-dependent steering mechanism is counterintuitive to most boaters and may contribute to PWC collisions (Bluewater Network 1998; NPCA 1999; NTSB 1998).

PWC manufacturers have addressed many of these design-related safety concerns. First, most new PWC models are larger, heavier and more stable. They do not leave the water as frequently as older models and are relatively difficult to capsize. Second, many newer PWC models have highly responsive reversible throttles that can be used to slow or maneuver the vessel. Many new models also have secondary steering mechanisms that enable riders to control the vessel if the throttle is disengaged. Third, all newly manufactured PWC models are equipped with mandatory "kill-switches." These switches are linked to the driver's wrist via a lanyard and automatically cut the power to the engine if the driver falls from the vessel (PWIA 2000).

Marine manufacturers have also partnered with government to reduce the speed at which PWC are designed to operate. Current government-industry recommendations state that new, factory-equipped PWC should not exceed a speed of 65 mph and various regulations have been proposed to prohibit the modification of PWC engines. Moreover, PWC manufacturers and their associates actively promote safe vessel operation by creating and distributing instructional brochures, manuals and videos (Martin 1999; PWIA 2000).

2.2.2 PWC Operational Behavior

Despite improvements to PWC design and safety, the improper, careless and inconsiderate behavior of some operators continues to be an issue for safety officials, boaters and marine resource users. For example, PWC riders launching or operating near public beaches can jeopardize swimmers and annoy beachgoers, while riders zig-zagging through congested waters or jumping boat wakes increase the likelihood of collisions, injuries and property damage. Although occurrences of these behaviors have not been quantified and are not unique to these vessels, but the operational behaviors of PWC riders have been closely scrutinized in recent years.

Boating safety studies show that, depending on state-specific boating education requirements, PWC operators may be lacking adequate boating education and experience. For example, the National Transportation Safety Board (NTSB) reports that over 80% of boaters and PWC users have never received any type of boating instruction (1998) and the American Red Cross reports that PWC use is highest among boaters with little or no experience (1991). This inexperience is due, in part, to the fact that PWC are relatively easy for aspiring boaters to access. According to research, PWC are more likely to be rented or borrowed than any other vessel and almost half of PWC renters have operated a PWC only once or never (Mangione *et al*. 2000).

PWC riders are often singled out because of the manner in which they operate their craft. For example, some riders travel at excessive or inappropriate speeds and many tend to ride in groups, with multiple riders on each craft. PWC operators can also perform stunts such as racing, spinning, spraying, wave jumping and weaving through vessel traffic (Bluewater Network 1998; NPCA 1999). These behaviors may contribute to PWC collisions, as well as the number and severity of subsequent injuries (Clarke 2000). While some contend that this type of behavior is typical of PWC users, others maintain that most riders are safe and courteous and that, in general, PWC operators are no more dangerous than other boaters.

Although the extent of irresponsible PWC use is not documented, there is clearly a need for safe operating practices to be followed. To this end, PWC manufacturers, associates and riders are actively trying to promote safe and responsible PWC use. In particular, the Personal Watercraft Industry Association (PWIA) dedicates significant time and resources to publish educational materials, endorse operator "codes of ethics", facilitate regulatory enforcement and develop safety protocols for PWC-rental operations.

2.2.3 PWC Accidents and Fatalities

PWC-related accidents and fatalities can be differentiated from other boating incidents in several ways (American Academy of Pediatrics 2000; American Red Cross 1991; Branche *et al.* 1997; NTSB 1998). For example, most traditional boating accidents occur when a vessel capsizes or a person falls overboard but most PWC accidents involve collisions. These collisions typically involve two or more vessels (often two or more PWC) and occur when riders are operating too close to one another. This spatially concentrated operation does not afford PWC riders enough time to react to each other's speed or directional changes and often results in personal injury and/or property damage (Branche *et al.* 1997; NTSB 1998).

Differences between boating and PWC-related accidents give rise to differences between boating and PWC fatalities. For instance, most boating fatalities are due to drowning, especially if the victim is not wearing a personal floatation device (PFD). Since PWC riders are more inclined than other boaters to wear PFDs (NTSB 1998), few PWC fatalities entail drowning. Instead, most PWC fatalities are due to blunt trauma sustained by a victim following a collision with the water, a fixed object or another vessel. Trauma-related PWC fatalities typically involve contusions and lacerations to the head, face and upper body (American Academy of Pediatrics 2000; Branche *et al.* 1997; NTSB 1998).

There are several other notable distinctions regarding PWC-related accidents and fatalities. First, most PWC incidents occur on either borrowed or rented vessels and tend to occur during the first hour of operation. Second, most PWC incidents occur while the operator is cruising, as opposed to wake jumping or spinning, and they typically occur at moderate speeds (i.e., below 30 mph). Third, most PWC incidents occur when riders are alone on a vessel. Accident rates tend to decrease significantly when two passengers are on board and very few accidents occur when three or four passengers are riding a single vessel. Finally, alcohol use tends to be substantially lower in PWC incidents than in boating ones (Branche *et al.* 1997; NTSB 1998).

2.2.4 Comparing Vessel Safety Data

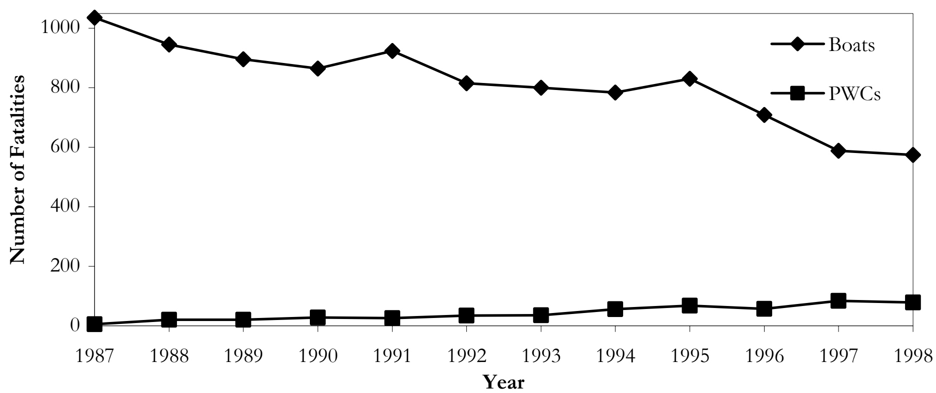
Definitive information on whether PWC have disproportionately high accident and fatality rates compared to their numbers on the water is unavailable at this time. Boating safety reports often contradict one another and make it difficult to determine if PWC are more dangerous than other vessels. These contradictions are due to inaccurate and/or insufficient reporting, as well as an overall lack of vessel exposure or use data.

Federal regulations require that a boating accident be reported to state boating officials if there is: 1) loss of life, 2) personal injury requiring more than basic first aid medical treatment, 3) property damage in excess of $2000 or the complete loss of a vessel and/or 4) the disappearance of any passenger (USCG 1998). However, boating safety experts suspect that a large number of accidents do meet these criteria but are not reported to the appropriate officials. For example, accidents resulting in property damage but not injury may only be reported to insurance companies, whereas accidents involving injury but not property damage may only be reported to hospital officials. In either case, the accident is not reflected in boating safety data (NTSB 1998). Insufficient reporting makes is difficult to accurately quantify the number of boating accidents that occur each year and, in turn, to compare the relative accident rate of different vessel types.

Boating accident comparisons can also be problematic because few safety reports record exposure or use data such as hours of operation. Since a vessel that is used for longer periods of time (i.e., more days/year or more hours/day) will have a higher chance of being involved in an accident, this data is necessary to compare relative accident rates among different vessels (NTSB 1998). Some boating surveys indicate that PWC are used for shorter periods of time than other vessels (Mangione *et al.* 2000) but site-specific analysis is necessary to determine relative vessel usage in a given area.

Due to the discrepancies of boating accident data, many experts suggest that boating fatality data is a better indicator of relative vessel safety. Fatality reporting tends to be highly accurate and, in general, fatality data is more complete and less skewed than accident data.

Table 2. Recreational Boating Fatalities



As is the case with accident data, though, fatality data cannot be used to draw conclusions about relative vessel safety unless the corresponding exposure and use data is available. For example, Figure 2 shows that each year, the number of PWC fatalities is significantly less than the number of recreational boating fatalities, leading some to conclude that PWC are safer. Alternatively, it also shows that the overall number of boating fatalities has decreased in recent years, while the number of PWC fatalities has increased (NTSB 1998; USCG 1997,1998), which suggests to many that PWC are an increasing public safety threat. However, when compared to sales data from the mid-1990s, the data in Figure 2 show that the increase in PWC fatalities corresponds to the mid-1990s surge in PWC sales and use and that the PWC fatality *rate* (i.e., number of deaths per vessel or number of deaths per hour of operation) has remained rather constant, even though the *number* of PWC fatalities has risen (NTSB 1998). Therefore, these data alone cannot be used to compare the relative safety of PWC and other vessels.

In general, most boating and PWC-related safety incidents can be attributed to operator-controllable factors, with relatively few being due to vessel or environmental factors. Moreover, there is little data or evidence to suggest that PWC are inherently more dangerous than other recreational vessels.

2.2.5 Education and PWC Safety

According to the NTSB, most PWC accidents and fatalities are due to three factors: inattention, inexperience and/or inappropriate use of speed (1998). These factors have little to do with the vessel itself and stem from the fact that PWC riders receive little, if any, training before they embark on the water. Consequently, they are not familiar with navigational rules and regulations, they are not aware of PWC safety precautions and they may behave recklessly and irresponsibly.

To rectify this, boating safety officials are turning to education to enhance the awareness and safety of the boating community. Many states have institutionalized boating operation and safety training classes and several have implemented mandatory education requirements for some or all boaters. Although these requirements usually focus on younger boaters (i.e., children and teenagers) and rental customers, the high-profile controversy surrounding PWC safety and use has prompted many states to mandate education and training for PWC operators of all ages.

In support of these efforts, the PWC industry and its partners have teamed up with local, state and federal officials to advance PWC safety and education throughout the country. For example, the PWIA encourages PWC operators to participate in voluntary education programs and it develops a variety of PWC-specific training materials. Furthermore, it works with state legislators to establish more effective safety regulations and it loans PWC to law enforcement agencies to boost their response and rescue capabilities. Finally, the PWIA actively campaigns to transform the reckless image of PWC users and it lobbies manufacturers to improve the safety of PWC design characteristics (PWIA 2000).

Boating safety assessments suggest that these efforts are paying off. Several states with strong PWC education and safety requirements have significantly reduced their PWC accident and fatality statistics. For example, the year after implementing mandatory PWC education, Minnesota reported one-third fewer PWC collisions than in the previous year. Similarly, in Wisconsin, PWC accidents decreased by 68% in the two years following mandatory PWC education. In Virginia, mandatory education has helped reduce the number of PWC accidents by 40% since 1999 and in California, PWC accidents have dropped 32% since 1998. Finally, despite the fact that PWC registrations have tripled in Connecticut in recent years, the state's number of PWC accidents have steadily decreased since it mandated PWC education in 1992.

2.2.6 Management Considerations

- Most PWC-related safety incidents are linked to inappropriate or irresponsible vessel use, not to the vessel itself.

- It is difficult to ascertain if PWC are a greater safety threat than other vessels because:
  - Incomplete exposure and safety data make it difficult to quantify or compare the relative safety of different vessel types.
  - Distinct differences between boating and PWC-related accidents and fatalities make them difficult to compare.
- PWC manufacturers have addressed design-related safety concerns in various ways:
  - Newer PWC models are larger, heavier and more stable than older models.
  - All new PWC models have safety lanyards and "kill switches" and many now have secondary “off-throttle” steering mechanisms.
- Boating safety assessments suggest that boating education efforts are effectively reducing PWC infractions.

2.3 MARINE ENGINE EMISSIONS

Recreational motorboats emit a variety of air and water pollutants (Table 1). Emission levels depend on engine specifications such as model year, horsepower rating, load factor and system design (Jackivicz and Kuzminski 1972; Juettner *et al.* 1995a), as well as operational characteristics such as vessel speed, hours of use and frequency of tuning (Warrington 1999). Therefore, emission levels vary both within and among vessel types. From a resource management perspective, it would be useful to compare the relative emission levels of different vessel types. This comparison would enable managers to effectively identify and regulate more polluting vessels. Thus far, however, researchers have only been able to accurately compare the relative emissions of different engine types.

Table 1. Pollutants Emitted from Recreational Marine Engines

BTEX	Benzene, Toluene, Ethyl benzene & Xylene
MTBE	Methyl-tertiary-Butyl-Ether
PAHs	Polycyclic aromatic hydrocarbons
CO	Carbon monoxide
NOx	Nitrogen oxides
PM	Particulate matter
SH	Saturated hydrocarbons

2.3.1 Marine Engine Comparisons

Most recreational motorboats, including PWC, utilize carbureted 2-stroke engine technology. Compared to their fuel-injected or 4-stroke counterparts, these engines are relatively inefficient and discharge a significant portion of their fuel intake into the water unburned (CARB 1998; VanMouwerik and Hagemann 1999; Tahoe Regional Planning Agency 1999;

Warrington 1999). Two-strokes also emit a bluish-gray smoky exhaust composed of toxic and smog-forming compounds. Overall, these emissions contribute to the degradation of air and water quality and compromise the integrity of coastal and marine ecosystems by threatening biological resources such as vegetation and wildlife.

In compliance with the U.S. Environmental Protection Agency's Clean Air Act rules, the marine manufacturing industry is addressing many of the concerns surrounding 2-stroke engines by developing cleaner, more efficient models and by improving the performance of traditional engine components. For example, the industry is redesigning piston-top deflectors (to reduce raw fuel throughput) and enhancing exhaust manifolds to decrease the release of airborne hydrocarbons and carbon monoxide. The industry is also using technologies such as direct fuel injection (DFI) systems and catalytic converters to reduce harmful hydrocarbon emissions and improve fuel economy (PWIA 2000). Despite these improvements, DFI-2-stroke engines still have higher emissions levels than 4-stroke engines (Bluewater Network 1998; Gabele and Pyle 2000). Therefore, certain manufacturers are now producing 4-stroke engines for a wider variety of vessels, including PWC and high-performance motorboats. (See Box 1 for more information about 2-stroke and 4-stroke engines.)

Box 1. Two-Stroke vs. Four-Stroke Engines

Two-stroke and 4-stroke engines derive their power in similar ways but they differ widely in their operational efficiency and emission levels. Both engine types burn a mixture of gasoline and air in an airtight cylinder. This combustion results in a buildup of gas pressure that pushes a piston down through the cylinder to create potential energy. In outboard motorboats, the potential energy is then transferred via connecting rods from the cylinder to the driveshaft where it powers a propeller and pushes the watercraft (Kuzminski and Jackvicz 1972). In PWC, the energy is transferred from the cylinder to an impeller that drives a pump and creates a pressured water jet that propels the vessel.

Two-stroke and 4-stroke engines utilize different lubrication methods that affect their overall emissions levels. Four-strokes have a separate lubricating system that minimizes the release of unburned oil into the water but 2-strokes require oil to be added directly into the fuel. The use of this mixture releases more oil, hydrocarbons and particulate matter than pure gasoline and results in a smoky blue exhaust (ENSR 1998).

Two-stroke and 4-strokes also differ in their power generation. Two-stroke engines generate power with every downward piston stroke, which requires them to combine fuel intake and exhaust into one stroke and fuel compression and ignition into the other stroke (Kuzminski and Jackivicz 1972). This combination creates power with every downward stroke but it allows significant amounts of unburned fuel to pass through the cylinder and into adjacent surface waters. Although 2-strokes frequently use deflectors to direct fuel away from the exhaust manifold, excessive throughput still occurs (Kuzminski and Jackivicz 1972). Therefore, marine manufacturers are beginning to outfit 2-stroke engines with direct fuel injection (DFI) systems such as the Ficht or Orbital.

DFI systems decrease fuel waste by injecting the gasoline-oil mixture directly into the cylinder after the exhaust port has closed. The Ficht system uses a tiny hammer-like part to force each injection spray into the combustion chamber. This creates smaller fuel drops, which evaporate more quickly for combustion. The Orbital system mixes gas and oxygen and then blasts the mixture into the combustion chamber at timed intervals. DFI systems use about half as much oil and have about 70% lower emission levels than older 2-stroke models. Generally speaking, however, DFI-2-stroke engines still have higher emission levels than 4-stroke engines (Gabele and Pyle 2000).

Four-stroke engines effectively minimize fuel throughput by performing fuel intake and exhaust on different strokes. Consequently, they can only generate power on alternate down-strokes and offer a lower range of power than 2-stroke engines (Kuzminski and Jackivicz 1972). Four-stroke engines also tend to be larger and heavier than 2-stroke engines, making them less desirable to some consumers. However, the demand for more fuel-efficient and environmentally friendly vessels is currently driving the development of 4-stroke engines that are smaller, lighter and more powerful and that can be used on a wider variety of vessels, including PWC.

2.3.2 Water Quality Impacts

There is some concern regarding the release of oil by recreational motorboats, particularly with older vessels that drain excessive fuel from the crankcase directly into the water. However, vessels manufactured since 1972 usually have scavenging devices that recycle the lost fuel and reduce oil throughput. Therefore, with regard to boating-related emissions, most researchers are concerned about the release of BTEX compounds (the primary constituents of gasoline), MTBE (a combustion-enhancing fuel additive) and PAHs.

Several studies suggest a correlation between BTEX, MTBE and PAH field concentrations and motorized recreational vessel use. These concentrations often increase throughout the summer boating season (May to September), with distinct spikes occurring after peak boating dates such as the Fourth of July and Labor Day (Allen *et al.* 1998; Allen and Reuter 1999; Miller and Fiore 1997; Oris *et al.* 1998; Reuter *et al.* 1998). These tend to diminish within weeks or months after the boating season and, given our present understanding of aquatic ecosystems, do not appear to significantly degrade overall water quality (Revelt 1994; Warrington 1999). However, BTEX compounds, MTBE and PAHs have been linked to acute and chronic toxicity in fish (Balk *et al.* 1994; Juettner *et al.* 1995; Tjaernlund *et* al. 1995, 1996) and may adversely affect fish growth and zooplankton survival and reproduction (Oris *et al.* 1998). Moreover, they may impact the surface microlayers found at the air-water and sediment-water interfaces. These ecologically vital layers support bacterial colonies that influence aquatic nutrient levels and sustain the planktonic and larval communities necessary to uphold aquatic ecosystems. They also serve as a spawning ground for many sport fish. Therefore, surface microlayers may be vulnerable to small and/or temporary increases in recreational boating-related pollutants (Warrington 1999; Von Westerhagen *et al.* 1987).

In general, BTEX compounds and MTBE are usually discharged with unburned fuel, while PAHs are exhausted following fuel combustion (VanMouwerik and Hagemann 1999). Once released, these pollutants react very differently in the water column and give rise to separate ecological concerns.

BTEX Compounds

BTEX compounds are single-ringed (monoaromatic) hydrocarbons that make up a significant portion of petroleum products such as gasoline and motor oil. They have a small size, low molecular weight and are highly soluble. They are also extremely volatile and, once released, they do not remain in the water for long because they quickly diffuse to either the air-water interface, where they evaporate, or to the water-sediment interface, where they become trapped in the sediments. Any remaining traces of BTEX compounds are usually broken down by biological degradation (Christensen and Elton 1996; Warrington 1999). Extreme levels of BTEX compounds are toxic to aquatic organisms but their short residence times tend to keep BTEX field concentrations orders of magnitude below established toxicity thresholds.

Most BTEX-contamination can be linked to leaky underground storage tanks and/or stormwater runoff (Christensen and Elton 1996), but the public has become increasingly concerned about the release of BTEX compounds from recreational motorboats. Studies suggest that current levels of boating-related BTEX emissions are not a major threat to marine environments (Allen *et al.* 1998; ENSR 1998; Revelt 1994), especially when compared to landside urban or industrial sources. However, it should be noted that areas with high petroleum background concentrations (i.e., harbors, marinas or industrial sites) may already exhibit BTEX toxicity and may be more sensitive to boating-related BTEX emissions.

Methyl Tertiary-Butyl-Ether

MTBE is a hydrophilic, organic compound that is added to gasoline to increase burning efficiency and improve engine performance (US EPA 1997, 2000). Although MTBE-use has been linked to air quality improvements in regions plagued by smog, researchers are concerned that MTBE use may threaten water quality (Reuter *et al.* 1998). Those areas using MTBE-enhanced gasoline usually observe elevated levels of MTBE in their fresh and/or marine waters. Most of this MTBE comes from automobile exhaust, stormwater runoff and leaky storage tanks but studies suggest that some MTBE contamination may be attributed to marine engine exhaust (Allen *et al.* 1998; Allen and Reuter 1999; Reuter *et al.* 1998).

Evaporation at the air-water interface is a primary mechanism for MTBE removal from surface waters (Miller and Fiore 1997; Reuter *et al.* 1998), but, due to its high solubility and small molecular size, most MTBE diffuses away from the surface before significant loss occurs. Consequently, MTBE tends to remain in solution and, in shallow-water systems, can rapidly penetrate groundwater supplies. Moreover, MTBE is not biodegradable, it does not react to UV light and it rarely adsorbs to suspended particulate matter (Tahoe Research Group 1997). This resistance to natural breakdown enables MTBE to build up in aquatic areas. Fortunately, preliminary research suggests that microbial communities may have the potential to mineralize MTBE, thereby removing significant quantities of it from the water column and/or sediments (Bradley *et al.* In Press).

At extremely high concentrations, MTBE may be acutely and/or chronically toxic to aquatic organisms (Werner and Hinton 1998). Adverse effects include the onset of cancer and disruptions to the renal, reproductive and nervous systems. However, ambient field concentrations are several orders of magnitude below toxicity thresholds and MTBE has not been shown to bioaccumulate in the food chain (Tahoe Research Group 1997). Therefore, it poses little or no threat to fish and wildlife and is not considered to be a major issue in marine ecosystems. (See Box 2 for more information about MTBE and drinking water).

Box 2. MTBE and Drinking Water

Methyl-tertiary-butyl-ether (MTBE) is an oxygenate that is added to gasoline to facilitate combustion and enhance engine performance. MTBE production and use has increased significantly since 1990, when Congress amended the Clean Air Act (CAA) and mandated the use of oxygenated, or "reformulated," gasoline (RFG) in regions with significant air quality problems (Tahoe Research Group 1997; US EPA 1997). In general, reformulated gasoline improves air quality by reducing the amount of toxic and/or smog-forming hydrocarbons that engines typically exhaust (US EPA 1995, 2000).

Several oxygenates are available for RFG production but most manufacturers favor MTBE because it is cost efficient and blends well. Recent reports claim that MTBE is used in over 80% of RFG supplies and that the U.S. currently produces over 200,000 barrels of MTBE each day (US EPA 2000).

Although toxic and smog-forming air emissions have decreased with the addition of MTBE to gasoline, research suggests that these air quality benefits are occurring at the expense of drinking water quality. MTBE has an unpleasant taste and odor that degrades the integrity of freshwater drinking supplies. Therefore, the EPA has established an MTBE Drinking Water Advisory Range of 20-40 micrograms per liter. This range is based strictly on taste and odor considerations and does not address potential threats to human health (US EPA 1997).

MTBE-related health concerns stem from the fact that MTBE is classified as a potential human carcinogen. However, laboratory studies show that toxic and cancerous effects require extraordinarily high concentrations or exposure levels. Since humans are indisposed to drinking water contaminated with even low MTBE concentrations (<20-40 micrograms per liter), it is unlikely that direct MTBE consumption poses a threat to human health. Nonetheless, the EPA has established a highly conservative MTBE safety threshold of 70 micrograms per liter (US EPA 1997). It has also begun to phase out MTBE use throughout the country.

Polycyclic Aromatic Hydrocarbons

PAHs are organic compounds composed of two or more fused carbon-ring structures (Albers 1995). Smaller PAHs (2-3 rings) are usually found in the gas phase and are more soluble than larger PAHs (4-7 rings), which are found in the solid phase (Albers 1995; Marr *et al.* 1999). When emitted into the water column, smaller PAHs readily evaporate or dissolve but larger PAHs tend to sink into the sediments (ENSR 1998). At the same time, all PAHs adsorb to organic material, which transports them throughout the water column and into the sediments. Adsorption also enables aquatic organisms to ingest PAHs, which introduces these toxins into the marine food web (Albers 1995; Eisler 1987).

Elevated PAH concentrations can be acutely or chronically toxic to fish and other aquatic organisms (Baumann 1989). These organisms are initially affected at the subcellular level when PAHs bind to DNA and cellular proteins. This inhibits biochemical processes and causes extensive cellular damage. More severe damage is manifested as mutations form in the liver and kidneys and malfunctions occur in the circulatory and nervous systems (Albers 1995). Laboratory studies also suggest that high concentrations of PAHs may cause cancer in fish but inadequate field studies weaken the case for a casual linkage between the two (Baumann 1989; Eisler 1987; Neff 1985).

As with other emission-related pollutants, surface water PAH-concentrations are usually significantly lower than toxicity thresholds (Albers 1995, 2000). This is due, in part, to the predominant use of 2-stroke engines, which primarily exhaust PAHs that are smaller, lighter and more evaporative. However, PAH levels may be significantly higher in sediment beds (Albers 2000; ENSR 1998) and areas with ample sediment suspension are often subject to long-term PAH contamination. Studies indicate that sediments are usually contaminated by the larger, heavier PAHs that are more prevalent in 4-stroke exhaust. Consequently, with regard to PAHs, the proposal to switch from 2-stroke to 4-stroke engines in order to preserve water quality may be problematic. Other studies suggest that exposure to ultraviolet light greatly increases PAH toxicity (Oris *et al.* 1998), thereby questioning whether or not PAH emissions reductions can adequately protect shallow-water organisms from lethal and/or sub-lethal photo-dynamic effects.

Similarly to BTEX compounds and MTBE, however, marine engine exhaust is a relatively minor contributor to overall PAH emissions. Hundreds of PAHs are produced from a wide array of sources including automobiles, trucks, buses, power plants, wood stoves, burning leaves and forest fires (Albers 1995). Recreational boating levels are rarely high enough to cause significant exhaust-related environmental impacts but they may exacerbate existing PAH contamination near urban or industrial sites (ENSR 1998).

2.3.3 Air Quality Impacts

The U.S. Environmental Protection Agency (EPA) has been regulating highway vehicle emissions since the 1970s; however, it only recently began addressing nonroad or off-highway sources of air pollution. These sources account for about 10% of all hydrocarbon emissions and regulating them is necessary if states are to comply with the National Ambient

Air Quality Standards (NAAQS). In accordance with the 1990 Clean Air Act (CAA) Amendments, the EPA now monitors and regulates an array of nonroad pollution sources such as lawn and garden equipment, construction and farm equipment, recreational all-terrain vehicles and marine vessels (US EPA 1999).

Through studies mandated in 1990, the EPA has concluded that the gasoline-powered engines found on motorboats, jetboats and PWC comprise about 30% of all nonroad emissions. Furthermore, in areas with extensive boating populations, marine engines alone can account for 10% of all hydrocarbon emissions. Consequently, in 1996, the EPA established new air emission standards for all gasoline-powered marine engines. These standards are being phased in from 1998-2006 and should reduce the hydrocarbon emissions of these engines by 75% in 2025 (US EPA 1996). In addition to these federal standards, the California Air Resources Board (CARB) has adopted a more stringent set of regulations to address that state's massive boating population and extreme air quality problems. CARB requires marine engine manufacturers to reduce their hydrocarbon emissions by 75% on 2001 models and by 90% on 2008 models (CARB 1998). Neither the EPA nor the CARB standards apply to engine models pre-dating the restrictions.

Both sets of standards enable manufacturers to average emissions reductions across their entire range of engines, thereby providing them the flexibility to develop their technological solutions based on competitive market demand (US EPA 1996). In other words, manufacturers can select which engines to improve based on vessel sales and/or consumer expectations. As a result, they have been able to respond to demands for cleaner PWC by enhancing PWC engine performance (i.e., ignition, acceleration and maneuverability) and reducing smoke, fumes and noise.

Finally, it is worth noting that marine engine exhaust also contains high levels of nitrous oxides (NOx), carbon monoxide (CO) and particulate matter (PM) (Gabele and Pyle 2000; Kado *et al.* 2000). NOx affects human pulmonary and respiratory health, CO contributes to ground level ozone and certain PM-associated pollutants are genotoxic, or DNA-damaging, to aquatic organisms (Warrington 1999). Although the current marine engine regulations mandate small reductions in NOx, they do not address CO or PM emissions. Since these compounds are easily channeled back into the water column, more research should be conducted to determine if these compounds should be regulated.

2.3.4 PWC and Emissions

Recently, public concern regarding recreational vessel emissions has focused on PWC. PWC, with their higher power ratings and load factors, are widely perceived to have disproportionately high emission rates (relative to other motorized vessels). These characteristics are hypothesized to cause PWC to burn fuel more quickly than other vessels, thereby creating higher emissions (Bluewater Network 1998; NPCA 1998). However, researchers have not been able to accurately quantify how much gasoline or exhaust is being emitted from specific vessels (Miller and Fiore 1997; ENSR 1998) or to determine how vessel emissions vary under conditions of actual use (Allen *et al.* 1998).

PWC are also singled out because of their ability to access shallow-water areas. Presumably, this enables PWC to contaminate waters that were previously immune to recreational boating exposure. However, researchers have found it difficult to link contaminated water samples to a specific source (ENSR 1998) and they have yet to quantify the input of PWC-related emissions to shallow-water areas.

Although the current data are inconclusive, research regarding PWC emissions levels and impacts, these vessels continue to be targeted by citizen and environmental groups concerned about recreational boating and water quality. Therefore, the PWC industry is taking steps to ensure that its products are meeting or exceeding current environmental standards. Newly designed models using technologies such as catalytic converters and DFI-equipped 2-stroke engines retain the light weight and premium performance of standard 2-stroke engines, while offering consumers advantages such as instant no-smoke starting, enhanced throttle response, reduced exhaust emissions and increased fuel efficiency (PWIA 2000).

2.3.5 Management Considerations

- Although motorboats and PWC do emit a variety of toxic pollutants, their overall environmental impact is usually much smaller than that of other pollution sources such as marinas or residential, commercial and industrial shoreline developments.

- Most of the engine emission levels reported in the literature are derived from studies conducted in the early 1970s. Given the advances in marine engine technology and the changes in fuel composition over the past few decades, estimates derived from these studies may not accurately reflect the emission levels of newer marine engines.

- The water quality impacts widely attributed to PWC use can also be linked to other vessels that utilize carbureted 2-stroke engine technology.

  - Although comparing PWC emissions to those of other motorboats would be useful, it is usually only possible to compare the relative emission levels of different engine types.

  - Until more conclusive evidence is available to determine the relative emissions levels of different vessel types, management efforts to regulate marine engine emissions should reflect the same standards for all motorized vessels.

- The PWC industry is compliant with current EPA marine emission standards. In addition, most PWC models manufactured since 1998 meet the EPA's 2006 requirements.

- Site-specific exposure and use data is necessary to determine the relative impact of the different vessels in a given body of water. Therefore, the following points should be measured and evaluated:

- The relative exposure (use) rates of different vessel types.
- The relative emission rates of different engine and vessel types.
- The relative solubility, transfer and fate of exhausted pollutants.
- The potential risk of these pollutants to human health, aquatic life and water quality.

- While gathering this data, it is important to keep in mind that:
  - There is insufficient evidence to verify that PWC--with their higher load factors and horsepower ratings--burn more fuel than other vessels.
  - In many places, PWC use and/or exposure time is significantly lower than that of other motorized vessels.
- Public education is needed to inform operators about water quality issues and stricter law enforcement is required to keep motorized vessels out of sensitive aquatic areas.
- Researchers need to address the following data gaps and scientific uncertainties:
  - The amount of toxic pollutants emitted by different vessels and engine types.
  - The effect of toxic pollutants on overall air and water quality.
  - The effectiveness of regulations that restrict PWC use in shallow-water areas.

2.4 WILDLIFE

Recreational boating generates noise, pollution and physical damage that can threaten coastal and marine wildlife. Box 3 lists a variety of impacts that directly or indirectly affect fish, waterbirds and marine mammals (Meehan 2000; Snow 1989). These impacts vary widely depending on the species at hand and the type/operation of the vessel in use, but they typically entail behavioral disruptions, ecological changes and/or health threats.

Box 3. Wildlife Impacts Linked to Recreational Boating

IMPACT	EXAMPLE
Alarm or flight	*Nest Flushing; Rookery evacuation*
Avoidance or displacement	*Nest abandonment; Migration disruption*
Behavioral alteration	*Decreased foraging or feeding*
Community alteration	*Increased predation (following nest desertion)*
Habitat loss	*Sea grass destruction; Shoreline erosion*
Injury or death	*Vessel collisions; Sediment-related gill damage*
Reproductive failure	*Decreased mating; Increased egg mortality*

Occurrences of these boating-related impacts are well documented but little is known about their cumulative effect. Furthermore, few studies effectively compare the relative impact of different types of recreational vessels and/or activities. Therefore, it is difficult to develop boating management strategies that effectively minimize wildlife disturbance.

2.4.1 PWC and Wildlife

PWC have extensive shallow-water capabilities that enable them to access sensitive aquatic and near-shore habitats. This generates concern because most PWC use occurs during the spring and summer months and coincides with critical wildlife phases such as spawning, mating and nesting (Bluewater Network 1998; Martin 1999; NPCA 1999). Therefore, PWC have the potential to cause adverse wildlife impacts by interfering with feeding, foraging, mating, migration, nesting and reproduction (Burger 1998; Lelli and Harris 2001; Mikola *et al.* 1994; Pfister *et al.* 1992; Rodgers 1995; Rodgers and Smith 1997). PWC also have the to potential to physically damage or chemically pollute shallow-water wildlife habitats (Ballestero 1990; Balk *et al.* 1994; Tjaernlund *et al.* 1995,1996; Snow 1989; Warrington 1999). These concerns are not unique to PWC, however. Non-motorized vessels also have extensive shallow-water accessibility and are widely linked to both wildlife disturbance and habitat damage. Outboard motorboats are equipped with the same engines as PWC and have similar types and magnitudes of toxic emissions. They are also just as capable (if not more) of churning up benthic habitats and are more likely to damage seagrass beds (Ballestero 1990; Snow 1989). Many conventional motorboats are also being equipped with technologies that enable them to access extremely shallow areas. These technologies include electric tilt mechanisms (which raise outboard motors out of the water), jack-plates (which lift propellers onto boat transoms) and jet-feet (which replace propellers with impellers).
In general, there is an overwhelming lack of scientific research regarding PWC-related wildlife impacts. Recent reports summarize extensive anecdotal information put forth by professional wildlife scientists and resource managers. Until more conclusive studies are conducted, however, it cannot be established if PWC threaten wildlife more than other recreational vessels.

Birds

Coastal waterbird populations are susceptible to disturbance by recreational boating, especially during critical mating, nesting and resting periods (Burger 1998; Mikola *et al.* 1994). Therefore, resource managers frequently restrict the use of recreational vessels in or near coastal habitat areas. In response to rising public concerns, many restrictions now target PWC use, but scientific information on the impacts of different vessel types on waterbirds is sparse.

Only a few studies compare the impacts of specific vessel types and these studies lack consensus on whether or not PWC are more detrimental to wildlife than other recreational vessels. One study examines the flushing responses of a single population of colonial nesting birds (Common Terns) at a site in New Jersey. It reports that PWC elicit stronger and more variable responses than outboard motorboats and that Common Tern flushing responses increase as PWC approach at closer distances or faster speeds (Burger 1998).

Conversely, a study of numerous waterbird populations throughout coastal Florida concludes that most waterbird species react similarly to PWC and outboard motorboats. Data from this study reveal that, of 23 waterbird species, 11 react the same to all motorized vessels, 4 react more strongly to outboard motorboats and only one reacts more strongly to PWC (Rodgers and Smith 1997). In addition, several studies beyond the scope of this review link non-motorized vessels such as sailboats, kayaks and canoes to coastal waterbirds disturbance.

Such contradictory evidence makes it difficult to effectively manage recreational boating impacts. Further analysis is necessary to determine the vulnerability of different bird species to various disturbances and to determine the relative disturbance caused by different vessel types. For example, both motorboats and PWC disturb birds breeding during peak boating season, but motorboats often disturb birds feeding or loafing during the colder periods when PWC are rarely used. Therefore, researchers should examine the temporal relationship between boating activity and waterbird activities to determine if short-term or seasonal restrictions should be implemented.

In the meantime, managers can minimize the disturbances caused by recreational boating by establishing conservative speed limits and setback distances for all vessels, particularly motorized ones. Researchers from Florida suggest that a uniform buffer zone of 180m (540ft) can be developed for all recreational vessels. This distance is based on species-specific setback distances of 180m for wading birds, 150m for ospreys, 140m for terns and gulls and 100m for plovers and sandpipers (Rodgers and Schwikert *In Press*). These findings are consistent with earlier research conducted in North Carolina and Virginia that suggested a setback distance of 200m for wading birds (Erwin 1989).

Marine Mammals

Recreational boating activity has been shown to affect various marine mammal species (Dornbusch & Company 1994; Evans 1991; Green 1991; US Department of Commerce 1990). For example, boating traffic frequently flushes harbor seals from the haul-out sites they use to rest, sleep, molt, nurse and give birth (Allen *et al.* 1984; Calambokidis *et al.* 1991; Lelli and Harris 2001; Mortenson *et al.* 2000; Suryan and Harvey 1999). Flushing from these sites disrupts normal rest and/or social interactions and separates pups from their mothers (potentially subjecting them to injury or predation and reducing the overall population size). Harbor seals are more likely to return, or rehaul, to these sites if disturbances are of short duration; therefore, high levels of boating traffic or prolonged vessel use may act as a continuous disturbance and prevent rehauling (Allen *et al.* 1984). Despite concerns regarding PWC use, several studies indicate that harbor seals tend to react more strongly to paddled vessels than to motorized ones (Calambokidis *et al.* 1991; Lelli and Harris 2001; Suryan and Harvey 1999).

Marine wildlife managers are also concerned that PWC may interfere with the daily activities of cetaceans and other marine mammals. A study linking jetboat-based parasailing to the interference of feeding and migration in humpback whales (Green 1991) prompted the state of Hawaii to classify PWC as "thrillcraft" and prohibit their use in certain areas during the peak whale season, December 15-May 15 (Bluewater Network 1998; NPCA 1998). Others suggest that marine mammals such as manatees or porpoises may be at risk of collision with PWC but there is no evidence to support this suggestion. In fact, the Florida Fish and Wildlife Conservation Commission has issued a special letter assuring concerned citizens that there has never been a PWC-related manatee death in Florida.

In general, most concerns regarding PWC and marine mammals stem from the audio-visual disturbances these vessels create. There is no scientific evidence to support these claims, but a wide range of anecdotal information is available. Many environmental groups, researchers and wildlife managers maintain that the acoustic qualities, high speeds and operational characteristics of PWC pose a greater threat to wildlife than other vessels. Some state that marine mammals have difficulty adapting to the erratic maneuverability and variable noise of PWC (Bluewater Network 1998; Gentry 1996; Martin 1999; NPCA 1999; San Juan County Planning Department 1998), while others suggest that prolonged PWC use makes it difficult for marine mammals to find safe escape routes and breathing spots (Gentry 1996). Others contend that, since PWC are essentially mute in the pelagic realm, they may be more likely to startle marine mammals (San Juan County Planning Department 1998).

Until more conclusive evidence is available, resource managers can effectively reduce marine mammal disturbances by using buffer zones, setback distances and zoning to keep recreational vessels away from critical marine mammal habitats.

Fish and Invertebrates

Recreational boating can adversely impact marine fish and invertebrate species. These impacts are most pronounced in shallow-water areas and are compounded by the fact that peak boating times usually coincide with the critical life stages of these species.

For example, outboard motorboats and PWC generate tremendous engine wash that can damage benthic eggs and larvae. Direct damage occurs as shear and rotational forces destroy fragile organisms (Stolpe 1992) and indirect damage occurs as organisms are smothered or buried by sediments kicked up by passing vessels (Morgan *et al.* 1983; Newcombe and MacDonald 1991).

Marine fish and invertebrates are also vulnerable to a variety of impacts linked to marine engine emissions. These emissions can increase egg mortality by contributing to shell thinning or they can decrease larval settlement rates by chemically altering the benthic substrate (Von Westerhagen *et al.* 1987). Moreover, many of these emissions have been found to be toxic to all life stages of fish and invertebrates (egg, larvae, juvenile and adult). More specifically, combusted hydrocarbons have been linked to an array of toxic side effects including sub-cellular mutations, biological systems damage and, in extreme cases, cancer. These effects, in turn, disrupt bodily functions such as growth, reproduction, respiration, circulation, osmoregulation and metabolism (Balk *et al.* 1994; Tjaernlund *et al.* 1995, 1996).

In general, ambient hydrocarbon concentrations are usually significantly lower than established toxicity thresholds and, in most areas, recreational boating-related pollution is not considered to be a major threat to marine organisms. However, studies show that toxicity levels may be elevated in shallow water areas due to 1) insufficient hydrological flushing (Warrington 1999) or 2) photo-dynamic magnification by ultraviolet light (Oris *et al.*

1998). Furthermore, preliminary research suggests that even marginal or short-term increases in hydrocarbon concentration may adversely impact organisms living in sea-surface microlayers (Von Westerhagen *et al.* 1987; Warrington 1999).

Researchers are beginning to question the ecological impacts that recreational boating may have on marine fish and invertebrate species. They are currently examining whether or not boating-related traffic and noise disrupts foraging, migration or schooling behavior or alters predator-prey relationships. No data have been published and there is no evidence to suggest that PWC are a more viable threat than other motorized vessels. In the meantime, managers can minimize potential impacts to marine fish and invertebrates by restricting all motorized vessel use in sensitive shallow-water habitat areas.

2.4.2 Management Considerations

- Recreational boating has been linked to noise, pollution and physical damage that adversely affects wildlife species and populations. However, it should be noted that:
    - Most wildlife disturbance is due to inappropriate or irresponsible operator behavior, rather than to the actual vessel itself.
    - Very few studies specifically examine PWC-related wildlife impacts and there is no consensus on whether or not PWC disturb wildlife more than other vessels.
    - Specific vessel and/or activity restrictions may be required in extremely shallow or near-shore areas.
- With regard to PWC, wildlife experts are predominantly concerned about their noise impacts and their ability to access shallow-water areas (but they note that neither of these is unique to PWC). Appropriate management strategies include:
    - Establishing buffer zones and setback distances to keep PWC and other vessels away from sensitive, shallow-water habitat areas and to reduce PWC noise levels.
    - Implementing preliminary mitigation strategies such as spatial/temporal zoning or operational restrictions to minimize potential disturbances.
- Essential and/or sensitive habitat areas should be identified and prioritized during PWC management efforts. For example:
    - PWC use should be restricted near waterbird breeding and foraging areas.
    - Resting or loafing sites along migration routes should be targeted for protection.
- More research is necessary to quantify the release of PWC-related pollutants and to determine the biological impact of these substances on aquatic organisms.

- Researchers should address the following data gaps and scientific uncertainties:

  - Wildlife responses to different vessel types and approaches and how these responses differ by species or change over time (i.e., daily, seasonally, annually).
  - The effects of vessel noise on wildlife activities such as feeding, foraging, loafing, mating, migrating, nesting and spawning.
  - The effectiveness of set-back distances, buffer zones and no-use areas as wildlife protection mechanisms.
  - The relative habitat damage caused by different vessel types.
  - The amount of toxic pollutants released by outboard motorboats and PWC and the biological impact of these substances on aquatic organisms.

2.5 SUBMERGED AQUATIC VEGETATION (SAV)

Underwater plants and algae, known collectively as submerged aquatic vegetation (SAV), are vital to aquatic ecosystems and their inhabitants. Although SAV refers to many vegetation types, this report focuses on seagrasses, which are subtidal marine plants that form dense beds in coastal estuaries. They are usually substrate-bound and their productivity is limited by the attenuation of light through the water column (Athanas no date). Since seagrasses exist exclusively in shallow-water areas, they are highly vulnerable to the impacts of recreational boating.

Seagrasses perform a variety of functions that contribute to estuarine health and productivity. For example, they stabilize estuarine substrates by trapping sediments in their fibrous, lateral rhizome systems. Furthermore, they protect and nourish estuaries by dampening hydrologic movement and filtering dissolved nutrients with their long, blade-like leaves (Short and Short 1984). Seagrasses also diversify breeding and nursery grounds for aquatic organisms and provide food and shelter to fish, shellfish and waterbirds (Phillips 1984; Thayer *et al.* 1984).

Seagrass communities are diminishing throughout the world. Seagrass declines are due primarily to pollution and disease (Short *et al.* 1987, 1989, 1993), but they may be exacerbated by human activities in the coastal zone. Many of these activities, such as residential or commercial development, occur on land but some relate to recreational boating and water use (Short *et al.* 1991). Examples include dock and pier construction, sewage discharge, anchor/mooring deployment, propeller scarring and vessel grounding.

2.5.1 Direct Impacts

The vessels and activities affiliated with recreational boating can harm seagrass either directly or indirectly (Ballestero 1990). Direct impacts usually occur when vessels contact and injure plant structures (Short *et al.* 1991). Common scenarios include:

- Boat hulls striking the sediment bed and destroying root systems.
- Propellers slashing rhizomes and leaf blades.
- Propulsion and/or hull pressure eroding roots and rhizomes.
- Vessel-induced waves and wakes causing shoreline vegetation erosion.

These occurrences result in bare patches or "scars" in seagrass beds and often cause extensive damage to seagrass communities (Dusek and Battle 1998).

PWC are widely perceived to scar nearshore and intertidal seagrass beds but researchers in New Hampsire and the Florida Keys found no significant PWC-related damage after subjecting test beds to extensive PWC use (Anderson 2000; Continental Shelf Associates 1997). In general, PWC-related SAV impacts are reduced by design characteristics such as shallow drafts, impellers and horizontally oriented jet propulsion systems. Moreover, they do not perform well in seagrass beds or extremely shallow waters areas. When PWC are operated in less than the manufacturer-recommended depth of 2 feet, their intake grates clog with suspended sediments and vegetative debris, causing their engines to overheat (Ballestero 1990). To avoid permanent engine damage, an operator must turn the PWC off, dismount the vessel, manually clear the grate and resume operation in a deeper, more appropriate area. By comparison, when an outboard propeller becomes clogged with vegetative debris, the operator needs only to stop, reverse the vessel (which rotates the propeller in the opposite direction and unwraps the vegetation), clear the vegetative debris and proceed through the seagrass bed.

Finally, PWC-related SAV damage is usually minor compared to the seagrass scarring and shallow water habitat damage caused by more traditional vessels. For example, studies indicate that conventional outboard motorboats are the principal cause of SAV damage (Dusek and Battle 1998; Snow 1989) and these vessels have been linked to extensive seagrass scarring in Florida, Maryland and elsewhere (Naylor 2000; Smith 2000). Non-motorized craft such as canoes and kayaks can also damage SAV, especially when inexperienced boaters use their oars and paddles to dislodge or maneuver their vessels in shallow water areas. Restricting recreational vessel use to appropriately deeper waters can effectively reduce most of these direct impacts.

2.5.2 Indirect Impacts

Indirect impacts usually occur when recreational boating impedes primary productivity (photosynthesis). As mentioned above, seagrass productivity is limited by the amount of light that passes through the water column to leaves. Dock and mooring facilities often shade surrounding waters and decrease photosynthesis by inhibiting the passage of light through the water column (Ross 1985). Photosynthesis may also be affected if algal blooms form in the water column and shade the plants below. Studies suggest that boating-related nutrient releases contribute to algal blooms, but these sources are usually insignificant compared to land-side sources such as septic systems or stormwater runoff (Short *et al.* 1989; 1991).

Seagrass health and productivity may also be compromised if sediments are disturbed by vessel waves and wakes. For example, suspension-induced turbidity may decrease light penetration enough to inhibit photosynthesis (Short *et al.* 1989; Stolpe 1992) or resettling particles may temporarily smother the photosynthetic receptors found on plant surfaces. These impacts are a function of sediment particle size, with greater disturbance occurring in systems with smaller, finer particles than in systems with larger, coarser particles (Stolpe 1992).

Although research indicates a correlation between boating activity and short-term turbidity levels (Anderson 2000; Koch 2000), there is little evidence to show that boating-related turbidity chronically decreases photosynthesis. This is primarily due to the fact that natural turbidity sources (i.e., wind or wave activity) usually outweigh vessel-induced turbidity (Koch 2000). However, it may also be due to the fact that most studies only examine the effect of single vessels travelling along single-pass transects. These studies quantify the amount of sediment suspension (and subsequent resettlement) affiliated with a single vessel but they neglect the cumulative impacts that arise when multiple vessels circle about in the same area for a prolonged period of time. Multiple vessel studies are necessary to determine the relative impact of different vessel types and to compare the impact of boating-related sediment disturbance to natural causes of turbidity such as wind, waves and runoff.

Although few studies have effectively compared PWC-related sediment disturbances to those of other motorized vessels, inferences can be made based on correlation between wave-/wake-size and subsequent erosion or resuspension rates. In general, sediment disturbance tends to increase with wave-/wake-size and vessel-generated wave-/wake-sizes tend to increase with hull length, vessel weight, draft depth, power rating and operational speed. Therefore, PWC—with their light hulls and shallow drafts—should create smaller waves and cause less sediment disturbance than larger motorboats. Furthermore, when operated at moderate to high speeds, PWC tend to plane across the surface of the water, which also reduces their wave size and ability to disturb sediments. Studies evaluating PWC use in seagrass beds report no significant difference between PWC-induced sediment suspension and that caused by other outboard motorboats (Anderson 2000) and show that, when operated according to manufacturer recommendations, PWC do not significantly affect erosion rates or ambient turbidity levels (Continental Shelf Associates 1997).

However, PWC are frequently operated in ways that enhance their capacity to damage seagrass communities. For example, PWC are often used in shallow water areas, where their jet wash is more likely to kick up sediments. PWC also tend to kick up more sediment when operators are performing acrobatic maneuvers, traveling at slower speeds or rapidly accelerating. These activities tilt PWC back into the water column and direct their jet wash downward into underlying sediments and seagrass beds. PWC-related seagrass damage may also be exacerbated if PWC operation is spatially and/or temporally concentrated. Multiple PWC circling about in that same vicinity may have a greater impact than a single PWC traveling through the same area.

No broad generalizations can be made about PWC-related SAV damage. To determine the capacity of PWC to disturb sediments and damage SAV, managers need to complete site-specific analyses that examine PWC use characteristics in the context of specific physical parameters such as water depth, sediment size and ambient turbidity. In the meantime, restricting outboard motorboat and PWC use from shallow water areas will effectively minimize these indirect impacts.

2.5.3 Management Considerations

- With regard to direct SAV impacts (i.e., seagrass scarring, rhizome slashing, substrate erosion, etc.), research suggests that PWC-related damage is less significant than the damage caused by propeller-driven vessels. In addition, design characteristics such as shallow drafts, impellers and horizontally oriented jet propulsion systems, make PWC use relatively benign in SAV communities.

- With regard to indirect SAV impacts (i.e., decreased primary productivity), very few studies specifically examine PWC-related damage and how it compares to propeller-driven vessel damage.

    - Since PWC create smaller wakes and waves than other motorized vessels, they may cause less indirect SAV damage.

    - Certain operational behaviors (i.e., shallow-water operation, concentrated use, acrobatic maneuvers, etc.) increase the potential for PWC-related impacts in sensitive SAV communities.

- Channel markers and/or tide gauges are useful tools for directing PWC use away from SAV beds and other sensitive shallow-water areas.

- Site-specific analyses that examine PWC use characteristics in the context of local physical parameters are necessary to determine the capacity for PWC to damage SAV.

- Researchers should address the following data gaps and scientific uncertainties:

    - The amount of sediment suspension and turbidity attributed to vessel use and how it varies with vessel type or operation, water depth and sediment characteristics.

    - The effect of vessel-induced sediment suspension and turbidity on biological factors such as primary production rates, SAV health and habitat quality.

    - The effectiveness of updated navigational charts and markers at restricting vessel-use in shallow water areas that are subject to erosion and/or turbidity impacts.

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CHAPTER THREE: POTENTIAL PWC MANAGEMENT STRATEGIES

POTENTIAL PWC MANAGEMENT STRATEGIES

Recreational boating is associated with a variety of natural resource impacts and multiple-user conflicts including air and water pollution, habitat destruction, wildlife disturbance and public safety threats. Although these issues can be linked to all vessel types, the past few years have seen an increase in public concern regarding PWC. These vessels, with their high-speed maneuverability and high-pitched whine, have drawn significant attention from local officials and resource managers and are often at the forefront of boating management initiatives.

Several management approaches can be used to reduce the adverse ecological and/or social impacts of recreational boating. They range from rather low-key voluntary measures to strict legal regulation and outright prohibition. In between there is an array of intermediate actions such as zoning, licensing, mandatory education and pollution and noise abatement measures (NWSC 1996). These approaches can be modified to address the specific issues or concerns of a given community and can be used either independently or in combination.

3.1 USAGE RESTRICTIONS

According to the USCG, PWC are classified as Class A inboard motorboats and are subject to the same rules and regulations as other motorized vessels. For example, PWC must be registered in their principal state of use, they must have registration numbers displayed properly and they must be equipped with certain safety devices. PWC operators must also obey the "rules of the road" laid out in the Inland Navigational Rules Act (33 U.S.C §2001-2073) and they can be punished for dangerous or negligent operation (USCG 2001). In addition to these federal regulations, many local and state governments also have the authority to restrict PWC use. Box 4 summarizes the most common PWC restrictions used in the United States. When properly enforced, these restrictions potentially reduce the number of accidents, fatalities and user conflicts commonly associated with PWC use.

Box 4. Number of States* Using Selected PWC-Specific Restrictions

Require PWC operators & passengers to wear PFDs	52
Require a minimum age for PWC operation	51
Prohibit PWC use at certain times of day or night	50
Prohibit wake jumping	44
Require "kill switches" and/or safety lanyards	42

**Includes American Samoa, the District of Columbia, Guam, the Northern Mariana Islands, Puerto Rico and the U.S. Virgin Islands.*

Source: *NASBLA's Reference Guide to State Boating Laws, Sixth Edition (2000)*

Almost all states have a minimum age requirement for PWC operation and 33 states require an adult to be on board when a minor is operating a PWC. Furthermore, 12 states have issued a PWC-specific speed limit and many other states regulate PWC speed by enforcing "negligent operation" statutes. These statutes include: 1)"Slow/No-Wake" restrictions near shorelines, fixed structures or public swimming areas, 2) restrictions on use near other vessels and 3) restrictions on wake jumping or the towing of waterskiers. Finally, 25 states require PWC renters to receive some sort of safety education a few states require PWC operators to have accident and/or liability insurance (NASBLA 2000). Appendix B, adapted from the National Association of State Boating Law Administrator's (NASBLA) *Reference Guide to State Boating Laws*, summarizes PWC usage restrictions by state. Appendix C contains model legislation that was developed by NASBLA to facilitate uniform PWC laws and regulations across the country. Several states have adopted the legislation as written and many other states use versions that are similar.

3.2 ZONING

Zoning is a planning and management tool that enables resource managers to accommodate a wide variety of human activities and resource uses in a given area. When properly designed, zoning balances the protection of sensitive natural resources and with a variety of human activities. Zoning restrictions are usually backed with subordinate legislation but, in some cases, compliance may be voluntary.

There are many types of zoning (i.e., ecological or social) but most strategies typically employ variations of temporal, spatial and regulatory zoning.

- Temporal Zoning
  Temporal zoning separates incompatible activities and resource uses by partitioning the time that they are allowed. Depending on the resources or factors involved, temporal partitions may be hourly, daily, seasonal or long-term. For example, temporal zoning could prohibit commercial fishing in a sensitive wildlife habitat area during the mating or nesting seasons but allow these uses at less critical time periods. Temporal zoning could also allow non-motorized vessels to operate all day, while restricting motorized vessel use to the afternoon hours.

- Spatial Zoning.
  Spatial zoning (also known as "conservation" zoning), divides geographic areas into sub-areas--or "zones"--that are distinguished by their unique resources and management objectives. Depending on these resources and objectives, human use is regulated and specific activities are either encouraged or restricted. For example, motorized boats might be prohibited from entering a designated swimming area, recreational diving might be restricted in sensitive coral reef areas and fishing might be limited (or prohibited) in an area with struggling fish populations.

- Regulatory Zoning.
  Regulatory zoning sets specific restrictions on activities that are permitted in a given area or time period. For example, motorized boating may be allowed but restricted to a

certain speed or recreational fishing may be allowed if conducted on a "catch-and-release" basis.

Although many resource management strategies only use one type of zoning, combinations of temporal, spatial and regulatory zoning have also proven to be quite effective. Zoning is most commonly associated with land use planning, but it is also being used, with variable success, in coastal and marine areas around the world.

3.2.1 Great Barrier Reef Marine Park

The Great Barrier Reef, located off the east coast of Queensland, Australia, is the world's largest and most diverse coral reef. It is over 1250 miles long, up to 70 miles wide and supports thousands of marine coral, fish, wildlife and invertebrate species. The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the "protection, wise use, understanding and enjoyment" of the Great Barrier Reef. To facilitate this objective, the GBRMPA uses marine zoning as its primary planning and management tool. The park is spatially divided into 13 zones (see Appendix D), each having a unique management plan and set of restrictions. For example, General Use Zones allow for a diverse range of recreational and commercial activities but Scientific Research Zones prohibit any human entry except for scientific purposes. Each zone has an underlying set of conservation objectives that were determined thorough a public participation process (GBRMPA 1994).

The GBRMPA's approach has been widely used throughout the world as a model of effective marine zoning. In the United States, the National Oceanic and Atmospheric Administration (NOAA) used this model as the basis for the U.S. National Marine Sanctuaries Program.

3.2.2 U.S. National Marine Sanctuaries

In 1972, Congress passed the Marine Protection, Research and Sanctuaries Act and established the National Marine Sanctuary (NMS) Program. This program is administered by NOAA and serves to conserve, protect and enhance the biodiversity, ecological integrity and cultural legacy of several marine protected areas (NOAA 2001). Of the thirteen sanctuaries in the NMS program, two currently use marine zoning as a resource management tool.

Florida Keys National Marine Sanctuary (FKNMS)

In 1990, Congress passed the Florida Keys National Marine Sanctuary and Protection Act to protect and manage the diverse environments of the Florida Keys. As described in its comprehensive management plan, the FKNMS uses zoning in selected areas of the sanctuary. This small-scale zoning approach enables managers to disperse resource users away from sensitive areas, minimize user conflicts and reduce the intensity of impacts in heavily-used reef areas. It also allows them to address specific concerns (i.e., coral reef protection) in certain areas, while addressing general concerns (i.e., water quality) throughout the sanctuary (NOAA 1996).

The FKNMS uses five types of zones to minimize user conflicts, limit human resource consumption and facilitate human respect for and enjoyment of the sanctuary (see Appendix D). Although these zones were designed to protect natural resources, they have, in certain areas, resulted in *de facto* regulation of recreational vessel use. As such, the FKNMS can serve as a general model of marine zoning and can be adapted to regulate recreational boating in other areas. (Note: When the FKNMS Management Plan was adopted in 1996, it included certain PWC-specific regulations. However, in 2000, Florida passed a state law prohibiting the adoption of regulations that discriminate against a particular type of motorized vessel. Accordingly, PWC use is now permitted in all areas of the FKNMS where motorized boating is allowed.)

Monterey Bay National Marine Sanctuary (MBNMS)

The Monterey Bay National Marine Sanctuary was established in 1992 and is the largest marine protected area in the United States. Encompassing over 5,300 square miles, the MBNMS is characterized by its scenic coastline, beautiful beaches and diverse array of marine flora and fauna. It is a popular site for commercial and recreational activity and is a nationally recognized center for marine biological and oceanographic research.

The MBNMS contains 72 sites that are categorized into 13 types of marine zones (see Appendix D). Each zone has a distinct set of management objectives and specific human activities are either restricted or promoted based on these objectives. For example, PWC are prohibited throughout the Sanctuary, except in four designated areas and their access routes. Spatially zoning the use of these vessels has enable sanctuary managers to protect the area's natural resources and minimize user conflicts, while allowing for continued PWC use within the area (NOAA 1992).

3.2.3 Hawaii Marine Life Conservation Districts

The tropical reefs surrounding the Hawaiian Islands support an extraordinary diversity of coral and fish species. In an attempt to protect these valuable and beautiful natural resources, the Hawaii Department of Land and Natural Resources (DLNR) has designated a number of Marine Life Conservation Districts (MLCDs) throughout the island state. These districts were selected for their size, environmental quality, boundary location, marine life, public accessibility and public safety aspects. Within each district, human activities are permitted or prohibited in accordance with the natural resources found in the areas. For example, PWC are banned in districts where they may damage coral reefs, disturb visitors or conflict with economically important industries such as recreational diving and commercial fishing (Save Our Seas 1992).

3.2.4 Barnegat Bay, New Jersey

Barnegat Bay, one of the EPA's National Estuary Program sites, is a shallow lagoon-type estuary located in central New Jersey. It is a valuable natural resource and a popular vacation destination that supports a variety of recreational and commercial uses, including sailing, beach combing, bird watching, fishing, clamming and crabbing. The Bay also supports a large and diverse group of motorized vessels (i.e., inboard/outboard motorboats, jetboats and PWC) (US EPA 2001).

In 1998, the Barnegat Bay Personal Watercraft Task Force (BBPWCTF) was formed to address the issue of PWC management. The BBPWCTF began by reviewing scientific literature, analyzing existing management strategies, listing relevant data gaps and identifying educational needs. Then, in May 2000, it released an "Issues Summary and Action Plan," which recommended a multi-faceted management approach entailing conservation zoning, enhanced law enforcement and public education.

The BBPWCTF Action Plan suggests that conservation zoning will enable resource managers to balance an array of issues and uses, including wildlife protection, commercial fishing interests and recreational use. The plan explains how temporal zoning can protect habitat areas during critical times of the year, while spatial zoning can keep PWC out of sensitive shallow water areas and confine them to more appropriate open water areas (Maxwell-Doyle *et al.* 2000).

In March 2001, the Tidelands Resource Council responded to the BBPWCTF's Action Plan by proposing New Jersey's first Marine Conservation Zone. The proposed zone, the Sedge Islands, is part of New Jersey's Island Beach State Park and has been placed under the jurisdiction of the state's Department of Environmental Protection (DEP). If approved by the necessary state officials and natural resource agencies, this plan will give the DEP the authority to restrict and/or prohibit PWC use within the Sedge Island Marine Conservation Zone (Southard and Collings 2001).

3.3 EMISSIONS REDUCTION INITIATIVES

Recreational motorboats and personal watercraft emit a variety of toxic pollutants such as BTEX compounds, MTBE and PAH. These toxic emissions degrade air and water quality and compromise the integrity of marine resources and ecosystems. To address these issues, the U.S. EPA passed new regulations regarding the manufacture of marine engines. These 1996 regulations are being phased in from 1998-2006 and are designed to reduce the hydrocarbon emissions of newly manufactured engines by 75% in 2025 (US EPA 1996). Similarly, in 1998, California's Air Resources Board (CARB) adopted its own, more stringent set of manufacturing regulations designed to alleviate the state's extreme emission and pollution problems. California requires newly manufactured marine engines to emit 75% fewer hydrocarbons by model year 2001 and 90% fewer hydrocarbons by model year 2008 (CARB 1998).

In addition to these overarching manufacturing regulations, state and local governments can pursue more specific regulatory and/or voluntary initiatives to reduce PWC engine emissions in their waters. Regulatory approaches include engine restrictions, certifications, permits and surcharges, while voluntary approaches involve consumer education and financial incentives (ODEQ 1999). Although few of these approaches have been utilized in the context of recreational boating, they are presented here to facilitate creative discussion and innovative problem solving.

3.3.1 Engine Class/Type Restrictions

The majority of recreational motorboats and personal watercraft are outfitted with carbureted 2-stroke engines. Research indicates that these engines are relatively inefficient and that they have significantly higher emission levels than direct fuel-injected (DFI) and 4-stroke engines (TRPA 1999). To reduce emissions, some communities are beginning to restrict the use of engines or vessels that are using older, more polluting technologies.

In June 1999, the Tahoe Regional Planning Agency (TRPA) passed a regulation prohibiting the use of carbureted 2-stroke engines on Lake Tahoe. PWC and motorboats operating in this area must now be equipped with either: 1) DFI-2-stroke engines; 2) 2-stroke engines that meets either CARB's 2001 or the EPA's 2006 emissions standards; or 3) 4-stroke engines. The TRPA Watercraft Enforcement Team enforces this regulation by patrolling the Lake every day during peak boating season. The Team also maintains a page on the TRPA website that provides information regarding the ordinance and specifically lists which PWC and outboard engine models are permitted on the Lake (TRPA 2001).

After some initial skepticism and challenges, TRPA's prohibition on carbureted 2-stoke engines has received widespread public support. Many local residents lend time and manpower to help patrol the Lake, looking for violators and educating visitors about the region's pristine resources and the need for the prohibition.

Engine class/type restrictions, such as TRPA's, enable communities to meet the demand for recreational boating opportunities, while reducing marine emissions and protecting the integrity of their marine and freshwater resources.

3.3.2 Model Year Class Restrictions

One of the arguments surrounding the regulation of marine engine emissions is that the regulations usually only apply to vessels and engines manufactured after the regulations are passed. Therefore, existing vessels are pre-approved under the regulations and a vast fleet of relatively highly polluting vessels remains in operation. This argument is especially pervasive in PWC management debates. It is suggested that, nationwide, there are over one million older PWC in use that continue to pollute coastal and marine environments despite the availability of newer, cleaner technologies. However, since the life span of a privately owned PWC is shorter than that of an outboard motorboat, the antiquated PWC fleet is turning over more quickly than the corresponding outboard motorboat fleet.

Regardless of relative turnover rates, local communities can regulate the use of older, more polluting vessels by implementing model year class restrictions that prohibit the use of engines that were manufactured before a certain date. For example, a community could try to reduce marine emissions by passing a bylaw that prohibits the use of PWC and/or outboard motors manufactured prior to 1998, when the EPA began phasing in its new marine emissions standards.

Model year class restrictions are an effective way for communities to enjoy the benefits of motorized recreational boating while ensuring that motorized vessels are using cleaner, more efficient engine technologies that pose less of an impact to the community's fresh and marine waters.

3.3.3 PWC Certification & Permitting Programs

Certification programs require all PWC to be approved by some governing body prior to being sold. Ideally, approval would hinge on the PWC industry's compliance with the new EPA emissions standards, which means that PWC engines should demonstrate at least a 75% reduction in hydrocarbon emissions by 2006. After 2006, no uncertified PWC (new or used) could be sold. Such a program would essentially ban the sale of carbureted 2-stroke PWC and remove them from the marketplace. However, certification programs place a heavy burden on both state agencies (because they require a costly and time-consuming amount of monitoring and enforcement) and PWC operators (because they are no longer able to sell their used crafts).

Permitting programs require PWC owners to purchase an engine permit (as well as their vessel registration) before operating on state waters. The cost of the permit reflects the relative emission level of each engine, with carbureted 2-stroke engine permits costing significantly more than DFI-2-stroke or 4-stroke engine permits. Ideally, the revenue generated by these permits pays for the program's administration and extra monies are channeled into consumer education and pollution remediation programs. Although permitting programs discourage consumers from purchasing carbureted 2-stroke PWC, they do not remove these polluting vessels from the market. Furthermore, like certification programs, permitting programs place a direct monitoring and enforcement burden on state agencies and a financial burden on PWC owners.

3.3.4 PWC Surcharge Programs

Surcharge programs impose an extra cost on the sale of carbureted 2-stroke PWC and reduce the cost differential between older, more polluting models and newer, cleaner ones. When combined with a rebate that is applied to DFI-2-stroke or 4-stroke PWC, a surcharge program would reward consumers willing to purchase a more expensive, yet more efficient PWC. While surcharge programs may be effective for new PWC sales, they do not guarantee that older, used PWC will be removed from the marketplace because consumers will most likely sell them through classified advertisements, yard sales and other venues.

3.3.5 Consumer Education Programs

Consumer education programs inform potential PWC buyers (and the general public) about the differences between carbureted 2-stroke, DFI-2-stroke and 4-stroke engines. These programs include information about the engines' design and performance attributes, as well as their relative environmental impact. This information is provided in various forms (i.e., brochures, posters, product labels, demonstrations and public service announcements) and can be distributed by a diverse array of partners (i.e., state agencies, marinas, boat dealers, boat launches, environmental groups, user groups, trade groups and schools). These programs help consumers make more informed decisions and, for some, offer the personal satisfaction that comes from making an environmentally responsible purchase.

3.3.6 Consumer Incentives Programs

States can complement consumer education programs by implementing consumer incentives programs. These programs offer financial benefits and rewards to buyers who make environmentally responsible purchases. There are three basic types of consumer incentives that could be modified to entice PWC buyers: buy-back programs, product bundling and tax credits (ODEQ 1999). These programs have been quite effective in other contexts but they tend to be rather expensive and usually require sponsors and legislative approval to provide financial and administrative support. The effectiveness of these programs will be maximized if they continue until the EPA Final Rule effectively removes carbureted 2-stroke PWC from the marketplace.

Buy-Back Programs

Buy-back programs entice consumers by offering money to individuals who are willing to turn in their old carbureted 2-stroke PWC and purchase a new DFI-2-stroke or 4-stroke model. These programs can be expensive because the monetary reward must reflect the cost of the newer, more expensive model. To defray these costs, PWC buy-back programs may be sponsored by an organization, or a group of organizations, with ample capital and a vested interest in the consumer behavior of PWC operators (i.e., marine manufacturers, state environmental agencies, etc.).

Product Bundling

Product bundling programs entice consumers by offering free or discounted products to individuals who purchase DFI-2-stroke or 4-stroke PWC. For example, coupons or rebates on trailers, gasoline, PFDs and/or other PWC accessories could be given to buyers at the point-of-sale. These programs can be complex because they require PWC dealers to partner with other businesses and a significant amount of negotiation and coordination is required. Product bundling can also be expensive because the "bonus" package must be rewarding enough to persuade the buyer to purchase a more expensive PWC model.

Tax Credits

Tax credit programs provide a strong monetary incentive by allowing consumers who purchase DFI-2-stroke or 4-stroke PWC to deduct a specified amount from their taxes. Like other incentives programs, tax credits are costly because the deductions must be large enough to entice consumers to buy more expensive engines. They also require legislative action and do not ensure that the older, more polluting PWC are removed from the market or state waterways.

3.4 NOISE ABATEMENT

Various management strategies can be used to abate PWC noise; however, when selecting an appropriate strategy, it is important to remember that human noise perception varies significantly and is highly subjective. Therefore it is usually difficult to select a strategy that pleases all constituents. To minimize this type of situation, PWC managers may want to solicit input regarding acceptable noise levels from a variety of stakeholders, including shorefront property owners, natural resource experts, beach-goers, PWC operators and other boaters. To be effective, this input must be examined collectively and used to generate strategies that most, if not all, stakeholders can accept.

3.4.1 Reduce Engine Noise

To balance consumer demand for larger, more powerful PWC models with demand for quieter PWC, manufacturers have recently begun outfitting PWC with cutting-edge noise-reduction technologies such as mufflers, baffles and insulation. These technologies, combined with redesigned intake and exhaust systems, have enabled the industry to create PWC models that are significantly quieter than they were just a few years ago. However, since a large number of older, louder PWC are still being used throughout the country, communities may need to phase these older models out in order to effectively reduce PWC-related noise impacts.

Many phase-out strategies are similar to the actions explained in the emissions reduction section. For example, model-year class restrictions can be used to ban vessels that do not utilize updated sound-reduction technologies and certification or permitting programs can be used to periodically test and approve or disapprove of individual vessels based on their noise output. Consumer incentives such as tax credits and buy-back programs can also be used to encourage operators to trade their old PWC in for a newer, quieter model.

3.4.2 Setback Distances & Buffer Zones

Since atmospheric sound intensity decreases rapidly over distance, setback distances and buffer zones represent simple, yet effective ways to reduce boating-related noise levels. In general, noise levels decrease by 5 dB per doubling of distance over water and 6 dB per doubling of distance over land. In other words, if a vessel's noise measures 70 dB at 20 feet, it will measure 65 dB at 40 feet, 60 dB at 80 feet and so on. Although this reduction may not seem like much, human-perceived loudness is halved for every 10 dB noise decrease. To someone standing on shore, a vessel operating behind a standard 150-foot setback distance will sound about half as loud as one operating just 40 feet offshore (Komanoff and Shaw 2000). Io this end, many communities have implemented setback distances ranging from 150-1500 feet, or .03-.25 miles.

However, as previously discussed, dB levels are often a moot point when it comes to PWC noise. Since these vessels have a relatively variable, high-pitched whine that is distributed fairly evenly across detectable octave bands, PWC are often more audible than other noise sources, which often makes them more annoying or disruptive to persons on shore. To address this specific issue, setback distances and buffer zones can also be designed using "speech interference" measurements. This method entails measuring sound intensities in certain octave bands (preferably the 500, 1000 and 2000 Hz frequencies). To prevent vessel noise from interfering with "normal" conversation on shore, the average sound intensity in each of these bands should be below 30 dB (San Juan County Planning Department 1998). An excellent example of the applicability of this method comes from the Tahoe Regional Planning Agency, which, in response to resident complaints regarding watercraft noise, used it to create a 600-foot (~1/10th mile) setback distance for all motorized vessels operating on Lake Tahoe (TRPA 2001).

3.4.3 Speed Limits

PWC and other motorboats make considerably more noise when operating at high speeds or full-throttle than they do at lower speeds. Consequently, well-enforced speed limits are often effective at reducing PWC-related noise (PWIA 2000). Speed limits can be developed with various factors in mind (i.e., distance from shore or proximity to critical habitat areas) and can be tailored to suit the needs of a given community or waterway. For example, speed limits can be reduced to "no-wake" levels (~5mph) in shallow-water nesting areas or they can be set at levels more conducive to maneuvering through vessel traffic (~25-35 mph).

3.4.4 Zoning

Another effective way to reduce overall PWC noise impacts is to concentrate PWC use at a few locations (Komanoff and Shaw 2000). This approach reduces PWC use in specific locations where aesthetic or resource quality is at risk or where there are large numbers of resource users. In turn, zoning encourages PWC use in areas where there is enough water surface area to support a variety of uses or in areas where PWC use can continue far enough away from shore to not disturb beach-goers.

3.4.5 Operator Education

In many cases, public education campaigns have effectively reduced the noise impacts associated with PWC use (Burger and Leonard 2000). By distributing information and enhancing awareness, these campaigns potentially improve operator behavior and foster environmental stewardship. Educational campaigns can utilize various forums or media, depending on resource and budgetary constraints, and they are often most effective when used in conjunction with other management actions (i.e., speed limits, buffer zones, etc.). An excellent example of using education to reduce PWC-related noise impacts comes from Little Mike's Island in Barnegat Bay, New Jersey. Historically, this island has been a haven for a large colony of Common Terns. Unfortunately, in the mid-1990s, scientists found that the tern colony's reproductive success was suffering due to increased PWC use around the nesting area. Scientists noted that PWC operators frequently raced through the channel adjacent to the nesting area, disturbing mating birds and scaring them away from their nests. Due to this noisy and disruptive PWC behavior, the birds suffered almost complete reproductive failure in both 1996 and 1997 (Burger 1998).

In light of this, in 1997, a local group of scientists and citizens convened a series of public forums to discuss PWC use and noise-related wildlife disturbance around the island. These forums, which were attended by private citizens, state officials, industry representatives, marine police officers, marina owners, livery operators and PWC owners, resulted in creation of a multi-faceted management strategy that protected both the birds and the interests of the PWC operators. The strategy entailed a broad educational campaign that provided PWC rental businesses and marinas with information to pass on to their clients regarding the nesting terns and the threats they faced due to PWC noise and operation. It also entailed creating no-use areas around critical nesting sites and marking them with buoys. These areas were patrolled by marine police officers who approached negligent operators and informed them about the harm they were causing. At the same time, the state of New Jersey began requiring all PWC operators to take a 3-hour course on PWC safety, noise and potential environmental impacts (Burger and Leonard 2000).

Taken together, these management efforts were extremely successful. Studies show that prior to their implementation, PWC represented almost 60% of the boats that went past Little Mike's Island and that over 50% of these PWC went "racing" by with a large wake. However, in the years following the start of the educational campaign and the installation of the buoys, these statistics dropped to 30% and 20%, respectively. More importantly, by 1999, the reproductive success of the island's Common Tern population returned to pre-1996 levels (Burger and Leonard 2000).

3.5 PWC LICENSING & CERTIFICATION

As previously discussed, most PWC accidents are attributed to three factors--inattention, inexperience and inappropriate use of speed. These factors typically arise from a lack of operator training and are exacerbated by the fact that PWC have certain characteristics (i.e., speed, maneuverability and power-dependent steering) that make them more difficult to control than other vessels. Although some states require teenagers and/or PWC rental customers to take a boating safety course, most PWC operators receive little or no training before taking off. As a result, this user group may be less familiar with navigational rules and PWC safety precautions and may be more likely to behave recklessly or irresponsibly (NTSB 1998).

In light of this situation, several states now require PWC riders to obtain a safety certificate and/or operational license similar to those required for driving an automobile. Licensing and certification requirements are presumed to enhance public safety by providing PWC riders with the knowledge and skills they need to operate on the water in a safe and responsible manner. Certification and licensing procedures acquaint operators with vessel operation, waterways rules and the specific laws and regulations that apply to their vessel, location and situation. Although most licensing or certification requirements only apply to minors and/or PWC rental customers, several states are beginning to extend these requirements to all PWC operators and/or other boaters (NASBLA 2000).

To obtain a license or certificate, operators are required to pass a knowledge test and, in some states, they must complete a specified amount of in-class or on-the-water training.

During the process, operators are exposed to general material, such as boating safety and navigational as well as special topics such as vessel operation, environmental sensitivity and public courtesy. The process usually entails a moderate fee, which is often earmarked and channeled back into boating safety and education programs. In many states, licenses and certificates must be renewed on a regular basis.

Finally, a poll conducted by the NMMA indicates that, although only 25% of PWC operators favor licensing and certification, 48% of them would like to see more PWC operation and safety courses. Conversely, 26% of experienced boaters and 30% of new boat buyers favor licensing but only 20% and 26%, respectively, would like more training courses (NMMA 1999). To bolster public support for boater licensing and certification, many insurance companies offer discounted rates to licensed and/or certified boaters and PWC operators.

3.6 PWC EDUCATION

Inappropriate operator actions and decisions cause most PWC-related safety incidents, legal infractions, environmental mishaps and social nuisances. Therefore, regardless of their different roles or opinions, almost everyone involved in PWC management agrees that operator education is the key to promoting safe and responsible PWC use. According to recent reports, 33 states require some sort of boating education, 25 states require further education for PWC operators and several other states have mandatory boating education laws pending (NASBLA 2000). Although these requirements usually only apply to minors and/or PWC renters, many states are considering mandatory education for all PWC operators.

Current PWC education programs vary by state and include both mandatory and voluntary approaches. These programs are used by local municipalities, government agencies and non-profit organizations to 1) inform riders about unique PWC design and operational characteristics, 2) raise awareness of PWC issues and clarify misperceptions regarding the environmental and social impacts of PWC use and 3) foster environmental stewardship among PWC operators. They typically entail formal in-class instruction and, in some cases, are supplemented with on-the-water training sessions.

3.6.1 PWC Education Standards

For over 10 years, NASBLA has been involved in boating education by creating content and curricula standards for boating education courses. NASBLA's standards guide the public and private entities that design classroom and training materials by outlining the knowledge level necessary to facilitate legal, safe and responsible boating. The standards, listed in Appendix E, delineate the minimum information that must be presented during a typical (6-8 hour) NASBLA-accredited boating education course. Educators are even encouraged to surpass these standards if they believe it will benefit their students (NASBLA 1999). For example, NASBLA recommends including information about specific vessels, geographic areas or weather conditions if it is relevant to the operators taking the course.

When NASBLA revised its boating education standards in 1998, it recognized the rising popularity of PWC and included a new standard relating to PWC use. The new standard explains the design and operational characteristics of PWC, informs riders about accidents and injury prevention, clarifies PWC-specific laws and restrictions and encourages courteous behavior by PWC operators (NASBLA 1999).

Although PWC education experts usually emphasize the merits of formal in-class instruction, many are beginning to advocate for expanded use of on-the-water training sessions. They claim that these sessions ensure that PWC operators learn to maneuver safely and ride responsibly because trained instructors can supervise and instruct PWC riders as they practice their operational skills.

3.6.2 PWC Educational Materials

In recent years, a wealth of materials has been created to facilitate PWC education initiatives. These materials include informational videos, manuals, brochures and fact sheets, as well as behavioral "codes of ethics." Box 5 lists some of the materials created by public and private organizations that address PWC issues. Similar materials can be ordered from local, state and federal agencies, non-profit organizations and industry groups that manage PWC use in one context or another (i.e., resource management, environmental protection, law enforcement, boating safety and public health or welfare).

Box 5. Examples of PWC Educational Materials

An Environmental Guide for PWC Operators -- Personal Watercraft Industry Association
Environmental Guide for PWC Operation -- National Safe Boating Council
Jet Smart -- United States Power Squadrons (video & manual)
Jet Ski (PWC) Safety Tip Sheet -- Pennsylvania Trauma Nurse Association
Personal Watercraft Rider's Handbook -- Kawasaki Motors Corporation, USA
Protecting the Aquatic Environment: a Boater's Guide -- Canadian Coast Guard
Protecting Fish Habitat: a Guide for Fishermen and Boaters -- U.S. EPA
Protecting Paradise: Florida Keys Safe Boating Tips -- Florida Keys NMS (video)
PWC and Seagrass Flats -- Personal Watercraft Industry Association
Riding Rules for PWC -- Personal Watercraft Industry Association
Safe Boating Hints for Personal Watercraft -- California Dept. of Boating & Waterways
Safe Boating Hints for Personal Watercraft -- Oregon State Marine Board
Wave Safe: a Guide to Safe Operation of PWC in Florida -- Florida Marine Patrol

Additionally, Appendix F lists "20 Ways to Protect the Environment", a set of operational guidelines for PWC riders that was compiled and published by the PWIA.

3.6.3 PWC Industry Efforts

The PWC industry has supported a wide range of PWC education initiatives. These efforts focus on donating money to boating education programs and providing consumers with educational materials at the point-of-sale (i.e., operator manuals, on-product warnings and instructional videos). The industry also supports more specific boating education initiatives sponsored by the four major PWC manufacturers (PWIA 2000). Some of these initiatives include:

- Bombardier's "Get Caught Doing It Responsibly" Demo Day initiative reaches thousands of current and prospective PWC operators with its "Boat Smart From the Start" safety message.

- Kawasaki and California State University (Sacramento) have developed the nation's first university-accredited PWC education course. The course is open to students and the general public and utilizes Jet-Skis® to demonstrate safe and responsible PWC operation. Kawasaki also donates Jet-Skis® and PFDs to local and state boating agencies during its National Safe Boating Week.

- Polaris administers a PWC training program that requires all buyers to receive formal instruction regarding PWC operation and regulations before their vessel warranty can be registered.

- Yamaha's Get W.E.T. (Watercraft Education and Training) initiative offers a boating education program in conjunction with the United Safe Boating Institute. PWC operators who complete this course are rewarded with discounts on insurance and selected Yamaha PWC accessories. Yamaha also offers a NASBLA-approved, USCG-recognized online boating course and provides free rental education kits to PWC rental operations.

The Personal Watercraft Industry Association (PWIA) also supports operator education. In recent years, the PWIA has developed model legislation that integrates mandatory education requirements with stricter operational regulations. This legislation, similar to NASBLA's (see Appendix C), has been adopted, in whole or in part, in more than 40 states and has institutionalized education as a means to enhance safety and environmental sensitivity among PWC operators. In addition, the PWIA continues to create an array of educational materials for government agencies, national boating organizations and the general public and provides PWC rental agencies with free informational kits containing videos, brochures, decals and fact sheets (PWIA 2000).

3.7 PWC RENTAL RESTRICTIONS

Government and industry efforts to promote and institutionalize PWC education, licensing and certification programs provide buyers with the information and training necessary to enjoy a safe and enjoyable boating experience. They do not necessarily ensure, however, that this knowledge is passed on to operators who rent or borrow PWC. This situation is problematic because PWC are more likely to be rented or borrowed than any other vessel types and most PWC safety incidents occur on rented or borrowed craft. In addition, nearly half of all PWC rental accidents involve out-of-state clients, most of whom are unfamiliar with the legal requirements, local restrictions and physical features of the waterways on which they operate (NTSB 1998).

Recent research suggests that PWC renters usually have significantly less boating-related knowledge and experience than PWC owners. For example, an NTSB survey shows most PWC owners have previously operated other types of vessels, whereas most PWC renters have not. In fact, the survey indicates that less than half of PWC renters have ever even operated a PWC. The survey also indicates that less than one-third of PWC renters receive operational or safety instruction from their rental agent or have to demonstrate riding ability prior to renting a vessel. Overall, these statistics substantiate NTSB's findings that most PWC rental accidents are attributed to inexperience and/or inattention and usually occur during the first hour of operation, while renters are trying to familiarize themselves with the vessel. Moreover, these statistics raise questions of whether or not rental agents are ensuring that their clients receive the information and training necessary to operate PWC in a safe and responsible manner (NTSB 1998).

In an attempt to enhance PWC safety, many states are tightening their restrictions on PWC rental agencies. At least 25 states now mandate some form of safety education of PWC rental clients and several states have increased their minimum age requirements for PWC renters. Meanwhile, a few states have developed comprehensive PWC rental regulations (NTSB 1998). For example:

- Minnesota requires PWC rental agents to provide required safety equipment and a copy of the state's PWC laws, as well as legal and operational information, free of charge to all clients. Minnesota also requires PWC rental agents to keep a record of all persons who rent PWC. For renters under the age of 18, this record must document the number of the "watercraft operator permit" that the state requires all minors to obtain.

- Idaho requires PWC rental agents to educate their clients about the safe operation of the vessel and to place a decal on the vessel that lists relevant boating laws and safety information. Concurrently, rental clients must accept the instruction and carry an "acknowledgement-of-education" form while operating the PWC.

- Florida requires rental agents to complete on-the-water checkrides of all clients prior to letting them take control of the craft.

- Nevada mandates that each person operating under a given rental contract must complete a PWC law/safety course.

Additionally, states can consider implementing measures such as mandatory supervision of PWC renters by trained staff members, mandatory insurance requirements for rental agents and their clients or the prohibition of PWC rental operations.

To facilitate these efforts, the National Recreation & Park Association (NRPA) and the USCG have created a reference manual that outlines "best business practices" for PWC rental operations. Building on standards put forth by NASBLA and the PWIA (see Appendix G), this comprehensive manual provides recommendations and guidelines for improving the educational and operational standards of the PWC rental industry and discusses topics such as personnel qualifications, legal requirements, customer education and safety/risk management (USCG and NRPA 2001). It also outlines several "Do's" and "Don't" for PWC rental customers (see Box 6).

Box 6. "Do's" and "Don'ts" for PWC Rental Customers

Customer Do's:

- Know the local water hazards and forecasted weather conditions.
- Understand the importance of protective wet gear, footgear, sunscreen, sunglasses, hat, etc, while riding a PWC.
- Scan the water constantly for other watercraft, bathers and objects.
- Ride defensively and use common courtesy and common sense.
- Follow the rules of the road and abide by all navigational aids.
- Obey all posted signs and stay clear of restricted areas.
- Be aware of and respect environmentally sensitive areas.
- Know the operational characteristics of the watercraft (stop, turn, reboard, etc.) and it capacities and limitations (fuel capacity & consumption, etc.).
- Respect the rights of all other water and land users.
- Know, understand and follow ramp and/or waterfront landing etiquette.
- Obey all posted speed limits and no-wake zones.
- Understand the regulatory and contractual necessity of proper boat handling.
- Understand all items as specified in the ride center rental agreement and waivers.
- Know the assumed risks and consequences, as well as the fines for non-compliance and the potential for injury caused by careless or reckless behavior while riding a PWC.
- Understand that the operator must stay tethered to the PWC with the safety lanyard and wear the authorized operator identification (where applicable).
- Understand that the rental can be summarily terminated at the discretion of the ride center for, among other things, inappropriate behavior and/or general misconduct.

Customer Don'ts:

- Use alcohol or drugs.
- Engage in reckless behavior and/or spraying others.
- Jump wake within restricted limits.
- Overload a PWC--know its capacity.
- Get too close to other vessels or users.
- Operate the PWC in shallow waters less than 2 feet deep.
- Pollute the environment or disturb local wildlife.
- Ignore sudden changes in apparent weather or water conditions.
- Disobey ride center guidelines, instructions or policies.
- Disobey local, state or federal boating rules, regulations and practices.
- Allow the PWC rental to be operated by anyone who has not completed the required ride center PWC rental training, testing and rental agreement documentation.
- Operate above idle speed within 100 feet of other PWC, boats, users, etc.

3.8 PROHIBITION

The most definite method of eliminating adverse PWC impacts is to ban their use completely. Although a less stringent approach may meet management objectives, outright prohibition may be necessary under certain environmental conditions or when certain community characteristics are at stake. Several attempts to prohibit PWC use throughout the country have had varying degrees of success. The following case studies provide insight into the rationale and legal processes underlying various PWC prohibitions.

3.8.1 San Juan County, Washington

In January 1996, San Juan County, Washington became the first local government to pass an ordinance prohibiting PWC use. San Juan officials took this action to respond to local residents, who had been expressing widespread concern regarding PWC design and use and the potential impacts that these vessels might be having on the area's serene character and pristine natural resources.

The ordinance called for a 2-year prohibition of PWC use, during which time researchers could more thoroughly examine the issue and determine if and where PWC use might be appropriate. However, shortly after the ordinance passed, the county was sued by a group of PWC business owners, operators and industry lobbyists. The group argued that, since the state's boat licensing rules did not distinguish between PWC and other motorized vessels, that regulatory actions could not single out PWC and restrict them more harshly than other vessels. This argument prevailed in the county's Superior Court but, after a 2-year appeal process, the Washington Supreme Court overruled the lower court and upheld the county's right to ban PWC use. This 1998 decision set an important precedent for all local governments hoping to prohibit PWC use (Urban Harbors Institute 1999).

During the appeal process, a group of scientists and San Juan County planners prepared a comprehensive report on PWC and their impacts on natural and social environments. This report synthesized an array of existing information regarding water quality, wildlife disturbance, safety and noise. It examined how PWC are designed, marketed and used and compared PWC safety records and usage demographics to those of other vessels. Moreover, it catalogued the region's unique marine resources and compared the effectiveness and feasibility of a variety of other management strategies (San Juan County Planning Department 1998). In the end, this report gave San Juan County the justification it needed to ban PWC permanently. Furthermore, it has been cited in PWC debates around the country and continues to serve as a model for local governments desiring to prohibit PWC use.

3.8.2 Marin County, California

In November 1999, officials in Marin County, California passed an ordinance that prohibited PWC use in the coastal waters and estuaries flanking the Golden Gate Bridge. However, county officials soon began to struggle with enforcement issues. For example, the county only had one boat to patrol a sizeable area comprised of two coastlines and several inland waterways. Moreover, the county only had actual jurisdiction over some of its waters. Remaining waters were controlled by various cities that were not willing to pass their own local ordinances to strengthen the county's ban. Consequently, the area became an erratic "jigsaw puzzle" of navigational rules (Urban Harbors Institute 2000).

This ordinance was quickly challenged by a group of PWC constituents comprised of PWC owners, dealers, manufacturers and lobbyists. This group sued Marin County and, in 2001, the Marin County Superior Court overturned the PWC prohibition on the grounds that it was unconstitutionally vague. However, in July 2002, a state appeals court reinstated the ban, ruling that maps, landmarks and other available information could reasonably define the county's jurisdictional area and that PWC infractions could be challenged in areas where county boundaries were not clearly marked. Barring another appeal, which is possible, the Marin County PWC ban could take effect in the fall of 2002.

3.8.3 United States National Park Service

Although local or state prohibitions affect PWC operators most directly, no PWC ban has generated more controversy, debate or media attention than the one enacted by the U.S. National Park Service (NPS). In April 2000, the NPS issued a Final Rule (36 C.F.R.§3.24) that prohibits PWC from all National Park units unless a superintendent can show that PWC use is compatible with his or her unit's enabling legislation, resources, values, other visitor uses and overall management objectives (65 Fed. Reg. 15, 077-15, 000, Mar.21, 2000).

By the Final Rule, the NPS immediately banned PWC from any park whose resource integrity, character or enabling legislation was inconsistent with PWC use. It then identified 21 specific park units in which PWC use might be appropriate and divided them into two categories (Table 7). "Park Designated PWC use Areas" included units in which water-based recreation was a primary purpose and where substantial motorized vessel use occurred. "Special Regulation PWC use Areas" included those units whose enabling legislation was vague or unclear regarding the relative importance or impact of recreational boating and PWC use. Each of these units was granted two years to evaluate the impacts of PWC use and, if appropriate, to allow PWC use via a Superintendent's Compendium or a Special Regulation (36 C.F.R.§3.24, 2000).

The NPS Final Rule was quickly challenged in court by the Bluewater Network, which argued that, by continuing to allow PWC use in these 21 park units, the NPS was violating its mandate to leave park resources unimpaired. As a result of this case's federally-approved settlement agreement, these parks are now required to undergo a formal rulemaking process to continue PWC use. In other words, a Superintendent's Compendium is no longer adequate and either an Environmental Impact Statement (EIS) or Environmental

Assessment (EA) must be completed in accordance with the National Environmental Protection Act (NEPA). PWC use is permitted in these units while they undergo the rulemaking process but the settlement terms mandate that the entire process be completed by April 2002 (for units that have created a Special Regulation under the Final Rule) or September 2002 (for units undergoing NEPA review) (US NPS 2001).

Table 7. Categories Regarding Potential PWC Use in Selected NPS Units

Park Designated PWC Use Areas	**Special Regulation PWC Use Areas**
**Amistad Natl. Recreation Area (TX)*	**Assateague Island Natl. Seashore (MD/VA)*
**Bighorn Canyon Natl. Recreation Area (MT)*	*#Cape Cod Natl. Seashore (MA)*
**Chickasaw Natl. Recreation Area (OK)*	*#Cape Lookout Natl. Seashore (NC)*
**Curecanti Natl. Recreation Area (CO)*	*#Cumberland Island Natl. Seashore (GA)*
**Gateway Natl. Recreation Area (NY/NJ)*	**Fire Island Natl. Seashore (NY)*
**Glen Canyon Natl. Recreation Area (AZ/UT)*	*#Gulf Islands Natl. Seashore (FL/MS)*
**Lake Mead Natl. Recreation Area (AZ/NV)*	*#Padre Island Natl. Seashore (TX)*
**Lake Meredith Natl. Recreation Area (TX)*	*#Indiana Dunes Natl. Lakeshore (IN)*
**Lake Roosevelt Natl. Recreation Area (WA)*	**Pictured Rocks Natl. Lakeshore (MI)*
#Whiskeytown Natl. Recreation Area (CA)	*#Delaware Water Gap Natl. Recreation Area (PA)*
	**Big Thicket Natl. Preserve (TX)*

Unit has prohibited PWC use or will prohibit use after the grace period expires.
* Unit is undergoing NEPA review to evaluate alternatives for managing PWC use.

In the wake of these legal actions, park superintendents and their staff have been scrambling to evaluate PWC impacts and use. Many of the National Seashores, such as Cape Cod, Cape Lookout, Cumberland Islands, the Gulf Islands and Padre Island, as well as the Indiana Dunes National Lakeshore have already banned PWC use (or plan to soon). However, many of the National Recreation Areas (except for Whiskeytown and the Delaware Water Gap), have decided to explore the potential for continued PWC use and are currently undergoing NEPA review. Therefore, at the time this document was printed, the final number of NPS units in which PWC use will be prohibited has yet to be determined.

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CHAPTER FOUR:
CREATING PWC POLICY

CREATING PWC POLICY

Since effective resource management begins with effective resource policy, this chapter of the *PWC Management Guide* serves to support those readers who are involved in policy development and implementation. It is intended to facilitate PWC management policies that balance the rights of PWC constituents with the rights of other boaters, recreators and resource users, while minimizing adverse PWC-related impacts and protecting the overall character, quality of life and visitor appeal of local communities.

The policy-making process may be divided into a series of interrelated phases or steps, each representing an interactive set of actions and ideas. Although the number of phases often varies, most policy-making frameworks entail some permutation of the same general steps or activities. This chapter outlines these steps and highlights the specific considerations that are pertinent to the creation of PWC policy. It also discusses several factors that influence the effectiveness of PWC policy.

4.1 Issue Recognition and Definition

The first step in policy development is to recognize or identify an emerging issue, problem or concern. Emerging issues and concerns are not always self-evident, but they often become apparent through focusing events, public feedback or changing trends in ecological and social indicators. For example, PWC debates often surface following severe safety infractions, after notable increases in public complaints regarding noise and safety, or because scientific and/or popular media link PWC use to environmental degradation. Emerging issues and concerns are also identified by broader indications that a certain problem is becoming widely recognized. The PWC ban enacted by the National Park Service brought PWC-related issues to the forefront of the recreational boating arena and continues to influence the way that many local and state governments approach PWC management and use.

Once an issue or problem has been recognized, it usually needs to be more comprehensively defined. This evaluative process involves separating and prioritizing the various components of the issue so that they may be appropriately framed and presented to the public. During this step, local resource managers and government officials should delineate the specific impacts or problems that are relevant to their community so that they may focus their management efforts accordingly. Some communities may need to reduce PWC-related water pollution or wildlife disturbance, whereas others may choose to focus on public safety issues.

Since the definition of a particular issue or problem is influenced by the values, goals, biases, assumptions and understanding of the individuals involved in the process, it is important to engage as many constituents and interest groups as possible. This inclusive approach enables policy makers to facilitate better understanding of the issue at hand by elucidating perceptions and creating consensus regarding the nature and extent of the problem (Putt and Springer 1982). Although the number and type of stakeholders will vary by community, potential stakeholders in PWC management include: PWC owners and operators; other recreational boaters and coastal recreators; natural resource scientists and managers; local citizens and shorefront property owners; marina operators and other commercial water-users; PWC dealers and livery operators; local harbormasters, law and safety officers and economic development officials; and all relevant government, industry and environmental representatives.

4.2 Issue Refinement

The second phase in policy development is to clarify or refine the issue that emerged in the first phase. By fine-tuning a specific problem or concern, issues can be scoped to raise public interest or to garner public support for a particular management strategies. During the refinement phase, general issues such as "wildlife disturbance" or "public safety," are transformed into more specific, tangible problems such as "disruption of nesting activities within a coastal wildlife sanctuary" or "excessive PWC operation near public swimming areas." When refining an issue, policy makers should gather as much site-specific data and information as possible (given time and budgetary constraints) and assess it in a holistic context that considers other related issues and problems. Appendix H, taken from guidelines created by the National Park Service's Environmental Quality Division, provides a useful checklist for the collection of data and information necessary to assess PWC impacts. The site-specific information on this list, combined with the general scientific information contained in the first section of this manual, offer a solid framework for refining PWC issues. As in the case of issue recognition and definition, involving a diverse group of constituents in this process helps to ensure that the refined issue balances the opinions, goals and needs of the community (Putt and Springer 1982).

An effective way to refine PWC issues is to solicit input from the public regarding their knowledge of PWC impacts, their participation in PWC use and their opinions about PWC management. Public workshops, hearings, interviews and surveys are useful ways to gather such input. For example, policy makers may conduct local hearings or interviews to gauge public opinion regarding PWC issues and determine how local residents view PWC use compared to other recreational and resource uses. Moreover, policy makers may administer surveys to delineate local boating activity, quantify vessel use and characterize public awareness of or concern for boating-related environmental issues. (See Appendix I for a sample survey regarding boating opinions and use.) In turn, survey results may be used to identify opportunities for public education and outreach (i.e., informing PWC users about the ecologically sensitive nature of shallow water areas) or to provide insight into the potential effectiveness of various PWC management strategies (i.e., zoning scenarios or set-back distances).

4.3 Development of Policy Alternatives

Once an issue has been recognized and refined, the development of alternative policy solutions can begin. It is useful to begin this phase by taking inventory of past or present policies and assessing their performance or effectiveness. This inventory enables policy makers to identify problems or concerns that were not addressed by previous policies and integrate them into the decisions and priorities of the issue refinement phase. Once all of the relevant issues and concerns are on the table, overarching goals should be developed to guide current and future policy-making efforts. Setting well-defined, achievable goals is important because they ensure that policy alternatives are properly focused and capable of addressing the issues at hand. After past policy efforts have been assessed and future policy goals are established, alternative policy solutions can be selected. Viable policy alternatives are selected by considering the potential outcomes of a wide range of options and carefully choosing those policies that are capable of addressing the primary issue and facilitating the established goals.

With regard to PWC management, policy development should begin by assessing 1) existing laws, regulations and usage restrictions; 2) applicable education and training requirements; and 3) current management strategies (i.e., zoning, vessel restrictions, prohibitions, etc.). Then, overarching goals such as "protecting wildlife" or "enhancing public safety" should be set according to the outcome of the issue refinement phase. Finally, new management policies—or combinations of old and new policies—can be developed to deal with issues that require more direct action. For example, if a community's primary goal is to protect wildlife, then its PWC policy alternatives should focus on ways to decrease PWC-related noise and disturbance. Appropriate options might include regulating PWC noise output or restricting PWC use near critical habitat areas. Conversely, if a community's main priority is to enhance public safety, then its policy alternatives should focus on strategies that improve PWC operation. Appropriate policy options might involve regulating PWC use, facilitating boating education and safety training or making PWC more compatible with other vessels and recreational activities.

4.4 Evaluation of Policy Alternatives

After a range of alternative policy solutions has been developed, the potential feasibility and outcome of each alternative should be evaluated. To assess feasibility, policy makers need to consider 1) the alternative's fiscal and human resource requirements; 2) the complexity of its initiation or implementation processes; and 3) the magnitude of change it requires of the public (Putt and Springer 1982). Laying out policy options with these demands generally facilitates a better decision-making process and, as many policy makers have discovered, it is usually more difficult to garner public support for policies with large resource demands and complex implementation processes than for policies that are relatively simple and direct. Many communities have opted for a PWC-specific speed limit or temporal use restriction rather than a spatial zoning system because, in most cases, spatial zoning involves a complex implementation process and requires substantial monetary and human resources. Similarly, policies that require the public to stray from familiar management scenarios may not be viewed as favorably as those that adhere to conventional pathways. In many cases, older or more experienced boaters who are not typically accustomed to or supportive of mandatory boating education may be more inclined to support voluntary PWC education programs.

4.5 Policy Initiation

Policy initiation is the phase in which a specific policy alternative or course of action is selected and put into practice. During this phase, policy analysts are often employed to provide more in-depth evaluations of the proposed alternatives and to advise stakeholders and other key decision makers. Some analysts recommend specific policies based on their probable outcome, while others project future conditions that could result from particular policy alternatives (Patton and Sawicki 1993). In either case, analysts usually examine policy aspects like effectiveness, efficiency, equality and responsiveness (Putt and Springer 1982).

Generally speaking, effectiveness refers to the magnitude of an outcome that a policy will provide. Decreasing numbers of PWC-related safety infractions and noise complaints, or increasing numbers of shorebird sightings, may reflect policy or program effectiveness. Efficiency, on the other hand, refers to such outcomes in terms of a particular level of effort. How much do safety infractions decrease with each dollar spent on additional law enforcement or boater education? Or how much do shorebird sightings increase with each hour of environmental education or voluntary monitoring? Equality signifies the overall distribution of a particular policy's costs and benefits within a given society. Are the individuals affected by a PWC policy bearing a proper proportion of its costs or are non-boaters and non-resource users paying for the policy? Finally, responsiveness refers to the degree in which a policy will meet the needs and goals of those individuals or groups affected by it. Will a proposed PWC management scenario adequately address a community's wide range of environmental quality or public safety concerns?

Upon examining these aspects of policy, analysts provide local decision makers with qualitative and quantitative information regarding the nature and extent of support that each policy alternative requires. They also provide insight into the logistical reality and potential feasibility of the proposed alternatives. With this in mind, decision makers can compare the proposed alternatives, select a specific policy and lay the groundwork for implementing it. This groundwork includes gathering and committing adequate time and resources and, in some cases, the passage of new legislation.

4.6 Policy Implementation

Whereas the previous phases represent intent, the policy implementation phase produces results. Implementation is where the "rubber meets the road" and it requires a myriad of actions and decisions. One of the primary tasks of implementation is to take the general goals that were established in previous phases and transform them into clear, detailed, measurable objectives. If a policy's goal is to minimize wildlife disturbance, then suitable objectives may be to reduce waterbird flushing from a known nesting site or to protect critical spawning areas for local finfish populations. Similarly, if a policy's goal is to improve public safety, then appropriate objectives may include reducing boating activity near public swimming areas or enhancing PWC operation among teenagers.

Once these objectives are established, they can be pursued through specific actions such as setback distances, zoning scenarios or boating education. During the implementation phase, policy makers may be tasked with creating new organizational units, establishing directives, recruiting personnel, assigning duties, budgeting and distributing funds, awarding grants or contracts, supervising staff, enforcing regulations and reporting to stakeholders (Putt and Springer 1982).

The activities and decisions associated with PWC policy implementation vary widely, depending on the established objectives. However, there are certain general conditions that facilitate successful policy implementation (Sabatier and Mazmanian 1981). For example:

- The policy's goals and objectives must be clearly defined and should reflect the needs and interests of relevant stakeholders.
- The selected course of action must lead to the realization of goals and objectives.
- The implementation plan must be structured in a manner that is conducive to success.
    - There should be sufficient human and financial resources.
    - The necessary responsibilities and supporting roles should be assigned.
    - There should be adequate access to relevant agencies and supporters.
- The program leaders should possess adequate managerial and political skill and must be committed to the selected policy or course of action.
- The selected policy or course of action must have the active support of relevant constituents.
- The selected policy or course of action should not be undermined by the emergence of conflicting policies or by changes within the relevant political or social context.

Keeping these conditions in mind during PWC policy clarification and initiation will increase the potential for successful policy implementation.

4.7 Policy Evaluation

Although evaluation is the last phase in this particular model of the policy process, it is far from being an endpoint. Instead, it is a feedback mechanism that frequently loops back into one of the previous stages. In general, policy evaluation enables stakeholders to better understand what happened during the issue recognition and refinement phases and provides insight into the success of the implementation phase (Putt and Springer 1982). Some evaluations describe past policies, while others assess ongoing ones (Patton and Sawicki 1993). Either way, the primary objective of policy evaluation is to learn from the past so that future actions may be more effective, efficient and fair. To this end, the evaluation phase serves to enhance the modification and continuation of specific policies or programs by: 1) assessing how well the selected policy or course of action is achieving its objectives; 2) delineating the least and most effective components of a particular policy or action; and 3) identifying unexpected side effects or unintended consequences (Putt and Springer 1982).

PWC policy evaluations may be conducted in various ways. One way is to monitor specific PWC management programs to ensure that incoming resources are being used efficiently and that desired outcomes are being achieved. For example, a local waterways zoning plan may be scrutinized to determine if law enforcement resources are being managed efficiently or whether or not the zoning scenario is adequately mediating multiple-use conflicts. Alternatively, specific PWC-related impacts may be assessed to determine if the necessary ecological and social changes are occurring. By collecting quantitative data on various impacts (i.e., public safety infractions, noise complaints, wildlife disturbances, etc.), changes can be linked to various components of a policy or action. This process enables policy makers to enhance future efforts and ensure the continuation of positive results. Finally, the implementation process itself may be evaluated to determine how well a given policy or action is performing and, if necessary, how to improve the process in order to accomplish the desired goals and objectives. For example, a PWC safety program may not be performing optimally if the funds allocated towards it are not substantial enough to provide adequate education and training to all boaters. By recognizing this downfall, stakeholders can redirect their efforts towards securing the necessary funds to increase the scale and reach of the program.

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APPENDICES:

A: Acronyms
B: PWC Usage Restrictions By State
C: NASBLA's Model Act for PWC
D: Zoning Scenarios In Selected Marine Protected Areas
E: NASBLA Boating Education Standards
F: The PWIA's "20 Ways to Protect the Environment"
G: NASBLA & PWIA Recommendations for PWC Rental Operators
H: Informational Needs For PWC-Specific Environmental Analyses
I: Sample Boating Opinion & Use Survey
J: PWC Information Sources

APPENDIX A: Acronyms

AWA	American Watercraft Association
BBPWCTF	Barnegat Bay Personal Watercraft Task Force (New Jersey)
BOAT US	Boat Owners Association of the United States
BTEX	benzene, toluene, ethylene, xylene
CAA	Clean Air Act
CARB	California Air Resources Board
CMMA	Canadian Marine Manufacturers Association
CZM	Coastal Zone Management
DFI	direct fuel-injected
EPA	Environmental Protection Agency
FKNMS	Florida Keys National Marine Sanctuary
GBRMPA	Great Barrier Reef Marine Park Authority (Australia)
HC	hydrocarbon
MBNMS	Monterey Bay National Marine Sanctuary (California)
MLCD	Marine Life Conservation District (Hawaii)
MTBE	methyl tert-butyl ether
NASBLA	National Association of State Boating Law Administrators
NMMA	National Marine Manufacturers Association
NOAA	National Oceanic and Atmospheric Administration
NPCA	National Parks Conservation Association
NPS	National Park Service
NRPA	National Recreation and Park Association
NTSB	National Transportation Safety Board
PAH	polycyclic aromatic hydrocarbon
PFD	personal floatation device
PWC	personal watercraft
PWIA	Personal Watercraft Industry Association
RFG	reformulated gasoline
SAV	submerged aquatic vegetation
TRPA	Tahoe Regional Planning Agency (California, Nevada)
USBI	United Safe Boating Institute
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USPS	United States Power Squadrons

APPENDIX B: PWC Usage Restrictions by State

APPENDIX C. NASBLA'S Model Act for PWC

This model legislation was adopted on September 26, 1991, amended in September 1996 and approved on October 2, 1996.

General: In addition to all other boating laws and regulations in this state, the following shall apply to personal watercraft:

Section 1. (Definitions.) As used in this chapter:

(a) "Personal watercraft" shall mean a vessel, less than 16 feet, propelled by a water-jet pump or other machinery as its primary source of motor propulsion which is designed to be operated by a person sitting or kneeling on it, rather than being operated by a person sitting or standing inside the vessel.

Section 2. (Regulations of personal watercraft.)

(a) No person shall operate a personal watercraft unless each person aboard is wearing a type I, type II, type III or type IV personal floatation device approved by the United States Coast Guard.

(b) A person operating a personal watercraft equipped by the manufacturer with a lanyard type engine cutoff switch shall attach such lanyard to his person, clothing or personal floatation device as appropriate for the specific vessel.

(c) No person shall operate a personal watercraft at any time between sunset and sunrise.

(d) No person under the age of 16 shall operate a personal watercraft on the waters of this state, except a person 12 to 16 years of age may operate a personal watercraft if a person at least 18 years of age is aboard the vessel.

(e) Every personal watercraft shall at all times be operated in a reasonable and prudent manner. No person shall operate a personal watercraft in an unsafe manner. **Unsafe personal watercraft operation shall include, but not be limited to the following:**

i. Becoming airborne or completely leaving the water while crossing the wake of another vessel within 100 feet of the vessel creating the wake.
ii. Weaving through congested traffic.
iii. Operating at greater than slow/no-wake speed within 100 feet of an anchored or moored vessel, shoreline, dock, pier, swim float, marked swim area, swimmers, surfers, persons engaged in angling or any manually propelled vessel.
iv. Operating contrary to the "rules of the road" or following too close to another vessel, including another personal watercraft. For the purposes of this section, following too close shall be construed as proceeding in the same direction and operating at a speed in excess of 10 mph when approaching within 100 feet to the rear or 50 feet to the side of another motorboat or sailboat which is

underway, unless such vessel is operating in a narrow channel, in which case a personal watercraft may operate at speed and flow of other vessel traffic.

(f) No person who owns a personal watercraft or who has charge over or control of a personal watercraft shall authorize or knowingly permit the personal watercraft to be operated in violation of this act.

Section 3. (Exemptions.)

(a) The provisions of Section 2 shall not apply to a person participating in an officially sanctioned regatta, race, marine parade, tournament or exhibition.

Section 4. (Mandatory Safety Instruction by Rental Operators.)

(a) No person shall rent a personal watercraft to another person without first providing safety instruction to that person. Such instruction shall include, but not be limited to: (1) operational characteristics of personal watercraft; (2) laws and regulations, boating rules of the road, personal responsibility; and (3) local characteristics of waterways to be used.

Section 5. (Towing Water Skiers.)

(a) No personal shall operate a personal watercraft towing another person on water skis or other device(s), unless the personal watercraft has, on board, in addition the operator, an observer who shall monitor the progress of the person(s) being towed.

(b) No person shall operate a personal watercraft towing another person on water skis or other device(s), unless there is adequate seating space available on the craft for the operator, the observer and each person being towed.

APPENDIX D: Zoning Scenarios In Selected Marine Protected Areas

APPENDIX E: NASBLA's Boating Education Standards

Part 1--The Boat

- *Boat capacities*
- *Boat registration requirements*

Part 2--Boating Equipment

- *PFD types & carriage*
- *PFD sizing & availability*
- *Wearing PFDs*
- *PFD serviceability*
- *Fire extinguishers*
- *Back-fire flame control device*
- *Ventilation systems*
- *Navigation light equipment*
- *Sound signaling equipment*

Part 3--Trip Planning & Preparation

- *Checking local conditions*
- *Checking local hazards*
- *Filing a float plan*
- *Boat preventative maintenance*
- *Transporting & trailering*
- *Fueling procedures*
- *Pre-departure checklist*
- *Passenger communication*

Part 4--Marine Environment

- *Environmental laws & regulations*
- *Human waste disposal*
- *Disposal of toxic substances*

Part 5--Safe Boat Operation

- *Operator responsibilities*
- *Influence of drugs & alcohol*
- *Navigational rules of the road*
- *Aids to navigation*
- *Docking & mooring*
- *Anchoring*

Part 6--Emergency Preparedness

- *Rendering assistance*
- *Capsizing emergencies*
- *Falls overboard emergencies*
- *Hypothermia prevention*
- *Fire emergency preparedness*
- *Grounding prevention & response*
- *Accident reports*
- *Boating accident report forms*

Part 7--Other Water Activities

- *Personal watercraft & jet-boats*
- *Water Skiing*
- *Diving & snorkeling*
- *Hunting & fishing*

Part 8--Boating Education Practices

- *Continuing education*
- *State-specific boating information*

Part 9--Course Format & Testing Requirements

- *Boat operator knowledge course formats*
- *Boat operator knowledge exams*

Recommended Boating Safety Information

- *Boat types & uses*
- *Boating terms*
- *Boat theft prevention*
- *Communication procedures*

APPENDIX F. The PWIA's "20 Ways To Protect The Environment"

1. Refuel on land to reduce any chances of spilling oil or gas into the water.
2. Slow down when filling the tank, do not overfill, catch any accidental spills with an absorbent pad and dispose of it properly.
3. Check and clean your engine well away from shorelines. Oil can harm the water's delicate micro-organisms and the animals that feed on them.
4. Do not operate in waters less than two feet in depth.
5. Ride in main channels and limit riding in shallow water.
6. When it is necessary to ride in shallow water, keep watercraft at an idle speed. This will help reduce turbidity (the stirring up of bottom sediments which limits light penetration and depletes oxygen, affecting fish and bird feeding).
7. In coastal areas, be aware of the low tide. The waters may be substantially more shallow at these times, exposing valuable fish nurseries such as sea grass beds and other delicate vegetation. Ingestion of these into your craft may cause engine or pump problems and reduce performance.
8. Birds feeding in shallow areas or on the shoreline should not be disturbed.
9. If you are riding near coral, do not use an anchor and be careful when diving to avoid coming into contact with these delicate organisms.
10. Stay away from kelp forests. Found close to shore, the kelp canopy covers the surface of the water and extends down, supporting a lush underwater community of fish, invertebrates, sea urchins and sea otters.
11. Avoid grass marshes found in salt or fresh water coastal areas or rivers. Hidden in the thickets are nesting birds, frogs, turtles, snakes and possible alligators.
12. Observe posted no-wake zones near shore. Excessive boat wakes may contribute to shoreline erosion, which can affect the habitats of plants and animals.
13. Be a courteous boat operator. Be aware that noise and movements of boats may disturb the local residents--including waterfront homeowners, birds, marine mammals and other wildlife.
14. Ride at controlled speeds so you can see any animals ahead of you.
15. Avoid areas of high animal population.
16. If you see an animal hit by a boat, note the location and report it immediately to your local wildlife commission.
17. When docking or beaching, look for evidence of turtles, birds, alligators and other animals along shore.
18. Avoid docking or beaching where plants such as reeds, grasses and mangroves are located. These essential plants control erosion and provide a nursery ground for many small animals and fish.
19. Be aware of the endangered species that are found in your riding area. The U.S. Fish and Wildlife Service is responsible for listing the hundreds of species in decline.
20. Wash off your boat after you use it to prevent the spread of exotic plants to other lakes and rivers. Exotics have no natural enemies and spread easily, killing off native species and decreasing important plant and animal diversity.

APPENDIX G. NASBLA & PWIA Recommendations For PWC Rental Operators

The following guidelines, compiled by the National Recreation & Park Association (NRPA) and the U.S. Coast Guard (USCG), represent the "best business practices" for PWC rental operators, as recommended by NASBLA and the PWIA.

1. PWC are not to be rented to anyone under the age of 18.
2. Boating safety instruction should be provided according to state-established rules and/or guidelines for all renter/operators not having a valid 'permanent' boating safety education certificate and valid identification.
3. Ensure that staff responsible for customer training have successfully completed a NASBLA approved boating safety education course or state equivalency exam.
4. Prior to the rental, provide rental customers with printed information on:
    - Local water hazards, no-entry zones, no-wake zones, channel routes and tidal flow (where applicable)
    - Boating regulations peculiar to the area
    - Operational characteristics of PWC
5. Review the common courtesies of operating a PWC and their effect on wildlife, the environment and other waterway users.
6. All PWC operators and passengers are required to wear a USCG approved type I, type II or type III personal floatation device. Inflatable PFDs are not to be used on PWC.
7. While the engine is running, PWC operators must utilize a lanyard type cut-off device designed to shut the engine off if removed from the PWC.
8. PWC are not to be operated in a reckless manner, including, but not limited to:
    - Weaving through congested traffic
    - Jumping the wake of another vessel within 100 feet
    - Operating at greater than slow/no-wake speed within 100 feet of an anchored or moored vessel, shoreline, dock, pier, swim float, marked swim area, swimmers, surfers, anglers or manually powered vessels
    - Disobeying navigation rules, including following too close and riding within 100 feet behind and/or 50 feet to the side of any other vessel at greater than 10 mph.
9. PWC are not to be operated between sunset and sunrise.

****The PWIA also recommends that PWC rental companies carry liability insurance of not less than $1 million dollars.**

APPENDIX H: Informational Needs For PWC-Specific Environmental Analyses

The following checklist, excerpted from National Park Service guidelines for the environmental analysis of PWC use, provides a useful starting point for communities that are evaluating PWC-related environmental impacts.

Basic Questions:

1. When did PWC use begin in the area?
2. How many PWC are observed during the primary boating season? (Estimated by counting PWC and PWC trailers in parking lots, launch ramps, etc.)
3. How many other boats and other types of boats visit the area during the peak boating season?
4. From what cities or states do the area's PWC users come? (Derived from trailer license plates, vessel registrations, boating fee receipts, etc.)
5. How far do PWC visitors travel?
6. How many PWC are rented in the area per month? (Collect data from PWC rental operations.)
7. In what areas do most PWC launch, operate and beach?
8. How do operators use their PWC (i.e., pleasure cruise, wake jump, water ski, etc.)?
9. What types of trips do PWC operators make (i.e., pleasure cruise, long-distance expedition, thrill-seeking)?
10. How many hours per day do PWC riders operate?
11. How many days per year?
12. Has PWC use been reported in any particular areas that create resource concerns or public safety threats?
13. How do PWC accidents & fatalities compare to other boating safety incidents in the area?
    - How do the numbers compare?
    - How do the accidents occur?
    - How bad are the resulting injuries?
14. Has your area collected any local PWC exposure or use data?
15. Has your area collected any resource data with respect to PWC use?

USEFUL INFORMATION SOURCES:

Maps/GIS data layers

- area zoning maps
- hydrology/water quality/watershed maps
- wetlands/estuaries delineation maps
- aquatic/riparian vegetation species, including native, exotic, threatened & endangered species
- critical habitat areas
- wildlife species, including endemic, exotic, threatened & endangered species

LISTS

- air/water pollution sources
- aquatic/riparian vegetation species, including native, exotic, threatened & endangered species
- wildlife species, including exotic, threatened & endangered species
- cultural resources

Data/Reports

- surface/groundwater water quality & quantity, including reservoirs supplies
- air quality districts/classification
- noise restrictions/studies
- noise sensitive areas
- wetlands types/functions
- visitation statistics/forecasts
- visitor activity in the area
- recreational & non-recreational uses of the area
- state boating laws applicable to PWC use in the area
- local boating safety data, including accidents, injuries & fatalities
- wilderness studies, especially those pertaining specifically to PWC use

APPENDIX I: Sample Boating Opinion & Use Survey

The following sample survey illustrates the type of boating policy information that can be obtained by administering a public opinion and use survey.

SECTION A: GENERAL BOATING INFORMATION

1. Which of the following types of recreational vessels do you or members of your household currently own? (Circle all that apply)

1 Open motorboat
2 Cabin motorboat
3 Houseboat
4 Pontoon boat
5 Sailboat (sail only)
6 Saiboat (auxiliary motor)
7 Jetboat
8 Personal watercraft
9 Canoe/Kayak
10 Rowboat
11 Other
12 None

2. During which months do you operate a recreational vessel? (Circle all that apply)

1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December

3. Do you do most of your boating on (Circle one):

1 Weekdays
2 Weekends
3 Both the same

4. In which types of boating-related activities do you usually engage? (Circle all that apply)

1 Pleasure Cruising
2 Sailing
3 Paddling
4 Racing/Speedboating
5 Waterskiing/Tubing
6 Wave/Wake jumping
7 Swimming
8 Diving/Snorkelling
9 Fishing
10 Shellfishing
11 Wildlife Viewing
12 Other

5. Why do you choose to engage in boating activities? (Circle all that apply)

1 Near home/lodging
2 Peaceful setting
3 Pristine environment
4 Low boating traffic
5 Adequate water quality
6 Adequate water depth
7 Adequate navigational aids
8 Adequate launch facilities
9 Fishing
10 Wildlife viewing
11 Scenic beauty

6. How do you rate yourself as a boater? (Circle one)

1 Novice/Beginner
2 Intermediate
3 Advanced
4 Expert

7. **Have you ever taken a boating operation or safety training course? (Circle one)**

1 Yes
2 No

If **yes**, when did you last take a course? ____________________________________

8. **Are you currently a member of any recreational boating clubs or organizations? (Circle one)**

1 Yes
2 No

If **yes**, please name the organization(s): ____________________________________

SECTION B: TYPICAL VESSEL CHARACTERISTICS

1. **Which type of recreational vessel do you use most often? (Circle one)**

1	Open motorboat	6	Jetboat
2	Cabin motorboat	7	Personal watercraft (jetski)
3	Houseboat	8	Canoe/Kayak
4	Pontoon boat	9	Other
5	Sailboat	10	None

2. **Is this vessel (Circle one):**

1 Owned by you or a member of your household
2 Rented
3 Borrowed from an aquaintance

3. **How many days per year do you use this vessel?**

________ Days/Year

4. **On days when you use this vessel, how many hours per day do you usually spend on the water?**

________ Hours/Day

5. **What length is this vessel?**

________ Feet

6. **If this vessel is motorized, what is its total horsepower?**

________ Horsepower

7. **How is this vessel propelled? (Circle one)**

1	Propeller	3	Manual (oars, paddles)	4	Air thrust
2	Water jet	4	Sail	6	Not sure

8. What is the primary type of engine on this vessel? (Circle one)

1 Inboard	3 Sterndrive	5 None
2 Outboard	4 Other	6 Not sure

9. How is the primary engine on this vessel powered? (Circle one)

1 Gasoline	3 Alternative fuel	5 Other
2 Diesel fuel	4 Electricity	6 Not sure

10. If the engine uses gasoline or diesel fuel, how many gallons do you use during an average day of boating?

________ Gallons/Day

SECTION C: BOATING OPINIONS

1. Individuals operating any recreational motorized vessel should be required to take a boating safety course.

1 Strongly agree
2 Agree
3 Disagree
4 Strongly disagree
5 No opinion

2. Individuals operating a personal watercraft (jetski) should be required to take a boating safety course.

1 Strongly agree
2 Agree
3 Disagree
4 Strongly disagree
5 No opinion

3. Individuals operating any recreational motorized vessel should be required to have licenses.

1 Strongly agree
2 Agree
3 Disagree
4 Strongly disagree
5 No opinion

4. **Individuals operating a personal watercraft (jetski) should be required to have licenses.**

   1 Strongly agree
   2 Agree
   3 Disagree
   4 Strongly disagree
   5 No opinion

5. **Individuals operating any recreational motorized vessel should be required to pass a test demonstrating their knowledge of boating laws and navigational rules.**

   1 Strongly agree
   2 Agree
   3 Disagree
   4 Strongly disagree
   5 No opinion

6. **Individuals operating a personal watercraft (jetski) should be required to pass a test demonstrating their knowledge of boating laws and navigational rules.**

   1 Strongly agree
   2 Agree
   3 Disagree
   4 Strongly disagree
   5 No opinion

7. **There should be more enforcement on local waterways to control reckless boaters.**

   1 Strongly agree
   2 Agree
   3 Disagree
   4 Strongly disagree
   5 No opinion

8. **The amount of boating traffic should be restricted on local waterways.**

   1 Strongly agree
   2 Agree
   3 Disagree
   4 Strongly disagree
   5 No opinion

9. The use of personal watercraft (jetskis) should be restricted in certain areas of local waterways.

1 Strongly agree
2 Agree
3 Disagree
4 Strongly disagree
5 No opinion

10. Personal watercraft (jetskis) should be prohibited on local waterways.

1 Strongly agree
2 Agree
3 Disagree
4 Strongly disagree
5 No opinion

SECTION D: ENVIRONMENTAL OPINIONS & CONCERNS

1. Do you think the quality of the natural resources (i.e. wildlife habitat, vegetation, etc.) in your areas is:

1 Increasing
2 Decreasing
3 Not Changing

2. Do you think the environmental health (i.e. water quality, biodiversity, etc.) of your area is:

1 Increasing
2 Decreasing
3 Not Changing

3. Do you think the aesthetic quality (i.e. scenic beauty, peaceful nature, etc.) of your area is:

1 Increasing
2 Decreasing
3 Not Changing

4. Recreational boating may adversely impact water bodies in various ways. Please identify which of the following potential impacts you are aware of (Circle all that apply):

1 Aesthetic degradation
2 Dumping of trash/human waste
3 Marine engine exhaust emissions
4 Public safety threats
5 Seagrass damage
6 Shoreline erosion
7 Water turbidity
8 Wildlife disturbance

5. Do you think you have adequate knowledge and information to help minimize the potential environmental impacts of recreational boating?

1 Yes
2 No

If **no**, what could your state coastal zone management program do to better inform you?

APPENDIX J: PWC Information Sources

Industry

American Watercraft Association
27142 Burbank Street
Foothill Ranch, CA 92610
(949) 598-5860
(949) 598-5872
www.watercraftassociation.com

Boating Industry International Online
www.boating-industry.com

Canadian Marine Manufacturers Association
243 North Service Road West, Suite 106
Oakville, Ontario L6M 3EM
(905) 845-4999
(905) 845-1701
www.cmma.org
info@cmma.org

National Marine Manufacturers Association
200 East Randolf Drive, Suite 5100
Chicago, IL 60601
(312) 946-6200
(312) 946-0388
www.nmma.org
webmaster@nmma.org

Personal Watercraft Industry Association
1819 L Street, Suite 700
Washington, DC 20036
(202) 721-1621
(202) 721-1626
www.pwia.org

PWC Manufacturers

Bombardier Sea-Doo
(715) 848-4957
www.sea-doo.com
info@Sea-Doo.com

Kawasaki Motors Corporation
P.O. Box 25252
Santa Ana, CA 92799-5252
(949) 460-5688
www.kawasaki.com/watercraft

Polaris Industries
2100 Highway 55
Medina, MN 55340
(763) 542-0500
www.polarisindustries.com

Yamaha Motor Corporation USA
P.O. Box 6555
Cypress, CA 90630
(800) 962-7926
www.yamaha-motor.com/wvnew/water

PWC User Websites

Personal Watercraft Illustrated
3505-M Cadillac Avenue
Costa Mesa, CA 92626
(714) 751-7433
www.watercraft.com

Personal Watercraft Underground
14751 Plaza Drive, Suite M
Tustin, CA 92780
www.jetski.com
jetman@jetski.com

Boating Safety Organizations

Boat Owners Association of the US
880 South Pickett Street
Alexandria, VA 22304
(703) 370-4202
(703) 461-2847
www.boatus.com/safety
mail@boatus.com

National Association of Safe Boating Law Administrators
1500 Leestown Road, Suite 330
Lexington, KY 40511
(859) 225-9487
(859) 231-6403
www.nasbla.org
info@nasbla.org

National Safe Boating Council
www.safeboatingcouncil.org
nsbcdirect@safeboatingcouncil.org

National Safety Council
1121 Spring Lake Drive
Itasca, IL 60143-3201
(630) 285-1121
(630) 285-1315
www.nsc.org

National Transportation Safety Board
490 L'Enfant Plaza SW
Washington, DC 20594
(202) 314-6000
www.ntsb.gov

PWC Safety School
www.PWCafetyschool.com

United Safe Boating Institute
P.O. Box 30428
Raleigh, NC 27622
(919) 755-0092
www.usbi.org
president@usbi.org

United States Coast Guard Auxiliary
www.cgaux.org

United States Coast Guard
Office of Boating Safety
2100 Second Street SW
Washington, DC 20593
(800) 368-5647
www.uscgboating.org
infoline@navcen.uscg.mil

United States Coast Guard
Office of Marine Safety & Environmental Protection
2100 Second Street SW
Washington, DC 20593
(202) 267-2229

United States Power Squadrons
P.O. Box 30423
Raleigh, NC 27622
(800) FOR-USPS
www.usps.org

Marine Protected Areas

Great Barrier Reef Marine Park Authority
P.O. Box 1379
Townsville, Queensland 4810
Australia
+61 7 4750 0700
+61 7 4772 6093
www.gbrmap.gov.au

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, CA 93940
(831) 647-4201
(831) 647-4250
www.mbnms.nos.noaa.gov

Florida Keys National Marine Sanctuary
P.O. Box 500368
Marathon, FL 33050
(305) 743-2437
(305) 743-2357
www.fknms.nos.noaa.gov

National Marine Sanctuary Program
1305 East-West Highway, 11th Floor
Silver Spring, MD 20910
(301) 713-3125
(301) 713-0404
www.santuaries.nos.noaa.gov
nmscomments@noaa.gov

Environmental Organizations

Bluewater Network
300 Broadway, Suite 28
San Francisco, CA 94133
(415) 788-3666
(415) 788-7324
www.earthisland.org/bw
bluewater@earthisland.org

National Parks Conservation Association
1300 19th Street NW, Suite 300
Washington, DC 20036
(202) 454-3392
(202) 659-8183
www.npca.org
npca@npca.org

Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20818
(800) 453-5463
(301) 548-0146
www.iwla.org
general@iwla.org

Surfrider Foundation USA
122 S. El Camino Real #67
San Clemente, CA 92672
(949) 492-8170
(949) 492-8142
www.surfrider.org
info@surfrider.org

Miscellaneous

San Juan Islands Regional Planning Authority
P.O. Box 947
Friday Harbor, WA 98250
(360) 378-2393
(360) 378-3922
www.co.san-juan.wa.us

Tahoe Regional Planning Authority
P.O. Box 1038
Zephyr Cove, NV 89448
(888) 508-TRPA
www.trpa.org
boattahoe@etahoe.com

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