Small Motorized Watercraft Workshops 2000

Linking Science to Management

Jacques Cousteau National Estuarine Research Reserve

Coastal Management Program, New Jersey Department of Environmental Protection

Institute of Marine and Coastal Sciences

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Small Motorized Boat Workshops 2000: Linking Science to Management is available in restricted amounts. For details, please contact: The Institute of Marine and Coastal Sciences at Rutgers University, 71 Dudley Road, New Brunswick, NJ 08901.

Table of Contents

Introduction

Increasing development coupled with growth in the recreational boating industry presents many challenges in balancing the use and protection of New Jersey waters. While power boating continues to be a popular water sport, there has been a rapid increase in the number of small motorized watercraft, including personal watercraft (PWC) in use. The need to manage boating activity, reduce conflicts between different types of watercraft, and minimize the environmental disturbances from these activities has become a critical issue in many areas. For the purpose of this report, a small motorized watercraft can be defined as a motorized boat capable of accessing shallow water.

In response to this issue, the New Jersey Department of Environmental Protection Coastal Management Program (NJDEP CMP), the Institute of Marine and Coastal Sciences at Rutgers University and the Jacques Cousteau National Estuarine Research Reserve (JC NERR) convened two workshops in the fall and winter of 2000. The steering committee was composed of the Barnegat Bay Personal Watercraft Taskforce, Institute of Marine and Coastal Sciences at Rutgers University, Kawasaki Motor Corporation, New Jersey Boating Regulation Commission, New Jersey Coalition of Lake Associations, NJ DEP Coastal Management Program, New Jersey Marine Trades Association and the Personal Watercraft Industry Association.

These workshops compiled scientific information regarding the impacts of small motorized watercraft on aquatic systems and presented a range of management models implemented around the United States. The workshops began with a Scientific Symposium on November 7-8, 2000, where speakers from around the country presented the results of research conducted on the impacts of small motorized watercraft to habitats, living resources, chemistry and water quality. A second workshop convened on December 12-13, 2000 brought together a range of successful management approaches from states, local governments, and public managed lands that have been designed to balance use and environmental impacts with respect to small motorized watercraft. The workshops were open to local government officials, scientists, resource managers, environmental groups, and marine trade businesses.

The first workshop included presentations on current available scientific information regarding small motorized watercraft and included the presentation of twenty-five studies on impacts to shallow water resources, including:

1. Noise impacts,
2. Hydrologic and water quality impacts,
3. Chemistry/toxicology impacts and
4. Habitat impacts.

These presenters showed unequivocally that more information is needed on the environmental impacts of small-motorized watercraft, including PWCs. Therefore, in order to develop management plans for these vehicles, more research on small-motorized watercraft use, scarring, noise, nuisance and movement impacts is needed for New Jersey. Additionally, this workshop resulted in the recognition that more baseline data on New Jersey shallow water systems is needed to formulate effective management planning for small motorized watercraft. The workshop also recognized the advances that the boating industry has made in respect to quieter and more efficient engines over the past few years. The participants recognized that social science research, inclusive of user surveys, should be included in the list of research needs for the New Jersey coastline.

The second workshop focused on management needs and responses to rising use of small motorized watercraft along the New Jersey coastline. Eight case studies were featured, representing approaches to managing impacts from small-motorized watercraft in shallow water. The combined information contained in these two reports is a resource for developing a plan of action regarding small motorized watercraft in New Jersey.

Impacts of Motorized Boats on Shallow Water Systems: Science Workshop Report

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Executive Summary

Results of the science workshop on "Impacts of Motorized Boats on Shallow Water Systems" held at Rutgers University on November 7-8, 2000, indicate that much more information is currently available on the environmental impacts of propeller-driven motorized watercraft than on the environmental impacts of jet propelled watercraft, including PWC. The workshop participants created the following definitions for the purpose of these workshops. A small-motorized watercraft is defined as one capable of accessing shallow water. It refers to jet-driven and propeller-driven boats less than ~6 m in length. For the purposes of these workshops, PWC are defined as vessels less than ~5-m long propelled by water-jets1. Thus, they are capable of operating in shallower water - even the narrowest tidal marsh channels - than conventional powered craft. Workshop participants defined propeller-driven watercraft as vessels propelled by one or more blades (screws) to create a backward thrust of water.[1]

Propeller-driven motorized watercraft potentially impact shallow water systems by altering water and sediment quality, benthic habitats, and biotic communities. Water quality changes are caused by inputs of chemical contaminants (hydrocarbons and metals) from boat engines and hulls, and propeller-induced sediment resuspension, which not only can raise turbidity levels but also nutrient and chemical contaminant concentrations in the water column via elemental remobilization from bottom sediments. Hydrocarbon compounds (large and non-soluble molecules) and trace metals released especially from two- and four-cycle engines and boat hulls are particle reactive, and therefore they tend to accumulate in bottom sediments. These contaminants can significantly alter sediment quality, particularly in heavily used urbanized regions. Propeller wash and propeller cutting directly impact benthic habitats by damaging submerged aquatic vegetation (SAV), scarring the substrate, and eroding sediments. These effects are detrimental to biotic communities, which may be completely eradicated at scarred sites. The impacts of scarring are particularly critical due to the number of years (3-7 years or more) needed for natural recovery by seagrasses. Deep propeller cutting also creates steep topographical depressions in the substrate that may remain uncolonized and barren for as much as 10-20 years. Benthic communities are most severely impacted where the water depth is less than 1 m, and boating activity produces multiple scars on the substrate.

Session findings noted potential impacts related to noise disturbance from small motorized watercraft, including PWCs on shallow water systems. Operation of small motorized watercraft near a Tern colony has been shown to adversely affect the behavior, reproduction, and distribution of one colony of colonial nesting birds (e.g., common terns) in a coastal environment (J. Burger). In another report, James Rodgers reports variation in flush distance among individuals within the same species and between species in response to jet and propeller-driven vessels. His study does not describe significant difference in flush distances by boat type for eleven species of waterfowl, while 5 species exhibit greater flush distances to propeller driven boats. Rodgers suggests a buffer zone distance could be developed for both fast moving PWC and propeller-drive vessels to minimize their disturbance at foraging and loafing sites in Florida.

Small motorized watercraft, including PWCs, also may affect nearshore habitats by accelerating sediment resuspension and eroding shoreline areas. The relationship between small motorized watercraft, including PWC, use and scarring impacts, however, has not been unequivocally established in New Jersey waters or elsewhere. More baseline data must be collected on small motorized watercraft and jet propulsion impacts on shallow water systems to help formulate effective environmental management strategies.

Introduction

A science workshop entitled, "Impacts of Motorized Boats on Shallow Water Systems," was held at Rutgers University on November 7-8, 2000. The workshop was convened by the New Jersey Department of Environmental Protection Coastal Management Program, the Institute of Marine and Coastal Sciences at Rutgers University, and the Jacques Cousteau National Estuarine Research Reserve, in partnership with state and local government agencies, industry representatives, and nongovernmental organizations, this workshop focused on documenting the current state of the science of small watercraft impacts on shallow aquatic systems. Accelerated use of power boats including personal watercraft during the past decade has raised concern regarding environmental disturbances that may adversely affect water quality and sensitive habitats and threaten the health and well being of aquatic organisms. The workshop was designed to highlight the research findings of scientists concerning an array of physical as well as chemical processes including prop scarring of benthic habitats (SAV in particular), shoreline erosion coupled to pressure wave and wake effects, sediment resuspension caused by propeller wash, and the release of hydrocarbons (e.g., polycyclic aromatic hydrocarbons) from engine fuels and oils and the diffusion of heavy metals (e.g., tin) from antifouling paints and primer bases on the hulls of the vessels. According to the PWIA personal watercraft is a vessel which uses an inboard motor powering a water jet pump as its primary source of motive power and which is designed to be operated by a person sitting, standing, or kneeling on the vessel.

Objectives

The purpose of the science workshop was not only to synthesize the current state of the science related to small motorized watercraft impacts on shallow water systems but also to generate information for use in managing impacts. To this end, the workshop identified data gaps, environmental impacts of concern, and science to management suggestions for managing vessel impacts. Four main categories of small motorized watercraft impacts were assessed by the workshop participants: (1) water quality alteration, (2) sediment quality changes, (3) benthic habitat modification, and (4) biotic community changes. These components were integrated into six sessions comprising the workshop including:

1. biology (SAV, plankton, benthos, fish, birds, mammals and turtles, productivity, fisheries/resources, and noise impacts on biota);

2. habitat (impacts of waves, scarring, seabed/SAV effects, shoreline erosion/deterioration, and turbulence);

3. chemistry (chemical contaminants, contaminant sources, contaminant concentrations, water quality, turbulence/turbidity, sediment resuspension, light attenuation, and marine engine emissions);

4. toxicology (aquatic toxicology and contaminant uptake, bioaccumulation, organismal response including bioaccumulation tests, biotransformation, behavioral toxicology studies, histopathology, lethal effects testing, sublethal effects testing, and toxicology testing including acute, chronic, static, flow-through, and sediment testing);

5. assessment of propeller boat and engine impacts; and

6. assessment of small motorized watercraft, including PWC impacts.

Workshop Contents-Workshop Overview

This workshop report contains the abstracts of 25 papers presented at the science workshop. These papers primarily deal with the following environmental factors: (1) biotic impacts (one session), (2) hydrologic and water quality impacts (one session), (3) chemistry/toxicology impacts (one session), and (4) habitat impacts (three sessions). An important component of the workshop sessions was a 15-minute panel interaction period devoted to synthesizing the output of the presentations. Scientists participating in the session were asked to discuss (1) the environmental impacts of concern, (2) existing data gaps, and finally, suggestions for guiding principles for managing identified environmental impacts.

Workshop Abstracts

The Personal Watercraft in Deep Time: Historical Context for the Evolution of a Radically New Boating Paradigm

1. Keynote

Kent Mountford, Estuarine Ecologist and Environmental Historian, Cove Corporation, 10200 Breeden Road, Lusby, Maryland 20657

Pleasure boating for other than Royalty is a relatively recent concept in the history of navigation, during which watercraft were vehicles of trade, discovery and war. The author views this behavior as an outgrowth of wealth and leisure widely available following the industrial revolution. A bifurcation between sail and power developed at the juncture of the 19th and 20th Centuries. The outboard motor may have been the most revolutionary addition, even impacting fisheries worldwide, as well as giving people portable mobility. Fiberglas enabled boating virtually without maintenance or skills and made room for an attitude shift, which could explain today's polarized opinions. The impacts and conflicts associated with the use of personal watercraft and small boats in shallow water systems are discussed as an introduction to the workshop.

2. Session A: Noise Impacts (Chair: Burger)

a. Managing Personal Watercrafts Around Tern Colonies

Joanna Burger, Department of Biological Sciences, Rutgers University, Piscataway, New Jersey 08854-8082

The number of personal watercraft (PWC) used in coastal and inland waterways has increased, potentially disturbing people, fisheries activities, and wildlife and recreational resources. In 1997, I examined the behavior of nesting Common Terns as a function of exposure to PWC and other boats. PWCs traveled faster than motorboats near nesting islands, and came closer to birds. The number of terns that flew up in response to PWCs was greater than that in response to motorboats. On one long-studied tern island, the terns suffered nearly total reproductive failure in 1996 and 1997. Because of these adverse effects, an educational and enforcement campaign was initiated in 1998. Public meetings included presentations by scientists, marine police, state conservation officials, PWC associations, marina owners, and the general public. These measures proved effective the following year: PWC traffic around the nesting islands was reduced, most PWCs that passed the tern nesting island did not venture outside the channel, and most PWCs reduced their speed. Although these measures did not eliminate the problem, they reduced the disturbance to the birds, allowing increased reproductive success, representing a successful co-management program. Two years later, the number of PWCs that went near the tern-nesting island continued to decrease. Without the intense public education program, people operating PWCs began to again drive them faster past tern-nesting islands, and to drive them closer to the tern colony. The terns response was varied: fewer birds nested on the island in 2000 compared to previous years, and they nested farther from the edge of the island. However, their behavioral responses were similar to those observed in 1998.

b. Buffer Zone Distances to Protect Foraging and Loafing Waterbirds from Disturbance by Personal Watercraft and Outboard-powered Boats (Submitted but not presented)

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Twenty-three species of waterbirds (*Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes*) were exposed to the fast (35-40 km/hr) approach of a personal watercraft (PWC) and an outboard-powered boat to determine their flush distances in Florida. Considerable variation in flush distances was detected among individuals within the same species and between species in response to both vessel types. Average flush distances for the PWC ranged from 19.53 m (Least Tern, *Sterna antillarum*) to 49.53 m (Osprey, *Pandion haliaetus*), whereas average flush distances for the outboard-powered boat ranged from 23.36 m (Forster's Tern, *S. forsteri*) to 57.91 m (Osprey). Larger species generally exhibited greater average flush distances for both types of watercraft. A comparison of the flush distances elicited by each watercraft indicated that only the Great Blue Heron (*Ardea herodias*) exhibited significantly (t-test, $p<0.01$) larger flush distances to the approach of the PWC, whereas four species (Anhinga, *Anhinga anhinga*; Little Blue Heron, *Egretta caerulea*; Willet, *Catoptrophorus semipalmatus*; and Osprey, *P. haliaetus*) exhibited significantly (t-test, $p<0.05$) larger flush distances to the approach of the outboard-powered boat. Eleven species (68.8%) showed no significant (t-test, $p>0.05$) difference in flush distances to either the PWC or fast-moving outboard-powered boat. These data on flush distances suggest that a single buffer zone distance can be developed for both fast moving PWC and outboard-powered vessels. Buffer zones of about 180 m for wading birds, 140 m for terns and gulls, 100 m for plovers and sandpipers, and 150 m for ospreys would minimize their disturbance at foraging and loafing sites in Florida.

2. Session B: Hydrologic and Water Quality Impacts (Chair: Smith)

a. Effect of Wave-wash from Personal Watercraft on Salt Marshes

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Over the past year, we examined the effect of "jet ski"* wave-wash on shallow marsh environments, conducting 10 marsh experiments in the Great Bay Estuarine Research Reserve (New Hampshire), 8 experiments in the ACE Basin Estuarine Research Reserve (South Carolina), and 8 experiments in the North Carolina Estuarine Research Reserve. Our experiments consisted of measuring pre- and post-levels of turbidity after the passage of a "jet ski," while simultaneously sensing wave properties and drag force on the channel bank. In addition, we collected sequential water samples over the same wave passage, filtered the water, and combusted the filters to determine any changes in particulate composition. Results of our investigation indicate that a wave from a "jet ski" is not significantly different than that of a small boat. However, "jet skis" can and do go into marsh channels where small boats cannot maneuver and, hence, lies the crux of the problem. We found that marsh sediment type strongly affected the amount of sediment disturbance by the "jet ski" wave. In some of our North Carolina experiments, sediments settled out of suspension in less than 20 seconds, whereas in South Carolina, the finer "pluff" sediment took 2 to 3 minutes to settle out after the passage of the "jet ski." The composition of the suspended particulate matter (SPM) was also affected by the wave resuspension. After passage of the "jet ski" wave, the SPM was lower in percent combustibles, sometimes decreasing by as much as 50%. Finally, the character of the wave generated by the "jet ski" was dependent on many factors, including the weight of the driver, number of passengers, and speed of the craft. Minor changes in these factors generated different wave heights in the marsh channels. Future investigations should examine the impact of the turbulent plume of the jet pump on the sediment bottom. This may even have more dramatic effects on shallow open tidal flats where "jet skis" tend to "open up."

" The term "jet ski" is used here as a generic class for all personal watercraft.*

b. Resuspension of Sediments by Watercraft Operated in Shallow Water Habitats of Anne Arundel County, Maryland

M. Stephen Ailstock, Sally G. Hornor, and C. Michael Norman, Anne Arundel Community College, Environmental Center, 101 College Parkway, Arnold, Maryland 21012

Shallow water habitats rank among the most important components of the Chesapeake Bay ecosystem. The operation of watercraft in these sensitive environments increases the hydrodynamic energy of the site through the generation of surface wakes and propeller wash. When this energy exceeds the sheer force of sediment material, sediment resuspension occurs. The degree and pattern of resuspension determines the impact to resident biota. In this study, a variety of common recreational watercraft were operated in the navigable headwaters of seven creeks in the mid-Chesapeake Bay area. The craft were operated according to existing regulations and the rules of good seamanship along an established course that ranged in depth from 0.3 to 2 m. Bottom sediments from the courses on each creek were analyzed for texture prior to testing. During testing, turbidity was measured in Nephlometer Turbidity Units (NTU) at the surface, middle, and bottom of the water column at each of the depths. No significant differences in turbidity were found among the 10 watercraft (personal - 235 hp displacement hull) tested on the different creeks; however, when re-suspension was intentionally induced, only turbidity at the lower portions of the water column was significantly increased. This suggests that studies of this type require sampling throughout the water column to fully evaluate potential adverse effects on sediment stability, regardless of the source.

c. Impact of Boat-generated Waves on Water Quality in a Submersed Aquatic Vegetation Habitat

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Boat traffic in shallow coastal areas is believed to be detrimental to submersed aquatic vegetation (SAV). This negative impact can be direct (prop scars) or indirect. An example of an indirect impact of boats is sediment resuspension by boat-generated waves which causes an increase in water turbidity. This can reduce light transmission in the water column which, over extended periods of time, leads to a decline of benthic vegetation like SAV. The objective of this study was to quantify the impact of boat-generated waves on water quality and light availability in a SAV habitat during high and low tide. A 21-foot long whaler was used to generate waves at two speeds during 15-minute intervals at high and low tide. Wave characteristics, total suspended solids (TSS), light availability, and nutrient levels were determined before, during, and after the period when the waves were generated in a vegetated and an adjacent unvegetated area. The low-speed, boat-generated waves did not result in sediment resuspension or nutrient pulses in the unvegetated area. In contrast, only minor resuspension and a small and short nutrient pulse was observed in the vegetated area. Although the high-speed, boat-generated waves were significantly higher than the ambient waves (and higher at low tide than at high tide), they only caused a short-lived nutrient pulse at low tide. Natural processes dominated over the changes induced by boating activity. Light levels remained above the levels required to saturate photosynthesis of Ruppia maritima colonizing the area. In summary, the impact of boat-generated waves on SAV habitat quality was minor in comparison to natural processes and did not compromise maximum photosynthetic rates of the SAV.

3. Session C: Habitat Impacts 1 (Chair: Naylor)

a. Physical Damage to Seagrass Beds: Some Theoretical and Historical Considerations Focused on South Florida

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Historically in south Florida, seagrass beds were not highly valued except by certain fishermen. In the past three decades, however, that has changed and seagrass meadows are considered to be valuable sources and are afforded protection by a variety of governmental agencies. Dredging and filling to create Venetian Canal developments - possibly the largest cause of seagrass loss historically - have been virtually eliminated. The visual images of seagrass meadows in south Florida formed by scientists, managers, and most local fishermen during the late 1960's was of dense, lush, and expansive beds of turtle grass, Thalassia testudinum. These ranged from seagrass covered banktops, to the basins of Florida Bay, to the deep (8-10m) beds of Hawk Channel. While they were magnificent in their extent, they may well be post-Columbian artifacts of the historic ecosystems. Today, as other stresses have been recognized, studied, and in many cases reduced, there is growing concern regarding the effects of boats and jet-powered watercraft on shallow seagrass beds. In many populated areas, the disturbance and damage to seagrass beds have increased over the past several decades due to an increase in boaters and increase in the size of the boats used. Damage caused by these vessels ranges from the shaving of leaves to the breaking of the rhizome layer to the total displacement of large amounts of sediment and the burial of adjacent habitats. In addition, human-induced changes are superimposed upon naturally occurring changes driven by climate and other environmental factors. Much of the banktop seagrass loss that is frequently attributed to prop damage, and the subsequent erosion is often the result of banktop seagrass die-off caused by natural sedimentation and the resultant dessication of the seagrasses. Considering the concern of prop-cut-induced seagrass losses and the significant impacts in some areas, it is surprising that not much scientific-driven (as opposed to management-driven) research has been conducted until very recently. Studies have focused on attempting to quantify the problem and attempting to restore damaged areas. Too little work has been done to determine which sediments and grass beds once scarred are most prone to erosion and which are more likely to remain stable and recolonize. Similarly far more work has been done on exploring different transplanting methods and their success rates rather than trying to learn the physical and biochemical reasons for successes and failures. Much work remains to sort out the relative effects of natural vs. anthropogenically driven changes in these seagrass meadows and to what extent scars cause detectable ecological degradation just being aesthetically unpleasing.

b. Boats Activity and Seagrass Problems in Florida

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Accidental groundings and propeller strikes of watercraft have caused extensive damage to large areas of seagrass beds in Florida since the 1970s. Damage of this nature can take from 3-7 years to recover under natural conditions, but may be permanent or lead to further seagrass loss in some areas. In 1995, the Florida Marine Research Institute estimated that the damage caused by vessel groundings in the form of propeller scars affected 70,065 hectares (173,000 acres) or 6.4% of Florida's estimated 1,093,500 hectares (2,700,000 acres) of seagrass beds. Predictably, most damaged seagrass meadows are found near more populated areas. Beginning in the late 1980s, municipal, county, and state agencies in Florida established motorboat restriction zones in seven Florida counties. The zones ranged from complete no entry, to restricted to vessels operating without combustion engines. Although assessment of the effectiveness of these zones has been limited, scarring has been reduced in most monitored areas. For example, assessment of pre- and post-closure of areas in the John Pennekamp Coral Reef State Park revealed a 56% decline in scarred area. Other protection zones are currently being monitored with the intent of providing for adaptation of the zones to effect maximum reduction of grounding damage.

Dock development, an indirect activity related to boating, has also been shown to cause seagrass loss due to shading. Florida county and state agencies permit the development of single family docks of less than 46.5 m2 (500 ft2) in aquatic preserves or 93 m2 (1000 ft2) outside of these water bodies without assessments of seagrass damage. A total of 200 of the more than 3,500 single family docks in Palm Beach County, Florida were surveyed for seagrass loss during the summer of 1999. Approximately 2% of the areal coverage of seagrass in this county has been lost due to the construction and placement of single family docks over seagrass. On average, in each case an area twice that of the dock structure itself was lost do to an observed "halo-effect" and shading from dock additions and moored boats. Direct damage to seagrass systems in this county's waters as reported for watercraft groundings in a 1995 study was shown to be comparable to the estimated damage for single family docks. The predominance of paddle grass (Halophila decipiens) and Johnson's seagrass (Halophila johnsonii), species with relatively low light level tolerances, in the seagrass community in most surveyed areas, indicates that the observed halo-effect may be greater in areas with seagrass species that require higher irradiance levels.

c. Impact of Expanding Use of Nearshore Waters on Submerged Aquatic Vegetation

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In 1994, a group of resource managers considered the available information regarding the environmental impacts of recreational boating. The discussions identified a number of adverse impacts. Since the Environmental Impacts of Boating Conference, the number of watercraft has risen above 12.6 million registered vessels. Research on 2-cycle engines reveals that they contribute 14 times the ozone pollution of 4-cycle engines and discharge up to 1/3 of their fuel, unburned. The U.S. Environmental Protection Agency issued rules, in 1996, for the phased reduction of those emissions. Fuel injection systems for 2-cycle engines and production of 4-cycle outboard engines have achieved the emission standards in the lower horsepower sizes. The physical impact of watercraft on aquatic resources continues to be a focus of attention. Vessel movement across sensitive, nearshore habitats is a particular concern. Water-jet driven, personal watercraft have come to represent a significant portion of the fleet and have earned special attention. Intertidal marshes and submerged aquatic vegetation represent important habitats for aquatic resources. Vegetated habitats have declined in areal coverage; one of the causative agents is recreational watercraft usage. Nearshore habitats are unable to accept the direct cutting and extirpation perturbations associated with both propeller and water-jet driven watercraft passage. High velocity water discharges from jet-driven watercraft and their shallow draft make these vessels a particular threat to intertidal and shallow water resources. High boat traffic in relatively quiescent waterways has exacerbated erosion of shellfish and wetland covered embankments, particularly in longer, boating season areas. Balancing the public use of the water with maintaining a healthy aquatic resource community has become a complicated challenge.

3. Session D Habitat Impacts (2) (Chair: Anderson)

a. Boating as an Ecosystem Stressor

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Massachusetts has regulations that indirectly come into play when considering effects of disturbances (e.g., dredging or dock construction) in coastal waters. Whether or not the ecological impacts of boat operation should be directly considered remains unresolved. An obvious physical effect associated with boating is habitat alteration. While this may be clear, it is difficult to establish predictive relations between boating activities and parameters, such as sedimentation, light attenuation, and benthic productivity. Links between biological change in estuaries and boating also are difficult to assess. For example, although nutrient loading has been linked to the loss of eelgrass meadows in many coastal areas, boating activity also may be an ecosystem stressor in this regard. This study examines the following: (1) whether sediment resuspension by boats operating in Waquoit Bay (Cape Cod) chronically reduces light levels below that required for eelgrass growth and reproduction; and (2) whether boating activity is coupled to alterations of other environmental parameters, such as dissolved oxygen concentration.

Waquoit Bay, covering an area of ~335 hectares, has a recreational fleet of more than 1,000 boats. About 70% of these vessels are powerboats. Investigations of in the bay indicate that sediment resuspension (and concomitant light reduction) in the navigation channel due to boating activity is greater in magnitude than that resulting from storms, although the boating-induced events are much more brief. In areas of maximum boat traffic, light levels are often insufficient for eelgrass growth. However, resuspended sediment settles quickly and does not drift far from the channel. Away from the navigation channel there is ample light for eelgrass proliferation. The case for classifying boating-induced sediment resuspension as an eelgrass stressor in this relatively moderately disturbed bay is weak, but other bays with greater boating activity could be more adversely affected. More consistent localized impact in Waquoit Bay is generated by boat operation at docks. Here, suspended sediment caused by boat traffic also settles quickly, with the magnitude of impact being related to the sediment type and particle size. Models supporting management regulations, therefore, must include data on sediment characteristics.

The influence of boating on other parameters is masked by strong spatial and temporal heterogeneity in hydrologic conditions in the bay. These remarkably persistent features are driven by the wind and tides and create microhabitats within the bay. They dominate the variability in the system on the scale of the measurements reported here. Variation in common hydrological descriptors other than turbidity (e.g., dissolved oxygen concentration, temperature, salinity, pH) that could be attributed directly to boating activity was not detected.

b. Responses of the Tropical Seagrass *Thalassia testudinum* to Propeller Damage and Production of New Rhizome Meristems

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Recovery of turtle grass, Thalassia testudinum, after damage by boat propellers in Tampa Bay required an average of 7.5 years. It was hypothesized that the slow regrowth is due to a strong dependence on production of a new rhizome meristem and the highly ordered proliferation of short shoots. Double short-shoot rhizome transplants were subjected to different levels of plant growth regulators, fertilizer treatments, and planting techniques in experimental field and tank nurseries. Field experiments demonstrated that the presence of intact apical meristems prevented the formation of new lateral branch meristems. Transplant survivorship in the field varied widely (29-75%) after 8 to 12 months and correlated with site elevation, exposure to wave activity, and method of planting. In contrast, survivorship in tank culture was 80-95% after 2-4 months. Use of various fertilizers and plant growth regulators had no observable effect on apical production. All new rhizome apices were produced from existing short-shoot apical meristems, never from the rhizome or older parts of short shoots, and no apices were produced if the original rhizome meristem was left attached. In addition, short shoots from young double genets (120-180 days old) without a rhizome meristem produced few, if any, rhizome tips even after 4 months of further growth. In contrast, older double genets (300-375 days old) showed significantly higher production of new rhizome tips over the same period. The studies indicate that Thalassia testudinum shows strong apical dominance by the rhizome. Release from apical dominance does not appear to be immediate after removal of the rhizome tips resulting in long-term (years) delays in regrowth into propeller cuts. Furthermore, production of new rhizome tips is primarily limited to older short shoots. Thus, future recovery studies and formation of turtle grass nurseries should include older transplants that lack rhizome meristems. The role of plant growth regulators needs further study.

c. Restoration of Large Coalesced Prop Scars as Mitigation for Port Dredging Impacts to Seagrass Beds in Tampa Bay, Florida: Why Not?

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The 1995 report of the Florida Department of Environmental Regulation's (now the Florida Department of Environmental Protection, FDEP) Florida Marine Research Institute documented 64,000 acres of moderate to severe prop scars in the coastal waters of Florida during 1992. Approximately one-half of all the existing seagrass meadows in Tampa Bay and adjacent waters (11,280 acres) were reported to have moderate to severe scarring. As of the year 2000, the State of Florida had taken no significant action to control the increase in scarring in these waters, even though most of the damage was on state-owned submerged lands within several major state-designated aquatic preserves. Consequently, when the Manatee County Port Authority sought permits to expand its port and move 6 acres of seagrass to restore or create nearly 30 acres of seagrass, significant large coalesced prop scars covering 11.4 acres were chosen as one of the mitigation sites. These large coalesced scars had been mapped by the FDEP in their 1995 report. Despite this documentation, FDEP denied that the scars were scars, and refused to acknowledge that their restoration was restoration, instead calling it "enhancement," and increasing the mitigation ratios significantly. In spite of significant opposition to the concept of restoring large coalesced prop scars and providing on-the-water protection in perpetuity as meaningful seagrass mitigation, the project has been permitted by the State of Florida, and will soon receive federal permits. Successful voluntary restoration of the prop scars began in April 2000. Such adversarial negotiations demonstrate the role of "denial" in thwarting meaningful progress towards addressing the prop scar issue in Florida.

4. Session E: Habitat Impacts 3 (Chair: Orth)

a. Anthropogenic Impacts on Submerged Aquatic Vegetation in Isle of Wight Bay, Maryland

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To determine the extent of anthropogenic impacts on submerged aquatic vegetation (SAV) in the Isle of Wight Bay, Maryland, aerial photographs were taken three times annually from 1998-2000. These photos have revealed two types of scarring: (1) apparently random linear scars passing through vegetation; and (2) discrete areas of near complete devegetation within an SAV bed. Total bed area and the area of focused scarring within SAV beds were measured from the aerial photographs from one photo set in each year. The area of focused scarring ranged from 2.3 to 3.2 hectares within an SAV bed area of between 40.2 and 43.9 hectares. Scarring was confirmed by quadrat sampling, which revealed an average crown density of 27% outside the scarred areas, and 5% inside the scars. SAV beds in Maryland's coastal bays are clearly subject to substantial annual physical disruption, resulting in a near complete loss of as much as 8% of the SAV acreage in a given area. While the SAV beds are affected by commercial fishing (hydraulic escalator dredging) and recreational boating activity, both of which have been demonstrated to be potentially destructive, the relative impacts of each activity cannot be statistically demonstrated. However, the most focused visible impacts are near buoys and in the immediate vicinity of shoreline establishments accessed from the water, neither of which can be expected to affect the activity of commercial fishing vessels.

b. The Potential Impacts of Recreational Boating on Submersed Aquatic Vegetation in Upper Chesapeake Bay

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One of the continuing questions in Chesapeake Bay over the last 25 years is whether various boating activities limit the survival of submersed aquatic vegetation (SAV) in shallow water. Past studies have focused on light availability and found that when the light attenuation coefficient in the water column (Kd) reaches 1.75 or more, SAV growth in the one to two meter deep shallows is inhibited in the oligohaline and mesohaline reaches of the bay. Two different approaches were used to address this issue. The first study initiated in 1990 was designed to determine if a slalom ski course in the Severn River (Maynedier Creek) caused elevated turbidity compared to a control (Saltworks Creeks). Investigations in the Severn River concluded significant differences between the creeks and any ski impacts were minimal compared to the water column turbidity evident during wind events from resuspension of sediment from eroding cliffs on the edge of Maynedier Creek. Another series of studies in 1993 and 1994 (Beard's Creek and Glebe Creek off the South River and in the northern Bay at Cabin John Creek and Churn Creek) came to the same conclusions. Further studies utilizing short-term deployment of PAR sensors in Dickinson Bay in the Choptank River (on the Eastern Shore) and the Rhode River (on the Western Shore) indicated that fast moving ski boats (which were planing over the water) and jet-skis had little impact on turbidity levels in the water column. However, there was substantial elevation of the Kd to levels higher than 2, when a 7 m-long Wetsig (which had been monitoring the trials) ran past the sensors at ~5 knots, within the proscribed speed in channels where boats are moored nearby. From this series of studies, we conclude that small light craft moving very fast over the water, do not impact turbidity enough to cause long-term problems for SAV, although we have had occasion to observe that their presence in SAV beds can literally tear out the grass when densities are high. Somewhat surprisingly, there may be greater problems due to potentially large excursions of turbidity resulting from slow moving vessels >6 meters, which often displace much larger volumes of water and create waves capable of resuspending fine grained particles off the bottom into the water column.

c. Impacts of Commercial Fishing Activities on Seagrass Habitat in Chesapeake Bay and Coastal Bays of the Delmarva Peninsula

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Seagrass or Submersed Aquatic Vegetation (SAV) in Chesapeake Bay and the Coastal Bays of the Delmarva Peninsula has been highlighted as a critical habitat by scientists, managers, environmental groups, and the general public because of its strong links to water quality and its significance as an essential fish habitat, especially for the blue crab. Over the last few decades, several policies have been approved by the Chesapeake Executive Council (the Governors and the top administrators in the federal and state environmental agencies) that highlight the conservation, protection, and restoration of this valuable natural resource. In addition, a fisheries management plan for the blue crab has included linkages to habitat quality, notably seagrass and adequate water quality for seagrass survival. Annual baywide aerial surveys of SAV distribution and abundance have detected disturbances to SAV communities that are related to certain fisheries activities. One type of fishery activity, hard clamming using dredges in Virginia and hydraulic dredges in Maryland, galvanized management agencies and state legislatures to pass legislation that provides protection not afforded by the approved policies. The survey documented a sudden increase in clam dredging from 1995 to 1997. Analysis of the photography for SAV in the coastal bays (1995-1997) revealed 252 individual circular scars (mean diameter of 80 m) impacting 126 hectares of seagrass in Virginia, while in Maryland hydraulic dredging, which causes linear scars, impacted 508 hectares of seagrass. Results of this survey, backed by previous policies for SAV protection and restoration, facilitated passage of legislation and regulations in Maryland and Virginia which prohibited dredging within seagrass beds. Regulations in Virginia were effective, as only 13 new scars were identified in 1998 and 9 in 1999. Observation of the recovery of seagrass into the circular scars, assessed from field inspection of scars created in 1996, 1997, and 1998, indicated a slow recovery rate of most scars. The rapid protection of seagrass beds was possible because of the strong linkage between science and management in this region. Ongoing work is now assessing the potential disturbance to seagrass from commercial fish haul seining, which includes the associated impacts from props of the fishing boats operating in shallow water environments. The above mentioned conflicts may become increasingly complex as efforts to improve water quality for living resources leads to expansion of SAV into areas that were unvegetated and which are now being used for commercial fishing.

d. Effects of Personal Watercraft Operation on Shallow Water Seagrass Communities in the Florida Keys (Submitted but not presented)

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Seagrass beds, which can cover hundreds of acres of contiguous seafloor in south Florida, are the base of a complex shallow water marine community including algae, invertebrates, and fishes that utilize the grasses for shelter and as a food source. Seagrass beds in south Florida have been subjected to disturbance and scarring for decades, with most of the shallow seagrass beds in Florida showing some level of scarring. This study was sponsored by the Personal Watercraft Industry Association to assess whether personal watercraft, when used in water depths of 2 ft. or more as recommended by the manufacturer, harm seagrass beds or other shallow water species associated with the seagrass community. One of the primary recommendations by the manufacturers is for the watercraft to be operated in a water depth of at least 2 feet.

A location in the immediate vicinity of Duck Key, which is situated to the northeast of Marathon in the Florida Keys, was selected as a the field test site. Abundant or common species within the seagrass beds included the seagrass species *Halodule wrightii, syringodium filiforme,* and *Thalassia testudinum,* the green algae *Penicillus capitatus* and *Halimeda incrassata,* the hard corals *Cladacora arbuscula, Manicina areolata, Porites furcata* and *Siderastrea radians* and various small sponges.

Data collected during this study indicated the following:

- No suspension of bottom sediments or turbidity was caused by 50 repetitive personal watercraft test runs along a 60-m long transect at speeds of 20 to 30 mph in water depths ranging from 19-36 inches;

- Water turbulence from the personal watercraft jet drive did not extend down to the level of the seagrass blades when watercraft were operated on a plane in a water depth of approximately 20 inches;

- No statistically significant differences in abundances of seagrasses or other benthic biota were found in randomly placed quadrats along the 60-m long transect following the personal watercraft test runs;

- A suspension of fine sediments and some exposure of seagrass rhizomes were noted in the shallowest areas (water depths of 21 to 28 inches) of two 10-m diameter circular test sites following up to 6 minutes of intensive starting stopping and turning maneuvers with personal watercraft; and

- No statistically significant differences in abundances of seagrasses or other benthic biota were found in quadrats randomly deployed within the 10-m diameter circular test areas following the intensive personal watercraft operations.

The results of the tests conducted in this study indicate the operation of personal watercraft in depths of 2 ft or more, as recommended by the manufacturers, does not detrimentally affect seagrass beds by causing a detectable change in the abundances of seagrasses or other common benthic biota within grassbeds. Additionally, personal watercraft used under the recommended guidelines during testing did not cause scarring of the grassbeds.

Conditions under which personal watercraft could cause significant impacts to seagrass beds and the associated community may include intensive and repetitive starting and turning maneuvers in water depths of less than 1.5 ft. This type of personal watercraft operation could also cause high amounts of turbidity through the suspension of fine sediments. In very shallow waters, seagrass blades and algae could also be drawn into the personal watercraft water intake, uprooting or cuttint off the seagrass or algae, and also clogging the watercraft intake. Small sponges, hard corals, bryozoans, and other attached or loosely living fauna could also be covered by sediments, displaced, or drawn into the watercraft intake. Repeated usage in this manner in a very shallow small or confined area may severely impact that specific seagrass area.

5. Session F: Habitat Impacts 4 (Chair: Durako)

a. Role of Storms in the Expansion and Propagation of Disturbances Initiated by Motor Vessels on Seagrass-Porites Coral Banks and the Consequences of Management Inaction

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While investigating the ecology of physically disturbed seagrass and *Porites* coral banks in the Florida Keys National Marine Sanctuary (FKNMS), we documented the effect of Hurricanes Georges on the recovery of injuries created by large motor vessels. Near the intersection of two main routes for vessel traffic in the Red Bay Bank region of the FKNMS, we found that blowholes (n = 146), as opposed to propeller scars (n = 50), accounted for a majority of the vessel injuries on shallow seagrass banks. Evidence from four large motor vessel grounding sites that were mapped before and after a category 2 hurricane (Georges) with wind speeds of 105 mph indicated an increase in injury size associated with the storm. In the case where a tugboat grounding had destroyed 100% of the macrophytes growing on 7200 m2 of a shallow bank, recovery was interrupted by Hurricane Georges. In January 1998, 4.5 years after the storm, 85% of the macroalgae and 11% of the seagrasses had recovered. In the first survey, two months after Hurricane Georges, seagrasses had declined to < 1% and macroalgae to 23%. A year and a half later, seagrasses and macroalgae had recovered to near pre-hurricane levels, but were still much less than the original cover. Three additional large vessel grounding sites exhibited at least a 65% increase in the size of their blowholes following Hurricanes Georges.

Unlike propeller scars which are long, narrow (< 1.0 m) features, large vessel groundings generally produce deeper and wider injuries, referred to as blowholes. In soft carbonate mud banks, blowholes are more severe than propeller scars because they form box-cut walls with steep topographical gradients at the injury margins. These steep walls are hydrodynamically unstable in high energy environments and will erode and undercut the adjacent seagrass meadow. Nearly all of the organic matter and seagrass rhizome structure are excavated from large blowholes, and only a thin layer of unconsolidated sediment remains over the coral and rock rubble inside the injury. Sediments ejected from the blowholes usually form berms adjacent to the injury and bury seagrasses, further slowing the recovery process. However, we documented an exception to these observations in one case study completed in mixed seagrass beds in the back-reef environment. Berms adjacent to large injuries were partially redistributed by a storm back into the blowholes, presumably improving the recovery potential. Despite regrading by the storm, recovery of blowholes in the back reef environment is likely to be slowed by nocturnal herbivores. Without protective caging, experimental transplants of *Halodule wrightii* and Syringodium filiforme were consumed overnight by grazers in the naturally regraded injury.

Our data and observations suggest that large blowholes created by vessel injuries will continue to be unstable and vulnerable to storm events many years after the original disturbance. Depending on the location, orientation, and proximity of a bank to the reef environment, consideration should be given to a range of pro-active and post-injury responses, including but not restricted to: (1) physically regrading and restoring large blowholes to conform to hydrodynamic conditions of the local environment; (2) strategic placement of navigational aids to direct vessel traffic away from shallow banks; and (3) the assignment and publication of motor vessel exclusion areas.

b. Propeller Scarring and Monitoring Techniques in Seagrass Beds

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There are many sources of marine habitat degradation, and propeller scarring of seagrass beds is but another to be investigated. Propeller scarring occurs when a motor boat travels in water shallower than the draft of the vessel, and the propeller(s) churns up rooted bottom vegetation, leaving behind a narrow strip of bare sediment. Personal watercraft and other types of jet driven-water propulsion watercraft also are capable of inflicting similar damage to benthic habitats. The recovery time required for the partial and full regrowth of scarred seagrass beds is of principal concern. Estimates of regrowth are 1-2 years for *Halodule wrightii* and 3-5 years for *Thalassia testudinum* in undisturbed sites. Heightened interest has led to numerous mapping and monitoring projects on propeller scarring and the regrowth characteristics of seagrasses in Florida. In 1992, a statewide survey was conducted in Florida waters to assess the extent of propeller scar damage. This assessment used a combination of aerial photography and aerial surveys to map scarred seagrass beds. The resultant information was incorporated into a geographic information system (GIS) for analysis and map production. Scarring was classified as follows: light, moderate, and severe, based upon the percent cover of scars. Areas of moderate and severe damage are of greatest concern since these levels of damage indicate that the seagrass beds have been subjected to continuing watercraft impacts.

Resource managers have initiated large-scale mapping and change detection programs within managed areas to locate and quantify the amount of damage that has occurred. In addition, these programs have enabled managers to monitor trends over time for early detection of problem areas. However, the use of 9" x 9" aerial photography for mapping is expensive, time consuming, and may not provide the information needed by resource managers to answer questions in a timely manner with respect to ongoing boat impacts or seagrass recovery/restoration. A variety of low cost alternatives are available for the mapping and monitoring of propeller scars and seagrass recovery. In place of traditional 9" x 9" aerial photography, for example, 35mm, medium format, and video can be used to effectively assess impacts over time. Monitoring transects established in areas of concern can yield additional information on scarring damage. These same transects likewise provide data on seagrass recovery and restoration. Cost reduction potential of 50% or more can be attained. The use of these low cost methods can provide valuable information on propeller scarring trends and seagrass recovery for resource management.

c. Comparative Analysis of Regrowth into Propeller Scars among Seagrass Beds in the Florida Keys: Providing the Scientific Support for Modeling Injury and Recovery and Choosing Restoration Strategies

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Scientific and public recognition of the ecological value of seagrass communities has encouraged managers to use their statutory authority to recover compensation from those who have damaged seagrasses by careless or irresponsible vessel operation. However, these management actions require quantitative injury assessments and calculations of lost ecological services for the damaged natural resources. In order to calculate lost services, it is necessary to have both an empirical estimate of recovery rates and the ability to accurately compute lost resource services. As part of NOAA's damage assessment and restoration efforts in the Florida Keys National Marine Sanctuary (FKNMS), we have been examining motor vessel disturbances in tropical seagrass communities ranging in size from propeller scars (~0.5 m wide and of variable length) up to ship groundings several thousand square meters in area. By studying these already existing disturbances and experimentally creating disturbances which simulate these injuries, we have begun to develop models for predicting the recovery horizons of tropical seagrass communities.

We experimentally simulated mechanical sediment disturbance in *Thalassia testudinum, Syringodium filiforme* and *Halodule wrightii* meadows growing on soft, carbonate mud banks in the FKNMS. After 700 days, results provided a quantitative confirmation of the long-standing paradigm that *H. wrightii* and *S. filiforme* recover significantly faster than *T. testudinum*. Extrapolation of experimental results in monotypic seagrass meadows forecast that *T. testudinum* recovery would take between 17 to 26 years in propeller scars ranging from 0.5 to 1.5 m in width, respectively. In monotypic *H. wrightii* or *S. filiforme* meadows, recovery of propeller scars is predicted to range between 3 and 5 years. Results also indicate that in mixed communities the subdominant opportunistic species, *H. wrightii* or *S. filiforme*, will colonize gaps as fast or faster than *T. testudinum*, suggesting that physical disturbance from motor vessels could alter the relative abundance of species on a seagrass bank.

The recovery rates of *T. testudinum* reported in this study are much slower than the rates previously reported for *T. testudinum* in Florida Bay, for artificially created scars in Tampa Bay, and for another small study that we conducted in the FKNMS. Differences between these rates may be partly explained by differences in sediment type, but more likely, the differences can be explained by the severity of injury as defined by the depth of excavation. It appears that we created deeper experimental excavations in this experiment than in earlier experiments and in other studies. Deeper sediment disturbances damage more rhizomes and apical meristems and create steep topographical depressions which we hypothesize could disproportionately inhibit the regrowth of *T. testudinum* into the scars. When developing injury recovery models and restoration strategies for vessel injuries, consideration should be given to the expected rates of recovery as a function of seagrass species?composition and the physical geometry of the injuries, especially the excavation depth. Moreover, deep propeller scars located in high energy environments may require more aggressive restoration techniques such as substituting faster growing species for injured *T. testudinum* and regrading the scars to prevent further erosion to enhance the probability of recovery.

d. Regrowth of Seagrasses into Experimental “Propeller” Scars: Climax-Versus Pioneer-species Patterns

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Seagrass recolonization of experimental ‘prop’ scars was monitored within monospecific beds of the climax species, *Thalassia testudinuum*, Banks ex König, (turtle grass), and a pioneer species, *Halodule wrightii* Aschers (shoal grass), in Weedon Island State Preserve in Tampa Bay, Florida. Both beds were adjacent to a mangrove-lined shoreline. Thalassia recovery data were fitted to a first order regression [short-shoots m-2 = 0.146(days) + 8.18, r2 = 0.84] that indicated it would take approximately 3.6 to 6.4 years for these scars to achieve natural short-shoot densities (ca. 400-700 short-shoots m-2). The spatial pattern of recovery for *Thalassia* was generally from seaward to shoreward. Regrowth data for experimental scars in the Halodule bed fell into two distinct groups, depending on the location of the scars. The regression for data from the first group of subplots [short-shoots m-2 = 1.17(days) + 17.0, r2 = 0.85], which were located near the fringe of the bed, indicated that natural short-shoot densities (ca. 2000-4000 short-shoots m-2) would be achieved after 2.3 to 4.6 years, whereas short-shoots in the second group of subplots [short-shoots m-2 = 3.03(days) - 40.3, r2 = 0.84], which were located in the interior of the bed, would take only 0.9 to 1.8 years to reach natural densities. The spatial pattern of recovery for *Halodule* was from shoreward to seaward.

6. Session G: Chemistry/Toxicology (Chair: O'Connor)

a. Small Boat-derived Chemical Contamination in a National Context

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Coastal contamination from small boats might be found in marinas. By definition, these are areas of tranquil water where fine sediments accumulate and, since fine sediments have higher specific surface areas than sand, they, in turn, accumulate chemical contaminants. Fueling and painting hulls with antifoulants are sources of low-molecular-weight hydrocarbons, copper, and tributytin. Available data on concentrations of chemicals in sediment will be surveyed to investigate the likelihood that, compared with all coastal sediments, marina sediments are enriched in such chemicals. While marinas are depositional areas, fine sediments in shallower sections are subject to resuspension by spinning props. This process could increase bioavailability of contaminants and be manifested in chemical concentrations in mussels or oysters from sites near marinas compared with sites throughout the coastal United States.

b. Sources, Fate, and Effects of PAHs in Shallow Water Environments

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Polycyclic aromatic hydrocarbons (PAHs) are aromatic hydrocarbons with two to seven fused carbon (benzene) rings that can have substituted groups attached to the carbons. Shallow coastal, estuarine, lake, and river environments receive PAHs from treated wastewater, stormwater runoff, petroleum spills and natural seeps, recreational and commercial boats, natural fires, volcanoes, and atmospheric deposition of combustion products. Abiotic degradation of PAHs is caused by photooxidation, photolysis in water, and chemical oxidation. Many aquatic microbes, plants, and animals can metabolize and excrete ingested PAHs; accumulation is associated with poor metabolic capabilities, high lipid content, and an organism distribution that coincides with high concentrations of PAHs. Resistance to biological transformation increases with increasing number of carbon rings; four- to seven-ring PAHs are the most difficult to metabolize and the most likely to accumulate in sediments. Disturbance by boating activity of sediments, shorelines, and the surface microlayer of water causes water column re-entry of recently deposited or concentrated PAHs. Residence time for PAHs in undisturbed sediment exceeds several decades. Toxicity of PAHs causes lethal and sublethal effects in plants and animals, whereas some substituted PAHs and metabolites of some PAHs cause mutations, developmental malformations, tumors, and cancer. Environmental concentrations of PAHs in water are usually several orders of magnitude below levels that are acutely toxic, but concentrations can be much higher in sediment. The best evidence for a link between environmental PAHs and induction of cancerous neoplasms is for demersal fish in areas with high concentrations of PAHs in the sediment.

c. Response of Suspended Matter and the Associated Elemental Composition to Tidal Resuspension in New York-New Jersey Harbor Estuaries

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At a time-series station in the Navesink River Estuary in March 1998, the dominating flood tide resuspended sediments resulted in total suspended matter (TSM) concentrations of 20 mg/L throughout the entire 7-m water column. Surface TSM concentrations decreased to a baseline of 5 mg/L during the following slack tide. In a transect of the estuary against a flooding tide, surface TSM concentrations reached a maximum of 10 mg/L around a mid-estuary shoal region, and increased with depth. Fe concentrations in the estuary suggest that suspended material was a mixture of Fe-rich terrestrial particles from the Navesink River and organic-rich oceanic particles. Concentrations of Cu, Zn, Cd and Pb on suspended matter were highest around this TSM maximum. Plots of Cu, Zn, Cd and Pb versus Fe indicate that both surface and subsurface samples collected within the TSM maximum were distinctly above the baseline for other surface samples having baseline TSM concentrations. TSM and metal data strongly suggest that fine, contaminated sediments were resuspended during the dominant flooding tide. A similar relationship between elevated TSM concentrations and elevated Pb concentrations was also observed in the Hudson River estuary in August 1998. The biological impact of resuspended matter with elevated metal concentrations will be discussed.

d. Sediment Contaminant Concentrations in Estuarine and Coastal Marine Environments: Potential for Remobilization by Motorized Watercraft

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Estuarine and coastal marine bottom sediments serve as major repositories for chemical contaminants derived from land-based and marine sources. Of particular concern are particle-reactive contaminants - such as polycyclic aromatic hydrocarbons, halogenated hydrocarbons, and trace metals - that are often toxic and recalcitrant, and commonly bioaccumulate in organisms. These contaminants rapidly sorb to fine-grained suspended sediments and partition out of the water column to surficial bottom sediments. Once deposited, the sediment-sorbed contaminants can be resuspended by natural turbulent processes (e.g., waves, currents, and storms) or anthropogenic activities (e.g., dredging and power boat use), which facilitate their remobilization and dispersal. Although chemical contaminants are widely distributed in bottom sediments along the U.S. coast, they attain highest concentrations in urbanized estuaries. Neoplasia in shellfish, fin rot in finfish, and other adverse biological responses to contamination have been observed in heavily degraded bottom habitats of Boston Harbor, western Long Island Sound, New York Bight Apex, Southern California Bight, and Puget Sound. Total PAH concentrations in bottom sediments near industrial centers have amounted to 100 μg/g dry wt or more. The levels of tDDT in bottom sediments generally range from near 0 in pristine systems to $\sim$100 μg/g dry wt in "hot spot" areas; those of other pesticides (e.g., aldrin, dieldrin, heptachlor, lindane, mirex, and toxaphene) are much lower, usually $<$50 μg/g dry wt. Total PCBs exceed 400 μg/g dry wt in some systems (e.g., Escambia Bay, Florida). Trace metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, tin, and zinc) exhibit a greater range of concentrations from near 0 at pristine locations to more than 2000 μg/g dry wt at impacted sites. The effect of power boat engine emissions, as well as power boat props, pressure waves, and wakes on the accumulation and remobilization of sediment contaminants is potentially significant in shallow water areas ($<$ 1 m) of heavily contaminated urban estuaries.

e. Toxicological Assessment of Aquatic Ecosystems

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Recreational boating and personal watercraft use have the potential to adversely impact shallow water systems through contaminant release and physical disturbance of bottom sediments. These nearshore areas are often already degraded by surface runoff, municipal and industrial effluents, and other anthropogenic inputs. For proper management, information is needed on the level of contamination and environmental quality of these systems. A number of field and laboratory procedures are available that can be used to provide this much needed information. Contaminants, such as metals, pesticides, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons, which enter aquatic environments generally attach to particulate matter, eventually settle and become incorporated into bottom sediments. Sediments serve as a sink as well as a source for contaminants, and environmental assessments generally focus on this matrix. Contaminant residues in sediments and pore waters reflect environmental quality, but factors characteristic of sediments (redox potential, sediment/pore-water chemistry, acid volatile sulfides, percent organic matter, sediment particle size) influence their bioavailability and make interpretation of environmental significance difficult.

However, comparisons of contaminant concentrations in pore water with water quality criteria and those in sediment with sediment quality guidelines provide insight into potential biological effects. Laboratory bioaccumulation studies and residue concentrations in resident or caged biota also provide information on potential biological impacts, and the usefulness of these measurements may increase as data are developed relating in-situ concentrations, tissue residue levels, and biological responses. Exposure of test organisms in situ or to sediment and pore water collected in the field is an additional procedure that can be used to assess the biological effects of contaminants. A battery of tests using multi-species and/or various life stages with different sensitivities to contaminants may provide a more conservative assessment of toxicity than single species testing. Using a preponderance of evidence approach, the Sediment Quality Triad provides a robust evaluation of habitat quality and includes a measure of contaminant concentrations in the sediments, an assessment of sediment/pore-water toxicity to laboratory animals, and an evaluation of in-situ biological assemblages. Field and laboratory procedures are available that can be used to ascertain habitat quality, identify contaminants causing environmental degradation, and delineate aquatic systems requiring mitigation or protective efforts.

f. Occurrence of Methyl-tert butyl ether (MTBE) due to Gasoline-powered Watercraft at Cranberry Lake, Lake Hopatcong, and Lake Lackawanna in Northwestern New Jersey

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Three lakes in northwestern New Jersey were sampled during the summers of 1998 and 1999: Cranberry Lake, Lake Lackawanna, and Lake Hopatcong. Typical concentrations of methyl-tert butyl ether (MTBE) found in Cranberry Lake and Lake Lackawanna at these times were between 20-30 (g/L and 5-14 (g/L. Typical concentrations in Lake Hopatcong during the summer of 1999 were ~10 (g/L for water less than 20 ft deep and ~2-3 (g/L for water greater than 20 ft deep. The source of the MTBE in the lakes is gasoline-powered watercraft as evidenced by negligible MTBE concentrations in samples taken during cooler months of the year when the lakes do not experience much boat traffic. MTBE concentrations in road runoff and precipitation are negligible sources of input given the total MTBE mass in the lakes. The total MTBE mass estimates in terms of equivalent gallons of oxygenated gasoline range from 160 to 170 gallons for Cranberry Lake, 5 to 20 gallons for Lake Lackawanna, and 600 to 900 gallons for Lake Hopatcong. Tert-pentyl methyl ether (TAME - another fuel oxygenate) and BTEX were also detected in the lakes but at much lower concentrations than MTBE. MTBE was detected in samples from 13 of 14 wells randomly selected at Cranberry Lake (at concentrations between 0.12 and 19.8 (g/L) and in samples from 4 of 5 wells at Lake Lackawanna (at concentrations between 0.05 and 0.19 (g/L). Lake/well interaction is a reasonable explanation for the near-ubiquitous occurrence of MTBE in ground water as many of the wells likely blend water derived from the lake.

Workshop Definition of Terms

A. Small Motorized Watercraft

A small motorized watercraft is defined as one capable of accessing shallow water. It refers to jet-driven and propeller-driven boats less than ~6 m in length.

B. Personal Watercraft vs. Propeller-Driven Motorized Boats

Personal Watercraft or PWCs are vessels less than ~5-m long propelled by water-jets. Thus, they are capable of operating in shallower water - even the narrowest tidal marsh channels - than conventional powered craft. Because they have a shallow draft and lack propellers, PWCs can be operated at high speeds along the shoreline (up to ~60 mph). Propeller-driven watercraft are propelled by one or more blades (screws) to create a backward thrust of water.

Workshop Session Findings

1. Noise Impacts (Session A)

Joanna Burger from the Department of Biological Sciences at Rutgers University presented information from her study regarding the behavior of nesting Common Terns as a function of exposure to PWC and other boats. Dr. Burger reported the noise from fast moving PWCs and outboard-powered vessels has been shown to disturb wildlife. The behavior of nesting birds is often modified in response to excessive noise, which can lead to reproductive failure and other detrimental effects due to reduction of "loafing activities." According to the Tern colony study presented in the science workshop, PWCs tend to travel faster than motor boats near bird nexting sites on land. Hence, the noise of PWCs appears to have a greater impact than the noise of motor boats on bird populations. Heavy use of motorized watercraft may also disturb finfish and other aquatic organisms in shallow water areas.

James Rodgers study reports considerable variation in flush distance among individuals within the same species and between species in response to jet and propeller-driven vessels. Average flush distances for the PWC ranged from 19.53 m (Least Tern, Sterna antillarum) to 49.53 m (Osprey, Pandion haliaetus), whereas average flush distances for the outboard-powered boat ranged from 23.36 m (Forster's Tern, S. forsteri) to 57.91 m (Osprey). Rodgers suggests a buffer zone distance can be developed for both fast moving PWC and propeller-drive vessels to minimize their disturbance at foraging and loafing sites in Florida.

Session participants identified the following environmental impacts of concern linked to vessel noise:

- Vessel noise adversely affects the reproductive success and habitat use of bird populations.
- Disturbed birds expose eggs and chicks to predators or thermal stress which increase mortality.
- The exodus of wildlife from an area eventually impacts the public image which in turn reduces the potential for eco-tourism.

Session participants identified data gaps on noise impacts. Additional information is needed on the following items:

- Wildlife responses to different types of boats, approaches, and the time of the day.
- Noise impacts on different species and species groups, as well as their response times during the breeding season.
- Flushing distances for breeding bird colonies in different geographic regions.
- Habitats (nesting and foraging) that birds or other organisms abandon because of boating activities.
- Effects of noise on wildlife foraging.
- Shallow water fish and seabird foraging.
- Effects of the buffer exclusion zone.
- Visitor experience related to noise impacts.

A number of "science to management" suggestions for management of noise impacts was proposed by the workshop participants. These included:

- Funding must be available to ensure that effective measures are implemented to protect nesting habitat for colonial birds.
- Loafing areas critical to bird life should also be targeted for protection.
- Watercraft use near known bird breeding colonies and critical foraging areas should be reduced whenever possible.
- Buffer zones need to be established for the most sensitive species, but it is also necessary to balance the buffer zones with public access.
- Provide additional funding for research regarding noise impacts.

Please see Addendum A for more information on PWC and sound.

2. Hydrologic and Water Quality Impacts (Session B)

Small motorized watercraft potentially impact shallow water systems via increased turbidity resulting from sediment resuspension, the release of sediment-bound nutrients and chemical contaminants due to propeller and pressure wave effects, engine emissions, and the diffusion of metals from boat hulls as noted above (Anderson, Alinstock, & Koch). All of these factors can degrade water quality conditions. The remobilization of chemical contaminants is particularly problematic because these substances can cause lethal as well as sublethal impacts on organisms. Sediment resuspension by boats has been shown to temporarily increase light attenuation, with the duration and intensity of the increase depending on the type and condition of the bottom sediments and the water depth (Albers, Paulson, & Kennish). Boat-induced turbidity reaches maximum levels in waters 1 m or less in depth. However, there is evidence based on data presented at the workshop that, if small motorized boats are operated according to no-wake regulations, impacts on turbidity in the water column may be negligible.

Workshop participants examined several environmental impacts of concern associated with hydrologic and water quality conditions. Based on their assessment, the participants recommended the following studies:

- Investigate nutrient regeneration from bottom sediments by surface wakes and propeller wash of motorized boats, and the significance, if any, of this regeneration on primary production in shallow aquatic systems.
- Test the effect of boat-induced turbidity throughout the water column.
- Document the variation of turbidity impacts with vessel configuration (length, weight, and design) speed, boat intensity, and time of day (phase of tide).
- Delineate the amount of toxic chemical releases from two- and four-cycle boat engines in shallow water systems.
- Conduct experimental work, such as running boat engines in a mesocosm and test for potential impacts ascribable to sediment resuspension and chemical contaminant releases.

Data gaps related to hydrologic and water quality impacts include:

- Biotic responses at the species level to boat-generated turbidity and toxic chemical inputs in shallow water systems, especially in sensitive habitat areas.
- Standardized measures which are needed to determine physical and chemical impacts of boating activity.
- Relationships between boating activity and expected turbidity and chemical contaminant impacts.
- Experimental work, such as running boat engines in mesocosms and testing for potential impacts ascribable to sediment resuspension and chemical contaminant releases.

The following "science to management" suggestions have been advanced to address hydrologic and water quality impact issues:

- Consideration should be given to mitigating erosion and water quality degradation by limiting motorized watercraft use to confined areas of shallow water systems.
- Greater enforcement is necessary on small watercraft use in shallow water environments.
- Consideration should be given to marking sensitive areas (e.g., SAV beds) with tide staffs so boaters can determine the water depth in a particular shallow area.
- Channels should be well marked to enable motorized boats to navigate in deeper areas of shallow water systems.

3. Chemistry/Toxicology Impacts (Session G)

It is important not only to quantify the concentrations of chemical contaminants released to shallow water environments by motorized boat activity but also to determine the bioeffects of these contaminant releases. Laboratory bioaccumulation studies and toxicological assessments provide valuable data to document contaminant impacts. Field and laboratory procedures are available that can be used to ascertain habitat quality, identify contaminants causing environmental degradation, and delineate aquatic systems requiring mitigation or the implementation of protective measures.

The following environmental impacts of concern regarding the release and remobilization of chemical contaminants by motorized boats have been formulated by the workshop participants:

- Chemical contaminant releases from motorized boats can potentially affect bottom dwelling organisms in urbanized areas where heavy boat use may be significant.
- The roiling of bottom sediments by boat engine propellers promotes the remobilization of contaminants which can be redistributed throughout shallow water systems.
- Some of the chemical contaminants derived from motorized boats may bioaccumulate in aquatic organisms and may pose a threat to humans consuming contaminated seafood products.

The following investigations are needed to fill data gaps linked to motorized boat use and chemical contamination:

- Boat engine releases of chemical contaminants and the responses (acute and chronic) of aquatic organisms exposed to these contaminants.
- Combined chronic laboratory studies and field investigations in high impact boating areas.
- Determination of experimental treatment levels based on contaminant concentrations found in high impact boating areas.
- Small motorized watercraft contaminant releases and their possible impacts on aquatic organisms.

The “science to management” suggestions for management of chemical contaminant releases/remobilization due to motorized boat activity include the following:

- Educate the public on the potential impact of contaminant releases from boats on the aquatic environment.
- Investigate and explore the use of alternative fuels and outboards.
- Confine boat traffic to designated transit areas, harbors, and marinas would limit high impact areas in shallow water systems. Explore the conjestion of vessels in “new” confined area and the effects of “push down, pop up” theory (ie., will vessels create greater adverse impacts by confining more boats to smaller areas than dispersing them).
- Restrict motorized watercraft use to areas devoid of sensitive habitat and rich biotic communities to minimize potential contaminant impacts.

4. Habitat Impacts (Sessions C, D, & F)

The greatest focus of the workshop was on habitat impacts associated with motorized boat use. Most of these impacts were coupled to propeller scarring of sensitive habitat (e.g., seagrasses). The effects of propeller wash, pressure waves, and wakes on benthic habitats were also investigated.

A number of environmental impacts of concern have been identified by the workshop with regard to habitat issues:

- Propeller scarring of seagrass beds by motorized boats has been documented to be a serious problem in shallow water systems in the Florida Keys.
- Propeller wash and propeller cutting along the substrate damage seagrass leaves, roil bottom sediments, and even dislodge rhizomes.
- Increased turbidity may create shading conditions that adversely affect benthic algae and vascular plants, contributing to a loss of benthic habitat.
- Heavy boat use may significantly increase the amount of time that sediment remains in suspension.
- Some scarring impacts are due to fishing gear impacts (hydraulic clam dredging) rather than boat engine propellers.
- Docks and moorings for boats may be the most heavily impacted habitat areas (shading effects and physical habitat losses) in many shallow water systems.

More work must be performed in the following areas to fill data gaps on habitat impacts identified by workshop participants:

- Propeller wash and water-jet wash effects on sediment resuspension.
- Effects of storms in accelerating seagrass damage in areas of propeller scarring.
- Predictive models need to be formulated in order to more thoroughly understand the impacts of motorized boats on benthic habitats.
- Relative significance of benthic habitat scarring due to jet driven motorized watercraft vs. propeller-driven motorized boats.
- Effectiveness of updated navigational charts and channel markers in mitigating benthic habitat impacts by motorized vessels.
- Impact of jet-propulsion on fisheries and the recovery rate of scarring.
- Conduct social science research to address user experience and user conflict.

There are several “science to management” suggestions of significance for management of habitat impacts as indicated below:

- It is critical to understand the system being investigated, including the scale of benthic habitats.
- Essential or sensitive habitats must be identified for protection.
- Commercial fishing nets should be banned in sensitive habitat areas, notably in seagrass beds.
- The implementation of rapid habitat damage assessment programs will help to mitigate long-term impacts of scarred SAV beds.
- The reduction of motorized boat impacts on sensitive benthic habitats in shallow water systems will require a combination of public education and enforcement of regulations.
- To mollify scarring of benthic habitats, motorized boat use must be restricted to channels and deeper water areas.
- No use zones should be considered in areas of sensitive habitat.

Discussion

One of the principal findings of this workshop is that much more scientific information exists on propeller-driven boat impacts than on jet-driven boats, including PWC impacts in shallow water systems. In addition, in the case of SAV beds, the larger the vessel, the greater the risk of resource damage. While the use of small motorized watercraft, including PWCs in these systems expanded rapidly during the 1990s, investigations of their potential impacts did not keep pace. It would be most useful for resource managers to have more data available to assess small motorized watercraft impacts on shallow water systems. Environmental studies of other motorized vessels have been conducted over a significantly longer period of time, and therefore substantially more data have been collected on their shallow water impacts. Databases have been developed on propeller scarring of benthic vegetation and the loss of faunal habitat and substrate stability, propeller-induced turbulence, shading effects, inputs of chemical contaminants from boats, contaminant remobilization from bottom sediments, and shorebird disturbance.

Session findings noted potential impacts related to noise disturbance from small motorized watercraft, including PWCs on shallow water systems. All vessels, including small motorized watercraft, operated in close proximity of colonial nesting birds as shown in the tern study, and Rodger’s study, can alter behavior and potentially result in reproductive failure.

The wave-wash of jet-driven boats including PWCs and propeller driven boats appears to increase turbidity in nearshore areas of shallow water systems, although the effects are likely to be ephemeral. In this respect, small motorized watercraft, including PWC wave-wash effects may be similar to those of small propeller-driven boats. Much more data must be collected on small motorized watercraft, including PWCs - both in terms of wave-wash and potential SAV scarring impacts - to devise effective management strategies for the protection of sensitive, shallow water habitats.

Propeller-driven motorized boat impacts fall into four broad categories: (1) water quality alteration, (2) sediment quality changes, (3) benthic habitat modification, and (4) biotic community changes. Water quality can be altered by hydrocarbon (e.g., uncombusted fuel/oil mix, PAHs, and other non-aromatic structures) and metal emissions from the motorized watercraft, as well as by the remobilization and resuspension of nutrients and contaminants from bottom sediments via propeller wash and propeller cutting. Motor-induced turbulence also increases erosion of sediments and turbidity which can have a significant influence on water quality. Because larger, less water-soluble hydrocarbon compounds and trace metals released from motorized boats are highly particle reactive, they ultimately accumulate in bottom sediments of shallow water systems, where they can greatly impact sediment quality (particularly in urban industrialized regions). More laboratory and field studies (e.g., Sediment Quality Triad Testing) are needed to document the magnitude of contaminant inputs to bottom sediments from motorized boats and their remobilization. These studies must address engine, propeller, pressure wave, and wake effects on sediment quality.

Propeller-driven boat movement in shallow water areas is a major concern because propeller scarring inflicts serious mechanical damage to SAV and other sensitive nearshore habitats. The increasing use of stainless steel propellers instead of softer aluminum may encourage boaters to "power through" shallow areas with impunity. Deep sediment disturbance by rotating propellers acutely degrades rhizome and apical meristems of SAV and creates steep topographical depressions which can retard regrowth of the plants into the scarred areas. The scarring of benthic habitats invariably decimates benthic communities, and the period of recovery can be protracted. For example, the regrowth of scarred seagrass beds may require several years to complete in some regions. These delays will have a dramatic effect on benthic fauna that rely on seagrass beds for survival, and the period of recovery can be protracted, usually requiring 4 to 10 years to complete.

Conclusions

Resource managers must proceed with particular caution when assessing the potential impacts of PWCs on aquatic organisms. More research must be conducted on these waterjet-driven watercraft, as well as on propeller-driven motorized vessels, especially in waters that are heavily utilized. This will require a concerted effort on the part of government agencies, the boating industry, and academic institutions working collaboratively to identify major problems and implement corrective actions which will protect the long-term health of these critically important environments.

The need to manage boating activity effectively, reduce user conflicts, and minimize the environmental disturbances from these activities in New Jersey waters was the focus of a second motorized boat workshop (Management Options) that was held at Rutgers University on December 12-13, 2000. This workshop brought together a range of management approaches from various states, local governments, and public managed lands that have been designed to minimize environmental impacts from small motorized watercraft.

Information derived from both the science and management workshops will be used to develop strategies and to formulate recommendations for managing small motorized watercraft use in shallow coastal waters of New Jersey. A State Small Watercraft Management Plan will be prepared to help address environmental concerns in shallow freshwater and marine systems. It will consider the level and types of watercraft usage and associated impacts on habitat, wildlife, and resources. Recommended strategies to minimize future impacts of small watercraft will consider a range of approaches including education, training, legislation, and enforcement policy to protect coastal environments. The "management plan" will be the product of input of federal, state, and local government agencies, industry, academia, and stakeholders. More "social science" research needs to be conducted to address public conflicts, legal issues, and user experience.

Addendum A: Noise

PWC and SOUND from the Personal Watercraft Industry Association

The Society of Automotive Engineers utilizes 3 methods of measuring sound from watercraft, including PWC:

SAE J34	This is the most precise measurement available, taken of a boat at a distance of 50ft with wide-open throttle (the near maximum noise of the boat). Although great for engineering standards, it is difficult for enforcement purposes in the field. The Coast Guard recommends 86 decibels (dBA), which most states have adopted as law.
SAE J2005	This measures the engine sound at idle with the microphone 1.5 m away. SAE recommends a limit of 90dbA for this method, which does not account for the speed or power of the boat.
SAE J1970	In realizing the enforcement difficulties of the previous methods, SAE designed this shoreline noise test enabling regulations keeping the boat under 75 dBA at 50 ft. by operation, not mechanics. The operator is responsible for controlling the noise of the boat.
dB	refers to the measurement in decibels. The (A) refers to the "A" weighting of the scale, which discriminates against lower frequency similar to the sensitivity of the human ear.

Sound energy dissipates with distance, other sound and wind. A comprehensive study on sound with motorboats (but not including PWC) found that sound dissipates up to 9.9dBA when the boat travels from 50 ft to 200 ft away (4.8 dBA reduction from 50 to 100 ft, additional 5.1 dBA from 100 to 200 ft.).[i]

Both the National Association of State Boating Law Administrators and the National Marine Manufacturers Association have Model Noise Acts, which manufacturers follow as NMMA members. These requirements are in compliance with the SAE recommended dBA standards. NASBLA required 88 dbA under SAE J2005, and 75 dBA under SAE J1970. NMMA recommends 90 dBA under SAE J2005.[ii] The Environmental Protection Agency has determined that 75 dBA at 50 feet is an acceptable noise level to protect public health and welfare, but does not address shallow water habitat and resources.[iii] There are two items creating the noise one hears from PWC: noise from the water splashing the hull and resonating, and the noise from the engines during normal operation of the PWC.

Tests comparing noise levels emitted by 2001 models found that a 3-seat PWC emits 70 dBA at 100 ft when towed, when engine is not running. When tested with a running engine at full throttle, the engine sound plus the water sound created 78 dBA, below the Coast Guard's boat noise regulation of 86 dBA at 50ft at full speed under SAE J34.

To reduce the noise intake, the PWC utilized air intake resonators with multiple maze-like chambers eliminating a direct path for the sound waves to escape.[iv] This series of tubes, termed the resonator, employs several different length tubes attached to the exhaust pipe. As sound waves pass into these tunnels, they bounce back, and their opposite direction cancels out incoming, identical but opposite "crest" waves.[v] Baffles are used for counter frequency and to quiet vibration. Manufacturers also employ noise-absorbing foam between the liner and the hull, so the boat is quieter and more durable (and therefore quieter under water.) These machines also have increased thickness to the crankcase wall muffles noise and vibration. Rubber is also used as padding around the jet pump dampers to absorb the shock loads and quell driveline noise.[vi]

In New Jersey, the state police measured the noise levels of PWC in 1996 in accordance with SAE J2005 (idle engines). These older model PWC were found to have decibel levels of 71 and 70 in these tests, well below recommended levels of 88 dBA by NASBLA. In contrast, the outboard engine measured 74 dBA, outboard engine with exhaust above the water measured 90 dBA, while the racing boats measured came in at 95-99 dBA.[vii]

Sound level tests performed according to SAE J1970 in California found PWC measure an average of 70.68 dBA comparing the 4 brands of 1992 models. This is also well below the standard 75 dBA limit set by NASBLA.[viii]

i Permanent International Association of Navigation Congress Working Group No. 6, Discussion of Personal Watercraft Noise-Related Issues

ii NASBLA Model Act for Motorboat Noise, Adopted 12/11/89, Amended 9/26/91

iii "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With An Adequate Margin of Safety." EPA 550/9-74-004, U.S. EPA, Washington, DC. 1974

iv from "The Yamaha Sound Suppression System and the Yamaha Platinum Plus System," Yamaha Watercraft brochure, 1999

v from "Bombardier Announces Quieter Watercraft for 1999," Bombardier press release, 1997

vi from "Kawasaki Marine Engine New Technology for Year 2000 and Beyond," Kawasaki press release, 2000

vii Data from Noise Unlimited Inc. Report No. 8077.1, New Jersey State Police-Marine Division, November 1, 1995

viii Brown-Buntin Associates, Inc., Environmental Noise Analysis, Sept. 14, 1992

Impacts of Small Motorized Boats on Shallow Water Systems: Management Workshop Report

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Introduction

The New Jersey Department of Environmental Protection Coastal Management Program and the Jacques Cousteau National Estuarine Research Reserve, in partnership with state and local government agencies, industry representatives, and non-governmental organizations, convened a management workshop at Rutgers University on December 12-13, 2000, entitled, "Impacts of Small Motorized Boats on Shallow Water Systems." The workshop focused on the management of small motorized watercraft as well as stakeholder input on management strategies that may be considered for implementation in New Jersey. In recent years, there has been a rapid increase in the number of small motorized watercraft in use, contributing to greater conflicts among recreationalists, waterfront residents and environmentalists. Accelerated use also has raised concerns about the environmental effects of motorized boat use on shallow water habitats, wildlife and water quality.

A science workshop held on November 7-8, 2000, at Rutgers University brought together a number of researchers to discuss the topic of environmental impacts of small-motorized watercraft. The results of this workshop indicate that much more information is available on the environmental impacts of propeller-driven watercraft than on the impacts of small motorized watercraft, including PWC. Propeller-driven watercraft can potentially alter water and sediment quality, benthic habitats and biotic communities. Deep propeller cuts also directly disturb the benthos by damaging submerged aquatic vegetation (SAV), scarring the substrate and eroding sediments. The outcome of the science workshop included lists of data gaps, environmental impacts of concern, and guiding principals that should be used for managing vessel impacts.

Some states and local communities have established regulations to address safety, conflicts with other recreational users, excessive noise, and marine pollution and wildlife harassment. Most states regulate boating activities and require boating registration; they enforce safe boating practices, specify buffer and no-wake zones, establish minimum age of operators, and require liability insurance. Additionally, states are more frequently requiring operators to complete a safe boating course. Increasing accident rates and environmental concerns led to a wave of state laws regulating watercraft use, including mandatory education programs, which are supported by the Personal Watercraft Industry Association (PWIA).

Small group discussions on the second day of this workshop resulted in a repetition of common themes. Each discussion group included impacts to submerged aquatic vegetation, turbidity/re-suspension, impacts to fish and wildlife, contaminants, user conflict and noise as environmental impacts that could be of concern. One group also pointed out that the impacts are going to vary according to the characteristics of the water body of concern (tidal/non-tidal, size, depth, species, etc.). During the plenary session, workshop participants requested the addition of invasive species to the list. Additionally, there were concerns about watercraft transporting invasive species from one water body to another.

Groups discussed some of the barriers to overcoming these concerns. Nearly every group determined that education and enforcement have barriers. Politics or lack of political will, funding, and research needs were also commonly discussed barriers to change. In the plenary session, the group agreed that the lack of clear goals and differing values and perceptions are additional barriers that should be considered. In terms of overcoming these barriers, groups concluded that education, funding for management activities (like enforcement), and research could be very useful. In the plenary session, participants requested the consideration of citizen education groups as a solution to overcoming barriers. In addition, the group suggested that it is important to bring all parties together into the discussion and that adding a liability mechanism on watercraft users should be considered.

Objectives

The management of small motorized watercraft is becoming a critical issue for New Jersey's lakes, rivers and coastal areas because of increased small motorized watercraft use, a perceived lack of management/enforcement by user groups and the environmental impacts of small motorized watercraft. The purpose of the second workshop was to assemble a group of interested stakeholders to evaluate the guiding principals developed by the scientific community, assess a range of management strategies that have been applied in other states, and document research and management needs which should be considered for New Jersey's shallow waters.

The workshop focused on eight case studies representing different ways to manage social and environmental impacts from small motorized boats in the shallow water environment. The case studies outlined an array of small watercraft education, regulation, and enforcement programs that have been applied across the country, and speakers included experts from both the public and private sectors. Case studies were organized into four sessions: (1) Experience from the States; (2) Experience from Local Governments; (3) Experience from Public Managed Areas; and (4) Education and Enforcement.

The science to management suggestions developed at the science workshop served as the basis for discussion of the management approaches. Workshop participants were assigned to small groups and tasked with reviewing these guiding science principals and identifying those, which applied to New Jersey. The small groups then delineated barriers to managing or addressing environmental impacts of small watercraft in New Jersey and discussed the strategies necessary to overcome those barriers.xi

Workshop Contents: Day 1

The second workshop began with a synopsis of the science workshop held November 7-8, 2000 at Rutgers University. Workshop participants were briefed on research dealing with environmental impacts of small-motorized watercraft on shallow water environments. Areas of agreement and discord on each topic were described. Definitions of small watercraft, personal watercraft and shallow water were discussed.

The second presentation focused on the public trust doctrine and jurisdictional issues on tidal lands in New Jersey. Subsequently, eight case studies were presented which described a wide range of models/management approaches that have been implemented around the country. The case studies were grouped into four sessions: (1) Experience from the States; (2) Experience from Local Government; (3) Experience from Public Managed Areas; and (4) Education and Enforcement. The case studies included the following range of management approaches:

- Enforcement of existing boating laws and other environmental laws
- User education
- Developing marine engine standards
- Use of buffer zones from shore, other boats, wildlife, etc.
- Conservation zoning
- Resource damage penalties

Abstracts from the presentations as well as question and answers from the workshop participants are included in the following section.

Use of the State's Public Trust Ownership of Submerged Tidal Lands to Manage the Operation of PWC. (William Anderson, Deputy Attorney General, Division of Law)

Abstract

The Public Trust Doctrine provides that the title to tidal and navigable freshwaters, the lands beneath, as well as the living resources inhabiting these waters is a special title. It is a title held by the state in trust for the benefit of the public, and establishes the right of the public to use and enjoy these trust waters, lands and resources for a variety of recognized public uses. In New Jersey, the Public Trust Doctrine extends the title to present and former tidal lands with some qualifications. It has encompassed some privately owned upland areas needed to reach these tidal lands, and also includes recreational uses of tidal lands, not only the historic public trust uses of navigation for commerce, fishing and fowling.

In New Jersey, the Doctrine is mainly asserted in decisions concerning waterfront harbor and marina development, and the sale or leasing of these lands. The first is handled by the Land Use Regulation Program, and the second, initially by the Tidelands Resource Council. The council is a 12-member body of non-state employees selected by the Governor with the advice and consent of the senate. It decides, in the first instance, whether to convey or lease state-owned or claimed tidelands. The council and the reviewing state authorities have very wide direction in such matters. Thus, actions by virtue of the Doctrine, and state statutes, must take into account public trust interests in the lands within their control. As a result, the council has rarely sold the fee to natural tidal lands since the 1970's. In addition, the council will not lease such lands unless the applicant has the proper federal and state environmental permits to develop the site.

The Tidelands Resource Council does not, in general, actively manage its high tidal and intertidal holdings in New Jersey, relying on other federal, state, and local agencies to do so. Occasionally, the council will allow state or local agencies to actively manage relatively small sites to maintain parks or preserve wildlife. Such a 'management agreement' arrangement is about to be proposed to the council involving the use of PWC in Barnegat Bay.

There are distinct advantages to proceeding on these issues before the council rather than acting in a regulatory fashion.

1. The council acts as the owner of these lands, not as a regulator. Thus, its actions are not subject to the claim that they are arbitrary or unreasonable, or a violation of statutory law. It has very wide discretion in this area.

2. The actions that the council takes may be modified promptly, without publication in the register and without regulatory hearings.

3. The council is familiar with the Public Trust Doctrine; its members come from a wide background and have strong expertise in many fields. They can make informed decisions on management issues relating to wildlife and other environmental issues, and recreational use of small boats and PWC.

4. The council has taken actions concerning management issues such as those involving the use of PWC in the past, with broad public participation, and no litigation.

Session 1: Groundbreaking Approaches to Managing Impacts from Motorized Boats in Shallow Aquatic Systems: Experience from the States

Overview of Legislation from the States (Sean Foertsch, Personal Watercraft Industry Association)

The Personal Watercraft Industry Association (PWIA) was formed in 1987 as an affiliate of the National Marine Manufacturers Association. It was created to bring together companies that manufacture or distribute PWC in order to:

- Promote safe and responsible operation of PWC
- Work with federal, state and local agencies which have regulatory responsibilities for recreational boating

PWIA has developed model legislation to aid communities and law enforcement agencies in making waterways safer and reducing conflict among all recreational users. A number of states have adopted this legislation or portions thereof. A copy of the model legislation can be found in Appendix III.

Model Legislation

In February 1998, the PWIA introduced a model act for state legislatures that called for mandatory education for all PWC operators. The association based its support of mandatory education on the positive results from a number of states which required mandatory education for some or all of their boating population. These states included Connecticut, Maryland, New Jersey and Utah.[xi] The states of Florida and Kansas have been added to this list, as they require mandatory education for certain age groups of their boating population. These state education efforts, as well as industry efforts to promote safe and responsible boat use, appear to be working in reducing PWC-related accidents and injuries.

Connecticut implemented mandatory education for most boaters and all PWC operators in 1993. There have been no PWC related fatalities in Connecticut since the inception of the program. Since 1995, the number of reported accidents involving PWC has remained fairly constant in Connecticut (six accidents in 1995 and eight accidents in 1998); however, the number of PWC registered in the state has grown by approximately 30%.

In October 1996, Florida established its mandatory education law requiring all persons born after September 30, 1980 to complete a National Association of State Boating Law Administrators (NASBLA) approved boater education course or competency exam, prior to operating a vessel powered by a motor of 10 horsepower or more. On October 1, 2001, all persons 21 years of age and younger will be required to comply with this law. Florida has seen a downward trend in the percentage of reported accidents in the 16 and under age group since the law was established. In 1996, the 16 and under age group was responsible for 14% of reported accidents involving PWC. By 1998, the percentage of reported accidents from this age group had dropped to 12%. In fact, PWC accidents have dropped about 15% in Florida since 1995, while the number of registered PWC increased over 31%.

In January 1995, Kansas began requiring mandatory education for PWC operators between the ages of 12 and 15. During 1998, 12.5% of PWC accidents involved youths, a significant drop from the 35.3% involvement in 1997. Overall, PWC accidents decreased significantly in Kansas during 1998. In 1997, PWC accidents comprised 56.1% of the total accident figure; PWC involvement dropped to 39.8% in 1998, a decrease of over 16%, while PWC registration numbers during the same time increased 11.5%.

Maryland enacted mandatory education regulations in the mid-1990s and the number of PWC registered in the state has grown enormously, increasing from 9,273 registered in 1995 to 14,365 registered in 1998, amounting to an increase of almost 55%. During this same time frame, the number of PWC-related accidents only increased by approximately 7%, with 56 PWC accidents reported in 1995 and 60 PWC accidents in 1998.

In comparison, New Jersey's mandatory education program began in 1997. Under state law all PWC operators must complete a boating safety course and carry an operator's certificate. According to state officials, there were 68 accidents, 53 injuries and one fatality reported to the state in 1998, in comparison to the pre-law statistics for 1996 of 89 accidents, 55 injuries and three deaths. This corresponds to approximately a 24% decrease in accidents, a 4% percent decrease in injuries and a 67% decrease in fatalities. These decreases occurred while PWC registrations in New Jersey increased during this time as compared to registration in 1996.

As another example, Utah continues to see reductions in the number of reported PWC accidents, despite the fact that the number of PWC registered in the state has risen since the implementation of mandatory education in 1995. Utah requires mandatory education for operators between the ages of 12 and 17. The results for this targeted age group are highly significant. Accidents involving 12 to 17-year olds have dropped by almost 72% since 1995. While education is only required for youths, the benefits are not confined to that age group. Since 1995, PWC registration increased almost 40%, yet accidents involving PWC decreased by about 18%. Fatalities involving PWC have dropped as well, with two recorded in 1998 and four recorded in 1995; this change amounts to a 50% reduction in fatalities.

Since February 1998 to date, the states of New York, Pennsylvania, Ohio and Oregon have all adopted mandatory education bills that were supported by PWIA. In addition, the PWIA has supported current legislation in Washington, California and South Carolina. The bills in both Washington and California have failed.

Marine Engine Emissions

In August 1996, the Environmental Protection Agency established new emission standards for new spark ignited gasoline marine engines. Covered by the rule are outboard engines and gasoline marine engines used in PWC and jet boat applications. Over the next six years, outboard and PWC marine engine manufacturers will reduce emissions of hydrocarbon (HC) and nitrogen oxides (NOx) from their products by approximately 75%. It is important to note that these new engine technologies may also significantly reduce sound levels.

2001 Update from PWIA

The PWIA has updated information presented at the 2000 workshop. In 2001, the number of states which have currently adopted PWC education, according to the NASBLA Reference Guide To State Boating Laws, includes Colorado, Connecticut, Delaware, the District of Columbia, Florida, Idaho, Kansas, Massachusetts, Michigan, Minnesota, Nebraska, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, Utah, Virginia, West Virginia and Wisconsin.

Florida, which is the leading state for PWC registrations, has enacted comprehensive PWC laws in recent years. As a possible result, PWC registrations have increased by 38% since 1995 while PWC accidents have been reduced by 22% over that period of time.

PWC manufacturers are now using engines that produce 75% fewer emissions than earlier models. Year 2001 PWC models now meet 2006 U.S. EPA clean air standards. Since the average life of a privately owned PWC is five years and rentals even shorter, one may expect that they majority of PWC will be in compliance with EPA standards in several years.

Discussion, Questions and Comments

1. State control vs. local control: In California the Department of Boating and Waterways enacts regulations, and local municipalities take funding for programs and enforcement. However, municipalities can not enact anything more restrictive. This may serve as just one model of control.
2. Is there an increased need for enforcement in areas where they have specific zones for PWC, and how effective are they? Monterey Bay National Marine Sanctuary developed exclusion zones for PWC; however, ridership is low so it has not been much of an issue. In Florida, if the management plan is accepted, it will cover a much greater area so more enforcement may be needed.
3. At the last Coastal Zone Managers regional meeting, there was a session on PWC, concerning what other states are doing. One of the outcomes of this session was that, with exclusion zones, it is important not to funnel all of the activity to an area which may not be identified as sensitive or critical, but which could become a problem with increased activity.
4. How does the PWIA model differ from the New Jersey legislation? The PWIA model legislation is just a boilerplate. New Jersey fits the boilerplate in almost every aspect; there is an education component, a reckless operation component, and an age component. However, the restricted distance from the shoreline for PWC use is not the same. PWIA recommends 200 feet.

New Jersey Legislative Efforts (John Hazen, New Jersey Department of Environmental Protection, Office of Legislative Affairs)

Abstract

Three bills have been introduced on the subject of small watercraft regulation. These bills include A-307, sponsored by Charlotte Vandervalk (Bergen County), S-102 sponsored by Leonard T. Connors, Jr, and A-704 sponsored by Assemblymen Christopher J. Connors and Jeffrey W. Moran. Bill A307 prohibits PWC use above idle speed in coastal wetlands. The bill cites studies on impacts to the environment, but otherwise is very straightforward. This bill has not seen any action in the last 2-3 sessions. Senator Connors' bill (S-102) is aimed primarily at giving municipalities the authority to control PWC by

enacting ordinances that could prohibit the operation of the watercraft within 100 feet of dwelling units. It also gives the Bureau of Marine Law Enforcement and local officials authorization to enforce municipal provisions. On the senate floor, Connors amended the bill to include other vessels, dwelling units, fishing piers, beaches, persons and shoreline in the 100-foot setback.[xi] The vote on this bill is currently pending. The assembly bill is nearly identical and will probably be similarly amended to reflect the changes in the senate bill.

There are several problems with these bills due to conflict with existing laws regarding distance from other vessels and the fact that counties and municipalities currently have powers to pass ordinances to regulate small watercraft. Localities must submit proposals to the Boating Regulation Commission to control watercraft. The Connors' bill would enable localities to enact ordinances directly.

Discussion, Comments, and Questions

1. The 100-foot buffer is not adequate. Local groups have proposed a minimum of 200 feet.
2. Localities will need funding to strengthen local enforcement.
3. Legislation does not address environmental impacts or impacts from other types of small watercraft.
4. The bills are piecemeal at best, and other laws address these issues. The problem is a lack of funding to adequately enforce existing laws.
5. Have there been any efforts to include environmental concerns in addition to nuisance concerns? The Barnegat Bay Estuary and Watershed Foundation has recommended legislation which takes the environment into consideration.
6. Funding and legislation should be considered together.

Session 2: Groundbreaking Approaches to Managing Impacts from Motorized Boats in Shallow Aquatic Systems: Experience from Local Governments

Lake Tahoe Marine Engine Emission Reduction (Steve Chilton, Lake Tahoe Regional Planning Agency)

Abstract

Lake Tahoe, the second largest lake in the world above 6,229 feet and the third deepest lake in North America, is losing one foot of clarity per year. Identified as one of a few outstanding national resource waters in the nation, Lake Tahoe is now subject to pollution from many recreational pursuits. This lake receives four times the visitors of Yosemite National Park, totaling 23 million visitor days per year.

The Tahoe Regional Planning Agency (TRPA) is a bi-state regional land use and environmental planning agency with jurisdiction over all portions of California and Nevada within the Lake Tahoe Basin watershed. A bi-state compact ratified by the U.S. Congress and the states of California and Nevada created the agency in 1969. It has developed environmental thresholds and a regional plan for the Lake Tahoe region and routinely acts on projects and issues within the basin. The agency has produced an Environmental Improvement Plan detailing 900 million dollars in projects over the next ten years designed to reduce and eliminate environmental degradation in nine environmental thresholds.

TRPA has been involved in scientific studies to determine the pollution contribution of two-stroke engines to Lake Tahoe. These studies have shown that two-stroke engines emit 20-30% of their fuel unburned to the water. In response to these findings, TRPA held public hearings and took action on June 1, 1999 to set standards prohibiting certain types of marine engines on Lake Tahoe. At the same time, the agency established a no-wake zone 600 feet from shoreline to reduce shoreline erosion and to limit noise disruptions to beach users and sensitive wildlife.

The marine engine standards provide for the use of cleaner engines, including direct fuel injected two-cycle engines, those that meet the California Air Resources Board 2001 and the EPA 2006 standards, and all four-cycle engines. The TRPA regulations do not provide for any "grandfathering" of older engines. The National Marine Manufacturers Association challenged the standards in court, and the challenge was resolved favorably to TRPA.

The standards have proven to be successful in reducing pollution from marine engines for a number of reasons. They are based on sound scientific information. A major media campaign to inform boat users was initiated before the standards went into effect. Funding was provided for a Motorized Watercraft Enforcement Team and yearly water quality monitoring. During the first year of the standards, TRPA initiated a May to October, seven day a week, lake patrol to inform and enforce the new standards. Monitoring during major visitor-use events showed dramatic reductions in the BTEX compounds (benzene, toluene, ethyl-benzene and xylene) and in MTBE.

Discussion, Questions, and Comments

1. Why did you decide not to use buoys to delineate the no-wake buffer zone? Buoys were not used because of the regulatory issues (they are difficult to obtain), scenic issues, cost, and maintenance issues. We do have a laser range finder that puts our patrol boat at 600 feet. We patrol at that distance and this allows other boaters to use the patrol boat as a guide.

2. You use 600 feet as a buffer regardless of depth? Yes, it is difficult enough to say 600 feet everywhere around the lake, let alone 600 feet here, 800 feet there, and so on.

3. Do you have an agency that you can refer arrests and other matters during the summer? Sheriff patrols, Coast Guard, and the Department of Wildlife all patrol the lake. In addition, we have a network and use our radios to let everyone know where we are and what we are doing. So you are part of a comprehensive enforcement program? We are, but no one else can enforce our regulations.

4. How did you overcome resistance from people who just purchased a $10,000 boat and the following year you tell them that they can no longer use that engine on the lake? Two years of work went into the program before the regulations went into effect including public hearings. The National Marine Manufacturers Association sued us - so the word was out. Everyone should have known about the regulations two years after the deadline.

5. What kind of monitoring is going on in that system? Has anyone done any coring of the sediments to take a historical account to determine what is really happening here and if the environment is really improving? Who is doing the studies? The University of California-Davis has been monitoring water quality monthly since 1972. In the last 5 years, they have been doing coring. TRPA provides approximately $500,000 of funding a year to the University of California and University of Nevada for monitoring. In addition, the U. S. Geological Survey has been involved in stream monitoring. We do have a thermocline in the lake, and about every 7 years the lake gets mixed from bottom to top. We've had some good indications of water quality improvement over the last several years, but we really need 10 years of data to show improvement before we can say that it is due to all of our recent efforts.

6. In terms of funding, we go to the States of California and Nevada with a budget request. There is a match system in place of 1/3 Nevada and 2/3 California. We also operate with a lot of Federal grants. We currently have a $600,000 program funded by the EPA 319/106 Program.

7. Is most of the enforcement done on the water or at boat ramps? Both. We have two boats out 7 days a week. Sometimes we park the boat and trailer at a ramp and make it a public education event. Our regulations are posted at all boat ramps. People know their old 2-stroke engines are dirty; it is not a hard sale.

8. In terms of an education budget, our budget is about 1/3 education and 2/3 staff. Additionally, we have a public relations person on staff. We buy radio spots and produce brochures. We are also thinking about involving a local environmental commission to form a community lake watch program.

San Juan County, Washington: The Case for Local Control of the Use of Personal Watercraft (Randall Gaylord, San Juan County Prosecuting Attorney)

Abstract

In 1995, a group of citizens petitioned their local government to ban jetskis throughout San Juan County, Washington (pop. 12,500). In response to the public's outcry, the county invited state, federal and local officials and jetski industry representatives to a series of public workshops and hearings. The public hearings confirmed many user group concerns with the operation of PWC: noise, conflicts with shoreline users, conflicts with recreational vessel traffic, conflicts with wildlife and conflicts with the tranquil lifestyle desired by the tourists and residents of the county. Several months later, the county commissioners enacted a sweeping ordinance prohibiting the use of jetskis throughout the marine and fresh waters in the archipelago. Minor exceptions were made to allow the continued use of jetskis engaged in foreign or interstate commerce, in emergency situations, and in law enforcement.

The PWIA and others swiftly challenged the ordinance in state court. Citizens throughout the nation rallied behind the county with an outpouring of letters of support and money. An early story on the case in the New York Times described the case as a "David vs. Goliath" battle. After losing in trial court, the county appealed to the State Supreme Court. In a 7-2 decision, the Washington Supreme Court upheld the ban on jetskis as a reasonable exercise of the police power under the State Constitution. The Washington Supreme Court's decision had sweeping implications throughout the nation because most states grant the same police power to local governments. At least one state (i.e., Idaho) has even gone so far as to expressly state that local government has the power to prohibit the use of jetskis. However, other states are facing model legislation that would "preempt" local provisions and require uniformity of jetski regulations statewide. Based on anecdotes, the San Juan County model has been adopted in only a few areas in California and Alaska.

Although San Juan County's system is simple to enforce, the county has few enforcement officers, and reports of "jetski sightings" occur every year. While the lawsuit provided good public awareness for the County's rules, more education will be needed.

Discussion, Questions, and Comments

1. How do you address the issue of fairness? You showed a picture of the whale that can just as easily be disturbed by regular boating activity? How can you regulate only PWC? This is the biggest weakness of the case. However, we argued that it is just a reasonable exercise of police power.

Session 3: Groundbreaking Approaches to Managing Impacts from Motorized Boats in Shallow Aquatic Systems: Experience from Public Managed Areas

Resource Damage Assessment in Florida Keys Marine Sanctuary (Toben Galvin, NOAA, NOS, Damage Assessment Center)

Abstract

In 1999, approximately 500 small boat-grounding incidents were documented in the Florida Keys National Marine Sanctuary. Of these incidents, nearly 60% were on seagrass beds that resulted in physical scarring. The cumulative impact of small boat groundings represents a serious threat to the healthy functioning of the Florida Keys marine ecosystem. Seagrass beds are renowned for their ecosystem functions ranging from nursery grounds for juvenile fish species to sediment stabilization. In addition, healthy seagrass ecosystems contribute both directly and indirectly to the ecological base and economic viability of important marine related activities such as commercial fishing and tourism.

Both NOAA and the Florida Department of Environmental Protection have increased their efforts to rapidly and cost-effectively prepare and implement damage assessment and restoration actions for seagrass beds in the Florida Keys. This presentation provided a brief introduction to the scientific, economic, and legal advances that are deemed necessary to streamline the assessment and implementation of restoration actions in this area. Topics presented included statutory justification for trustee actions, recent advances in seagrass recovery modeling, and the use of habitat equivalency analyses for the calculation of primary and compensatory restoration plans and associated costs. The presentation concluded with suggestions on how this team approach may be transferable to other locations.

Island Beach State Park - Sedge Island Conservation Zoning Model for New Jersey (William Vibbert, Superintendent, Island Beach State Park)

Island Beach State Park is a narrow section of barrier beach stretching for ~16 km along the central New Jersey coastline and separating the Atlantic Ocean from Barnegat Bay. Island Beach, which is a spit, represents one of New Jersey's last significant remnants of a barrier island ecosystem that once existed along much of the coast. It is also one of the few remaining undeveloped barrier beaches on the north Atlantic coast. Over 1,200 ha and 16 km of coastal dunes remain almost untouched since Henry Hudson first described New Jersey's coast from the ship, the Half Moon, in 1609.

Miles of sand dunes and white sandy beaches provide habitat for maritime plants and diverse wildlife that is almost the same as it was thousands of years ago. Island Beach State Park contains outstanding examples of sand dunes, thicket community, freshwater wetlands, maritime forest and tidal marshes. The state's largest osprey colony, as well as peregrine falcons, wading birds, shorebirds, waterfowl and migrating songbirds, are found here. Island Beach State Park is nationally known as a unique resource with over 300 plants identified, including the largest expanses of beach heather in New Jersey. Nearly 20 km of pure white sand beach attract swimmers, sunbathers, anglers and surfers. Modern bathhouses, beach access ramps, a mile of beach with lifeguards, historic buildings, trails, naturalist programs, bike paths and facilities for people with disabilities combine to make Island Beach a popular place.

The bay side of the island is a nutrient-rich feeding ground for birds, fish and other wildlife. Naturalist guided canoe and kayak trips during the summer months take participants through the tidal marsh where they can observe a wide variety of wildlife, including nesting ospreys, falcons and wading birds. A bird observation blind gives visitors the opportunity to scan the bay and estuary.

Island Beach State Park has recently made application to the New Jersey Tidelands Resource Council to utilize Conservation Zoning to manage watercraft use within the tidal portions of the park. Pending approval, sensitive areas such as tidal creeks and submerged aquatic vegetation can be mapped, and motorized watercraft can be restricted during all or portions of the year to minimize impacts to wildlife and sensitive habitats. Conservation zoning is a tool that can be used to manage watercraft access, speed, and use of sensitive areas. Conservation zoning has been successfully employed in other coastal areas worldwide and in marine sanctuaries in the United States. It is a management model that has not yet been applied in New Jersey.

Session 4: Groundbreaking Approaches to Managing Impacts from Motorized Boats in Shallow Aquatic Systems: Education and Enforcement

Florida Keys National Marine Sanctuary Boating Education and Enforcement (Mary Tagliareni, Florida Keys National Marine Sanctuary)

Abstract

Within the 2800 nm2 of the Florida Keys National Marine Sanctuary surrounding the Florida Keys there are hundreds of hectares of shallow seagrass beds and emergent coral reefs. With one boat per every two households for the residential population of 85,000, 2.5 million visitors annually, and hundreds of boats rented to non-trained and inexperienced operators, the impacts to the shallow water resources by recreational boaters have been significant. Within the sanctuary in 1994, over 500 boat groundings were reported to authorities. Aerial surveys in 1993 revealed that there were over 6,000 ha of moderately to severely damaged seagrass beds from boat prop scarring. Administrators of the sanctuary have worked with the community and have used creative strategies to reduce these impacts.

The Team OCEAN program has been one of the most successful endeavors to teach boaters about stewardship of the resources, proper navigation to prevent resource damage, and techniques for minimizing habitat degradation when removing grounded vessels. Team OCEAN consists of three different components including an on-the-water interpretive volunteer effort; a business community program; and a boater education initiative. In addition to Team OCEAN, the Sanctuary has produced posters, brochures, and weekly TV segments. We are a founding and active member of the Seagrass Outreach Partnership (SOP), a local multi-agency partnership that focuses efforts at reducing boat impacts to seagrass.

In addition to a strong education campaign, the sanctuary has a pro-active law enforcement squad that enforces the regulations targeted at protecting the shallow water resources from boating impacts. The officers use a combination of interpretive enforcement and civil penalties when violations occur.

Discussion, Questions, and Comments

1. Do you have any areas closed to all watersports? Yes, we do have a number of areas (list) closed off to all vessels. We also have four small research reserves that are closed to all water activities such as diving or fishing. You can only cross these areas in a vessel, but you can't stop.

2. Recreational fishing interests claim that they have been closed out of the sanctuary and are concerned with the implementation of zoning here in New Jersey. We have 18 sanctuary preservation areas that make up less than 1% of the entire 2,800 nmi2 sanctuary. They are the most heavily used areas by divers and snorkelers; therefore, most of the fishermen were not concerned about giving those areas up. Recreational fishermen may be talking about the establishment of three ecological preserves that were in the sanctuary's Final Management Plan. One would have been an Ocean Reef Reserve that has been cut completely; there is one in the Lower Keys and a proposed reserve in the Tortugas. It is important to note that the recreational fishing interests in the Keys have supported the plan in the Tortugas.

New Jersey State Police, Marine Law Enforcement (Lt. Pete Matonis and Trooper Jeff Andres, New Jersey Marine Police)

Abstract

New Jersey State Police patrols the waters of the state, 24 hours per day, 365 days per year, protecting lives and property, while enforcing criminal, boating, and environmental laws. There are nine marine law enforcement stations throughout the state staffed by approximately 120 troopers. The Division of State Police vessel fleet consists of approximately 80 boats ranging from 13 feet to 55 feet in length in both covered and open versions.

All troopers that operate vessels are trained in marine law enforcement and are certified vessel operators. Certification starts with a four-week vessel handling and marine law enforcement school. Eligibility for certification requires successful completion of the school and at least 120 hours of underway time, including at least 40 hours of night operation. Applicants for certification must then complete a hands-on proficiency test demonstrating their ability to perform the required tasks to the satisfaction of the certifier. There are three types of certification: outboard vessels, inboard vessels, and special purpose vessels (e.g., jet-boats or fan boats).

Patrol related observations indicate that both jet propelled and propeller driven craft can cause damage to shallow water systems. The research presented in this workshop indicates that a single pass from a propeller driven vessel in a very shallow area can cause significant damage that may actually become worse after the initial impact, due to increased water velocity in the trough area created by the propeller. However, as significant as the damage may become, this type of impact to the shallow water system may not be as great as the overall damage caused by jet-propelled craft.

PWC operators tend to congregate in shallow areas to avoid the inherent danger of being in close proximity to larger, less maneuverable craft. Larger propeller driven vessel operators tend to stay away from shallow areas because they may run aground and risk personal injury and damage to their vessel.

Research conducted upon a newly approved PWC rental zone would allow investigators to monitor shallow water systems and how they are impacted by the repeated passes of jet-propelled craft, prior to the increase in traffic when the rental zone opens. When requested, the Division of State Police can provide certain information to researchers that pertains to PWC rental zones.

The impact of vessels on shallow water systems has been well documented. The repair of the damage through grading and seeding shows promise. The remaining piece of the mission is prevention. The New Jersey Boat Safety course now requires that the effect of PWC on the environment is addressed in boat safety classes.

Discussion, Comments and Questions

1. Are there any laws that you would like to see on the books that are not there now? No, none that I can think of. Our legislators and the Boating Regulation Commission put through a lot of laws, and we can have input in that process.

2. How often do you respond to nuisance calls versus true violations and how do you distinguish between those calls? Do you respond to nuisance complaints? We try to respond to every call. With our limited resources, we do have to prioritize the calls. If there is an (accident or medical) emergency, we need to address those first. Otherwise our response is 'We will try to make it down, but please give us a call if the problem goes away.'

3. Comment: Often a complaint about PWC will be made when the PWC operator is engaging in legal activity.

4. Does your agency have any jetskis or use citizen enforcement? No, the craft that we use is very versatile, and we need to be able to access shallow water, transport a victim, tow if needed, and so on. If we had more officers, we would probably explore PWC.

5. Comment: The Maryland marine police use PWC because other PWC operators were outrunning many of the officers.

Workshop Contents: Day 2

Day two of the workshop focused on stakeholder response to the Science principles developed in the Scientific Workshop (November 7-8, 2000) and the range of management approaches presented during day one of the Policy Workshop. Workshop participants and facilitators were assigned to one of five groups. Efforts were made to ensure that each group included broad representation from a range of interests. Groups answered the following questions:

1. What are the environmental impacts (or scientific principles) that apply to motorized boats in shallow waters of New Jersey?
2. What are the barriers to managing or addressing them?
3. What can be done to overcome these barriers?

The small group reports are included in the section that follows.

Small Group Reports

GROUP 1

1. List of "Environmental Impacts of Concern" related to small watercraft for New Jersey

A. Direct and Indirect Impacts to Biological Resources:

- Fish and wildlife habitat
- Submerged aquatic vegetation and other plant communities
- Groundings
- Impacts to fish spawning areas due to added use and access
- Impacts to wildlife
- Human-animal interaction

B. Water Quality

- Engine by-products (fuel spillage, gas and oil leakage, emissions)
- Turbidity
- Litter and Debris

C. Aesthetic Impacts/Values

- Visual impacts
- Litter and debris
- Noise impacts (decibel level, duration pitch)
- Effects on fish and wildlife
- High speed wake, buoy, and bay island jumping

D. Economic Impacts

- Influence on revenue (tourism, recreation)
- Influence on property values
- Commercial development and associated side effects
- Infrastructure to support use/access

E. Access

- Access to shallow water
- Trespassing on private property

F. Concentrated Use

- Geographic
- Temporal (tidal, seasonal, weekend)

G. Shoreline Erosion

- Landings
- Wave wash

2. List barriers to addressing concerns

Barriers could include a lack of: political will, adequate enforcement, funding, legal action, burden of proof, necessary applied science, education, clear goals and objectives (standards, management, monitoring, indicators), and consistency.

3. How to overcome barriers

Actions that would be helpful to overcome these barriers include: workshops, willing political leadership, education of public, clear definition of different management jurisdictions at all levels of government, bringing all stakeholders to the table, and an accurate characterization of the issue.

GROUP 2

1. List of "Environmental Impacts of Concern" related to small watercraft for New Jersey

In New Jersey, the major environmental impacts of concern with respect to small motorized watercraft are tidal vs. non-tidal (soil, submerged aquatic vegetation, wildlife, water flushing/retention, species present), water depth, size of waterbody, social impacts and user conflicts.

2. List barriers to addressing concerns

Some more barriers include a lack of enforcement, politics, municipal level regulations, general ignorance, and a need to study the impacts, social impacts, management decisions, and differing user group values.

3. How to overcome barriers

In order to overcome these perceived barriers, there is a need for: stable funding, interim management, new regulations, education (judiciary, boaters, public), targeted research, zoning, speed limits, manufacturing improvements, and volunteer patrol.

GROUP 3

1. List of "Environmental Impacts of Concern" related to small watercraft for New Jersey

More perceived environmental impacts of concern include: erosional impacts on tidal creek banks, direct substrate (scarring, no seagrass beds), turbidity, chemical contaminants, impact of small motorized watercraft, including PWC on user experience, direct/indirect impact on wildlife, impact on fisheries, impact on birds and land mammals, impact on fishermen catching fish, 2-cycle engine pollution and noise impacts, boating user conflicts, and safety in terms of accidents in shallow water.

2. List barriers to addressing concerns

More barriers include: legislation (lack of authority to regulate riparian land), inadequate enforcement, absence of a resource-based approach, no zoning to exclude/regulate use, anti-regulation attitude, lack of coordination of federal/state/local governments, lack of visitor experience survey, lack of funding at all levels, lack of education, technology (challenge manufacturers for less polluting/quieter engines with marketable product), and inherent rights of boaters.

3. How to overcome barriers

We need to educate public/decision-makers, promote appropriate levels of enforcement, provide stable funding needed for all programs, give incentives to phase out 2-cycle engines, utilize and support natural and social science research, focus on appropriate conservation zoning techniques, enact statewide legislation, stimulate behavioral changes, pilot programs, and maybe even establish small motorized watercraft parks.

GROUP 4

1. List of "Environmental Impacts of Concern" related to small watercraft for New Jersey

More environmental impacts of concern delineated by workshop participants include: direct and indirect damage to SAV and its habitat (prop scarring, hull scour, increased turbidity, and other water quality impacts), docks (submerged aquatic vegetation scaring, prop scour to access docks, desire for dredging), noise pollution and impacts to nesting birds, resuspension of contaminants in sediment (from boats, docks and upland sources). Additionally, shellfish impacts should be addressed in terms of (1) consumer health issues; and (2) lethal and sublethal impacts to eggs, larvae and juveniles.

2. List barriers to addressing concerns

There is a perceived lack of public and politician education on environmental issues (some areas not suitable for docks, boat operation, etc.), data gaps regarding small motorized watercraft impacts, lack of noise standards and environmental capabilities, lack of funding for comprehensive education and research, lack of submerged aquatic vegetation mapping, and no strategy for a comprehensive plan.

3. How to overcome barriers

Education in schools and at boat ramps needs to be implemented, as well as vessel licensing, education of politicians and homeowners (i.e., some areas are not suitable for docks), promote responsible recreation and improve dock designs, adequate funding for comprehensive education and enforcement programs, and address data gaps regarding small motorized watercraft and annual submerged aquatic vegetation mapping.

GROUP 5

1. List of "Environmental Impacts of Concern" related to small watercraft for New Jersey

Group 5 gave their perceived environmental impacts of concern as being: submerged aquatic vegetation damage, shoreline erosion, sediment resuspension, air/water quality, noise impacts (to birds, wildlife and humans), user conflict, damage from docks and Boat/PWC rental operations.

2. List barriers to addressing concerns.

Group 5 perceived a lack of enforcement, scientific uncertainty, uncertainties regarding jurisdiction, fairness (smal motorized watercraft vs. larger boats), funding, and lack of awareness.

3. How to overcome barriers

The final group believed that funding (state allocations, fuel tax user fee, grants, volunteers, auto license plants, donations), more enforcement staff, each town contributes to enforcement, and research of impact and management solutions would be beneficial in terms of overcoming barriers.

Workshop Results

Stakeholder Response to Scientific Principles from Science Workshop

• Several workshop participants stressed that the capability of small motorized watercraft to access very shallow areas makes them different from small boats, and therefore they should be regulated accordingly.

• There was much disagreement on defining shallow water. Some participants felt that it must be expanded beyond 1 m depth to include fish and wildlife impacts in different areas. Most agreed that it would vary according to each waterbody. In Lake Tahoe, a standard distance from the shoreline was used because boaters did not know water depths.

Stakeholder Identified Data Gaps

Workshop participants repeatedly returned to data gaps and the need for more applied research on the topic. Data gaps identified by stakeholders include:

• Social science arena. The need to look at impacts on users of recreational areas and noise impacts on humans. Also, the need to review the National Park Service's visitor experience survey and conduct local visitor experience surveys.

• Natural science arena. The need to study submerged aquatic vegetation in New Jersey in terms of productivity and mapping. Determine the aerial distribution of SAV, identify potential SAV habitats, and identify historical distribution. Are groundings a problem? More data are needed.

Synthesis of Small Group Discussion

1. Environmental impacts of concern

The most common themes repeated in each group include impacts to submerged aquatic vegetation, turbidity/resuspension, impacts to fish and wildlife, contaminants, user conflict and noise. One group also pointed out that the impacts are going to vary according to the characteristics of the waterbody of concern (tidal/non-tidal, size, depth, species, etc.). During the plenary session, workshop participants requested the addition of invasive species to the list. There are concerns about watercraft transporting invasive species from one waterbody to another.

2. Barriers to addressing concerns

Nearly every group determined that education and enforcement have barriers. Politics or lack of political will, funding, and research needs were also common responses. In the plenary session, the group agreed that the lack of clear goals and differing values and perceptions are additional barriers that should be considered.

3. How to overcome barriers

Education, funding for management activities (like enforcement), and research were among the most common themes expressed by each group. In the plenary session, participants requested the consideration of citizen education groups as a solution to overcoming barriers. In addition, the group suggested that it is important to bring all parties together into the discussion and that adding a liability mechanism on watercraft users should be considered.

New Jersey Experiences

New Jersey stakeholders involved in small motorized watercraft issues include the NJ DEP CMP, Local Action Groups (Barnegat Bay), recreational and commercial fishers, the boating industry, federal management agencies (NOAA, National Park Service) and tourist/local recreational boaters along with other users of the coastal areas. The New Jersey coastline is one of the most densely populated and ecologically sensitive coastlines in the United States. There is an overall recognition in New Jersey, that there may be enough regulation, but there is not enough enforcement. There may be educational resources, but no funding to implement those programs.

It is important to note that New Jersey state legislation does not allow for governing bodies of municipalities to adopt resolutions or ordinances restricting the operation of small motorized watercraft, as geographic conditions dictate and the municipality or other subdivision may determine without state permission.

Some attempts to regulate usage of small motorized watercraft have been undertaken in New Jersey by state agencies. The Southern Natural Area Conservation Zone Proposal outlines a management agreement requested by the Division of Parks and Forestry and the Division of Fish and Wildlife from the Tidelands Resource Council that would include riparian (submerged lands and water) areas surrounding the Sedge Islands into the Southern Natural Area of Island Beach State Park. This jurisdiction is necessary for New Jersey because the tidal marsh ecosystem functions as one biological unit including creeks, ponds, ditches and the surrounding shallow water areas. Additionally, current state law does not permit anyone to establish management policies over water areas without a grant, license or management agreement from the Tidelands Resource Council.

The Island Beach State Park initiative could prove to be a model for coastal communities along the New Jersey coastline wherever the state has jurisdiction over public lands. When each community is provided with sufficient scientific data (see scientific appendix and research needs), and coastal decision making tools such as coastal Geographic Information Systems (GIS), communities can make wise use decisions in regard to buffer zones, complete bans and other types of conservation/varied use zones.

Next Steps for New Jersey

One major point that was noted during the workshops was that all areas need additional studies. It was evident from the presentations that most studies are being conducted elsewhere in the United States, and there is not a strong body of work for New Jersey concerning small-motorized watercraft usage.

A complete small boating and small motorized watercraft coastal use strategy, with special sensitivity to current protected areas, should be devised. This coastal management strategy could be designed through a task force that integrates leaders of current management areas and coastal user groups (citizens who live on the coast, recreational fishermen, scientists and New Jersey small motorized watercraft users). Prior to the development of this strategy, identification of critical ecological habitats with accompanying user conflict strategy would be necessary. The task force could be responsible for setting up planning sessions in coastal areas deemed "ecologically sensitive."

Preliminary assesment of ecological sensitivity of the New Jersey coastline to small motorized watercraft use can be evaluated through utilization of a Geographic Information System (GIS) for the New Jersey coastline in the coastal decision making process. This GIS mapping interface should be publicly accessible via the Internet and could be modelled after the one produced by the Florida Marine Research Institute (part of the Florida Fish and Wildlife Conservation Commission). According to the scientific workshops held at Rutgers in the fall of 2000, consideration should be given to marking sensitive areas (e.g. SAV beds) with tide staffs so boaters can determine water depth in particularly shallow areas. This is not legally possible in New Jersey, but an alternative would be to integrate this SAV information into GIS systems accessible by the public. Additionally, workshop participants noted that channels should be well marked to enable motorized boats to navigate in deeper areas of shallow water systems.

Detailed marina, boating statistics and other socio-economic information is necessary for management decisions regarding boating in New Jersey waters. This information information could be combined with benthic habitat information, physical oceanographic data and socio-economic data to create a robust New Jersey coastal GIS system. New Jersey DEP and Rutgers Remote Sensing and GIS Laboratory currently possess an excellent land-based GIS resources. Critical/sensitive habitat areas developed by Dr. Rick Lathrop at Rutgers University are part of the scientific characterization of Barnegat Bay. Future publicly accessible coastal GIS development could build upon the strong land-based foundation that New Jersey possesses.

A summary of available management tools for New Jersey include:

- Management
- Zoning
- Regulation
- Education
- Habitat Monitoring
- Usage Monitoring
- Enforcement

A combination of these tools, including more emphasis on putting resources toward research, education and enforcement should assist New Jersey in managing use in coastal waters.

Conclusions

Throughout the second workshop a number of management models were presented and discussed. Several key issues/concerns emerged. It was emphasized that enforcement needs to be empowered with the development of any future small motorized watercraft management strategy. There must be a connection between the legislation and budget - it is recognized that funding can be difficult to obtain, but that it needs to be attached to any legislation. Additionally, state versus local control should be addressed and control divided to promote highest efficiency of regulation and enforcement.

During a follow-up phone enforcement interview, Lt. Pete Matonis, of the New Jersey State Police, provided insights on the needs of the enforcement community in response to any small motorized watercraft regulation. These responses could be useful in the design of an enforcement strategy that would accompany innovative New Jersey small motorized watercraft management strategies. Lt. Matonis stated that we need to consider how boaters would be made aware of protected areas/conservation zones. He stated that it would be necessary to mark out the areas, in addition to marking them on maps. A process for this mapping would have to be outlined. It would also be necessary to determine if these markers would be evident to boaters from outside the area (i.e., from other local jurisdictions or out-of-state summer visitors).

Another factor to consider would be discrepancies between state and local regulations. About 98% of marine law enforcement is conducted by the state, but laws can differ locally (e.g., by township). It would be necessary to determine how officers would keep track of the changing regulations as they cross political boundaries during patrols. Additional enforcement support on the local level (county, township, other) would make effective enforcement more realistic. There is the additional need to provide more staff to enforce small motorized watercraft regulations. This is necessary because an insufficient staff will result in some areas receiving little (once a day) or no enforcement presence during the course of a day. Enforcement requests are addressed in the priority of safety (accidents, medical attention, and tows) first, and environmental/social impacts and nuisance second. As an example, if three boats are patrolling Barnegat Bay, and one is responding to an accident and another the towing of a disabled boat, one boat will then attend to enforcement for the entire Bay.

Education efforts also need to be increased in response to additional small motorized watercraft regulations in order to make boaters aware of the regulations, and the potential impacts of their boating activities on the environment. New boaters attend a mandatory safety course, but existing boaters who have already completed the course must also be made aware of new regulations and information. Efforts could be made to include more information in the current educational efforts on the potential environmental impacts of irresponsible boating. Finally, Lt. Matonis indicated that any new regulations would only be as effective as the amount of enforcement staff available, and that more effort should be focused on effective preventative education. It is important to note that the State Police will be acquiring 1-2 fan boats in the near future which would allow officers to access very shallow waters otherwise inaccessible to patrol.

Additionally, coastal benthic information is necessary for the development of any small motorized watercraft management strategy. Then, policy makers can make informed decisions about whether or not regulations should take this into account. In developing zoning, consider that shallow vs. narrow areas can affect the type and extent of impacts. New Jersey must develop a standard set of definitions for watercraft types and slow speed used in Florida which is based on Coast Guard's and NASBLA's definitions.

A series of next steps can be refined from the bounty of information and experiences shared at these workshops. First, more research on the effects of small watercraft use on the New Jersey coastal areas is needed. This research should include research gaps identified in the Science Workshop Report along with socio-economic research regarding the use of small motorized boats in New Jersey waters. Second, benthic habitat mapping is needed for the entire New Jersey coastline. This mapping should include submerged aquatic vegetation information, bathymetry, bottom characterization, aids to navigation and any jurisdictional boundaries such as National Parks or other protected areas. Socio-economic information including accurate mapping of marina/ports and current recreational boating statistics would be a highly useful addition to the habitat mapping discussed above. Social research inclusive of user surveys and perceptions of small motorized watercraft, in New Jersey would be a necessary compliment to the above coastal characterization and would be highly useful in creating policy that truly reflects the needs of New Jersey constituents.

These maps could be used to create zoning scenarios based on the scientific reality of habitat conditions in combination with important socio-economic indicators. The big picture message gleaned from these workshops was that small motorized watercraft , including PWC management must be part of a bigger picture management strategy that addresses other motorized boating interests as well as other uses of coastal areas.

Up until this point, mandatory education has focused on safety. During and after the creation of habitat mapping and then regulatory measures, New Jersey needs to do more public education concerning impacts on sensitive habitats and wildlife (Barnegat Bay Task Force has done a great deal to forward this issue). Additionally, a media campaign could be useful for the seasonal/tourist audience that uses rentals associated with marinas (Lake Tahoe speaker reported having success with festivals using "the Beach Boys" to promote responsible use of small watercraft). A "Beach Keeper" program could also be valuable in getting the community to participate in enforcement (following Lake Keepers program model in Lake Tahoe or the Team Ocean model.) We may promote social science research to better understand audiences using bay resources. We could utilize signage in sensitive habitats that respond to tidal influence - "When the water is this high - you should not operate a jet-ski in this area."

These suggestions combine some of the relevant advice and lessons learned from the two workshops. The format of these workshops highlighted the synergistic way that science institutions, policy makers and public user groups can work together to evaluate necessary information and produce action items to move quality policy forward. Additionally, these workshops were effective as a forum for variant user groups to come together and share information concerning a policy issue that has been heatedly addressed numerous times in other state and local governments. Therefore, we have been able to look at other models of policymaking concerning this topic and can now build upon those foundations to find the best solutions for the sustainable use of the New Jersey coast.

Addendum B

PWC Statistics, Number of States that:

• Require operators and passengers to wear PFDs	52	NJ-Yes
• Set a minimum age for PWC operation	51	NJ-16
• Prohibit use at certain times of day or restricted visibility	50	NJ-Sunset to Sunrise
• Impose limitations on wake jumping	44	NJ-Cannot jump another vessels wake within 100 ft of that vessel
• Require the use of a “kill switch”	42	NJ-Yes
• Prohibit operation in specific areas	38	NJ-Rental PWC must stay within marked boundaries
• Require adults on board when minors operate	32	NJ-No
• Require PWC education for renters	26	NJ-Yes
• Mandatory education for PWC operators	25	NJ-Yes for all users
• Set specific speed limitations	12	NJ-No