A REVIEW OF PERSONAL WATERCRAFT AND THEIR POTENTIAL IMPACT ON THE NATURAL RESOURCES OF EVERGLADES NATIONAL PARK

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OBJECTIVES

The major objectives of this review are:

1. To provide background information on the use and regulation of personal watercraft;

2. To familiarize management with the **potential** environmental disruptions associated with the use of personal watercraft.

3. To provide an overview and evaluation of the **potential** effects of these disruptions on wildlife behavior, habitat, and populations.

4. To present a general description of possible approaches to minimize negative effects.

"Environmental disruption" is defined for the purpose of this review as a human-caused modification of the environment associated with the use of personal watercraft that may ultimately result in adverse effects on wildlife. It includes changes of a physical nature, and changes in the level or type of wildlife activities in an area.

A disruption represents the mechanism through which wildlife is affected. An "environmental disruption" is the common denominator allowing comparison between various use activities (e.g. personal watercraft, motorboats, aircraft, etc.). This approach and much of the material herein is modified from Bromley (1985) Wildlife Management Implications of Petroleum Exploration and Development in Wildland Environments. General Technical Report INT-191. Ogden, UT: USDA.

"Personal watercraft" for the purpose of this review is defined as any jet-driven craft that the operator stands, sits, or kneels on, not in. This is the definition adopted by the Personal Watercraft Industry Association (PWIA), an affiliate of the National Marine Manufacturing Association (NMMA).

RECOMMENDATIONS

I. A NPServicewide prohibition on the use of personal watercraft should be proposed for inclusion in 36 CFR, similar to that for waterskiing (3.20), and for similar reasons. Suggested wording:

(a) The operation of water jet-driven craft where the operator stands, sits, or kneels on or behind the vessel, as opposed to inside; known as "personal watercraft" and by various tradenames such as "Jet Ski"; is prohibited, except in designated waters.

(b) Where operation is authorized, the following are prohibited:

(1) Operating between the hours of sunset and sunrise.

(2) Operating without wearing a personal flotation device.

(3) Renting to persons under 15 years of age.

(4) Operation by persons under 15 years of age without the direct supervision of a parent or guardian.

II. The prohibition of personal watercraft use in Everglades National Park under the above proposed regulation would appear warranted, based on (a) conflicts with traditional uses and the park's primary purpose, (b) concern over boating safety, and (c) potential adverse impacts to wildlife and other natural resources.

CONFLICTS

National Park Service and Everglades National Park legislative history provides for protection of wildlife from incompatible recreational uses. The use of personal watercraft in Everglades National Park appears inconsistent and interferes with the park's primary purpose "as a wilderness, (where) no development...or plan for the entertainment of visitors shall be undertaken which will interfere with the preservation intact of the unique flora and fauna of the essential primitive natural conditions...". It is not apparent that the use of personal watercraft within the park serves to preserve or restore these natural resources.

In general, the use of personal watercraft is not dependent on park resources. Excluding the park, there are many areas in South Florida that appear to meet the requirements of users.

The exception made for motorboat use in Everglades National Park's wilderness designation is structured for the continued allowance of traditional activities such as fishing and sight-seeing. Reference is made to the expanse of park waters and the need to use motorized craft to properly experience the park. These activities are not generally

supported by personal watercraft. No mention is made of needing an exception to allow for waterskiing or related types of use, e.g. personal watercraft.

SAFETY

The number of accidents with personal watercraft appears to be increasing. Their limited visibility, high rates of speed, high maneuverability, instability at slower speeds, frequent use by careless or inexperienced operators, and the tendency to run multiple unpredictable circuits makes their use incompatible with the safe operation of other watercraft in limited waters such as narrow channels or in congested areas such as around marinas.

WILDLIFE

Allowing the use of personal watercraft and afterward determining whether that use is harmful to natural resources should not be permitted. The determination must be made first, if at all.

Section 7 of the Endangered Species Act allows for the prohibition of activities that are <u>perceived</u> as having adverse impacts on listed or proposed species, until such time as studies determine otherwise. This would appear to apply to Everglades National Park.

The environmental disruptions of noise, human intrusion and traffic, alteration of vegetation and soil, and harmful substances associated with the use of personal watercraft are expected to be locally concentrated, producing effects that are more geographically limited yet potentially more severe than conventional motorboat use. This would be due to repeated disruptions and an accumulation of impacts in a shorter period of time.

The potential primary impacts of these environmental disruptions include: interruption of activity/alarm/and flight; avoidance and displacement; permanent loss of habitat use; decreased reproductive success; interference with movement; direct mortality; interference with courtship; alteration of behavior; change in community structure; and nest abandonment.

III. However, the types of environmental disruptions and potential effects associated with both personal watercraft and conventional motorboats are similar. Therefore, it seems inappropriate to prohibit personal watercraft use without also committing to the complete review of the impacts of conventional motorboats on the natural resources of Everglades National Park, and the adoption of appropriate restrictions on their use.

An example of an appropriate restriction would seem to be one directed towards the protection of sea grass beds from unnecessary disturbance. The following wording is suggested for inclusion in the Superintendent's Compendium:

"In those areas of the park where motorized vessels are permitted, operation

in a manner which causes damage to submerged vegetation is prohibited."

METHODS AND ORGANIZATION OF THIS REVIEW

This review includes personal observations and numerous communications with personnel of the National Park Service, Fish and Wildlife Service, Environmental Protection Agency, Coast Guard, National Marine Manufacturing Association, Personal Watercraft Industry Association, Society of Automotive Engineering, Kawasaki Motor Corp., Florida Marine Patrol, International Jet Ski Boating Association, state and local government officials, and local personal watercraft dealers and service departments (see Appendix F).

A computer search of the current literature using Wildlife Review Data Base, revealed a shortage of information specific to the impacts of personal watercraft. Approximately 235 citations were retrieved reporting on the effects of recreational activities on wildlife. The search results are on file at the Resources Management Office of Everglades National Park.

By necessity this review represents a synthesis of information from a wide variety of species, geographical locations, and a number of resource uses that appear to generate similar environmental disruptions (e.g. motor boats, personal watercraft, aircraft, etc.).

Legitimate concern exists over the validity of generalizing or extrapolating from one situation or species to another. Local observation, site and species specific study may be necessary to provide more definitive conclusions concerning the effects on natural resources.

USE AND REGULATION OF PERSONAL WATERCRAFT

The regulation of personal watercraft is a controversial topic at some local, state, and national levels. Some states still do not know how to categorize these water vehicles, while others are trying to close down waterways to the craft.

These personal watercraft come in an incredible variety of styles including stand-up, sit-down, and mini-boat styles. As indicated above the majority of these craft are sat, stood or knelt-on by the operator rather than inside it. In some cases the operator rides behind the vessel. Personal watercraft are generally designed for one and sometimes two passengers.

They are variously referred to by both generic names, specific trade names, and trade names applied generically, including: personal water vehicles, personal watercraft, water vehicles, water scooters, mini-boats, pocket yachts, Jet Skis, WaveRunners, WaveJammers, Wet Jets, Wetbikes, Fastracs, Fazers, Fun Boats, and Surf-Jets (see Appendix A). Note that Jet Ski, the most commonly used name for these vessels, is a registered trade name of Kawasaki Motors Corp.

First introduced in the U.S. in 1974 approximately 30,000 to 40,000 personal watercraft are now sold each year. It is anticipated that this will expand to over 100,000 units annually in 5 years. Eight manufacturers represent approximately 95% of the sales of personal watercraft. Industry officials estimate there are 500,000 personal watercraft in the U.S., many owned by rental operators.

The industry is represented by the Personal Watercraft Industry Association (PWIA), RM. 1150, 401 N. Michigan AVe., Chicago, IL 60611. They are under the umbrella of the NMMA and are primarily concerned with responsible operation through education and promotion of the product. The PWIA has produced a pamphlet, Fun with Safety on Your Personal Watercraft, to help users understand their responsibility as boaters (see Appendix B). The Personal Watercraft Committee (PWC) of the Society of Automobile Engineers (SAE) is concerned with developing industry standards for safe design, construction, and operation. Users are organized at the local level by clubs and at the national/international level by International Jet Ski Boating Association, Inc. (IJSBA) 1239 E. Warner Ave., Santa Ana, CA 92705. The IJSBA is primarily oriented towards competition.

In addition to general recreational use by owners and renters, there is a well organized statewide, national, and international racing circuit which includes Florida and the Keys. Informal competition for trophies and prize money is also organized at the local level. Personal water vehicle endurance records have been set for Australia's 1800 mile east coast and the shores of the Great Lakes from Duluth to New York City.

Several magazines are on the newsstand including Water Scooter: The Flagship Magazine of Personal Water Vehicles; Splash: The Complete Personal Watercraft Magazine; and Personal Watercraft Illustrated.

Most states currently categorize personal watercraft (PW) as "motorboats" or "watercraft under 16 feet long". All states require PW to be registered. PW in Florida are recognized and regulated as a Class A vessel, specifically as Class A-1, 12 feet or less.

PW must carry a US Coast Guard approved B-1 fire extinguisher and operator must carry a US Coast Guard approved PFD. PW must abide by the states "Rules of the Road". In addition the industry recommends operators always wear a PFD, eye wear and other appropriate safety apparel such as helmets, wet suits, gloves and foot wear. Personal watercraft users in units of the National Park System are regulated under 36 CFR in the same manner as other watercraft of the same classification, unless park specific regulations are adopted.

In an effort to police itself the industry recommends users' ride responsibly, never ride under the influence of drugs or alcohol, ride in authorized areas only, and respect the rights of shoreline residents and other marine recreationists. Recent editorials, newspaper articles, and advertisements indicate PW users and their publications are concerned with maintaining access to waters (see Appendix B).

PW are mostly powered by 2-stroke Single or Twin water cooled inboard engines, propelled by a jet pump and shielded water-jet impeller. They are usually about eight feet long. Factory engine displacement ranges from 294cc to 634cc. Fuel capacity is 3 to 9 gallons. While speeds of over 40mph are possible on factory PW, 30 mph is more common. Speed enhancements and other modifications by users are common. A large secondary industry exists to support these needs. A few PW use outboard or inboard engines and propellers. The draft on most PWVs ranges from 4" to 9". PWVs range in price from $2000 to $4900 (see Appendix A).

Some personal watercraft require very little skill to operate properly. Most, however, require varying degrees of athletic skill and some type of learning curve to operate properly.

According to the Florida Marine Patrol there are 644,807 registered pleasure vessels in the state. There are 55,466 pleasure craft registered statewide in the A-1 Class of 12 feet or less. This figure includes PWVs and any other boat meeting the class definition and the requirements of registration. Class A-1 pleasure vessels statewide represent 9% of all registered pleasure craft. Together Class A-2 (12' to 16') and Class I (16' to 25') pleasure vessels statewide represent 83% of all registered pleasure craft. The 6791 registered Class A-1 pleasure craft in Collier, Dade, and Monroe Counties represent 1% of all registered pleasure craft in the state.

A significant concern of recreation managers is that while the machine is classed and regulated as a boat, and recognized by industry as a high performance machine, they are used as toys by their owners or renters with no knowledge of the rules of the road or seamanship.

Safe operation of personal watercraft is a growing concern. Statistical data on accidents with personal watercraft are not readily available. The US Coast Guard accident report form does not isolate PW from conventional craft.

Kawasaki Motor Corp. reported 330 accidents in 1987 involving their machines, up from 115 in 1983, which probably reflects their growing popularity. Seven deaths have been reported since 1983. It is estimated that only about 10% of non-fatal personal

watercraft accidents are reported (see Appendix B).

Most injuries occur in collisions between PW and other craft, run-overs by PW of people in the water, "crash-downs" where the operator leaves the vessel and then falls down on it, falling off at high speed, running aground, and striking objects in the water. Operator carelessness and inexperience are most often cited as the causes of PW accidents.

There are no records kept of PW use in Everglades National Park. Personal observation and recollection by Key Largo District Personnel indicates a **very low use level on park waters, possibly one or two observations a month**. Case incidents for 1987 and 1988 were searched for reports related to personal watercraft and none were found.

Areas where district personnel recall PW as being observed are Blackwater Sound, the Boggies (one PW on plane was stopped in the "no wake" zone), the vicinity of Crane Key and East Key, the Cowpens area just outside the park, once at North Nest Key, and on the Intercoastal Waterway.

Communication with PW users and local dealers indicate the Florida Keys and Hobe Beach, Miami (the farside of Rickenbaker Causeway) are popular use areas. Gilbert's Marina, Key Largo, is an area frequented by personal watercraft and club sponsored events (see Appendix B). Personal watercraft can be rented at Gilbert's and numerous other locations in South Florida and the Florida Keys.

Personal watercraft have occasionally been seen in the boat basin at Everglades City. But, again no records of PW use have been kept. The Key Largo District was asked to keep an informal log of PW contacts and observations.

SUMMARY OF POTENTIAL ENVIRONMENTAL DISRUPTIONS

Four types of environmental disruptions are associated with the use of personal watercraft. They are noise, human intrusion, alteration of vegetation, and emissions of harmful substances. To a large extent these disruptions and their related impacts are shared by both personal watercraft and conventional motorboats, and to a lesser extent aircraft.

Studies specific to the impacts associated with personal watercraft are not available.

An important difference is that personal watercraft most commonly make repeated passes in a localized area, similar to motorboats towing water skiers, and unlike destination pleasure craft or sport fishermen. Because personal watercraft are highly maneuverable, they run circuits that are constantly changing and therefore often unpredictable.

Another dissimilar characteristic between personal watercraft users and conventional craft is the habit of traveling in groups of two to five vehicles and occasionally fifteen or more.

In general, personal watercraft can travel faster, when closer to shore, than conventional boats in the same water. However, it should be noted that the continuing development of shallow draft motorboats appears to be eliminating some of the differences between motorboats and personal watercraft.

A. NOISE

Personal watercraft are perceived as noisy, and because they are often operated close to shore, the vehicles are often considered a nuisance. Their noise has been compared to that of "dirt-bikes". The editor of Personal Watercraft Illustrated blames noise for increasing restrictions on their use and writes that "exhaust systems that sound tinny and give off abusive noise must be stopped". The PW industry recognizes noise as their number one problem, and the base for most complaints.

The "tinny" sound reported above would indicate different frequency components compared to conventional craft. This may be one reason why PW are perceived as more annoying than conventional pleasure craft. No data on frequency components were available.

Resource and recreation managers generally agree that on open water conventual motor boats are "noisier" than personal watercraft, but because of where and how PW are used, they are perceived as louder. That is PWs can travel faster when closer to shore than conventional boats in the same waters.

Roger Hagie of Kawasaki Motors reports that their vehicles and most PW generate sound levels of 76-81 dB at 50 feet when conducting a standard SAE single pass-

by full-throttle test (see SAE J34). Hagie believes this meets most state standards. Hagie also considers these levels to be on par with most conventional pleasure craft.

However, Hagie and many states recognize this single pass measure as an inadequate measure of personal watercraft noise, as it does not measure or describe the cumulative effects of numerous passes over a specified time period. This is important as personal watercraft most commonly make repeated high speed passes in a localized area similar to motor boats towing water skiers, and unlike destination pleasure craft or sport fishermen.

Another dissimilar characteristic between PW users and conventional craft is the habit of traveling in groups of 2 to 5 vehicles and occasionally 15 or more, referred to as "wolf packs".

The literature supports the notion that most physiological systems can be influenced by noise. Numerous behavioral studies have documented a startle response in wildlife. The accompanying physiological response to noise has not been well studied in the field. The noise associated with personal watercraft use may be more significant than that generated by conventional motorboat use because of their repeated operation in a localized area.

Adverse impacts to be considered include the interruption of activity, alarm and flight; avoidance and displacement; interference with movement and predator-prey relationships; and interference with courtship. Species potentially at risk include the park's nesting raptors; the rookeries of wading birds, diving birds, gulls and terns; and manatee aggregations. Staging migratory birds may also be at risk.

Noise and the physical intrusion (flooding from wakes) of personal watercraft are implicated in declining production of Western Grebes, Pied-billed Grebes, Coots, and Moorhens on the backwaters of Imperial National Wildlife Refuge. Repeated passes resulted in constant flushing and the flooding of nests from wakes. Nesting attempts continued but success dropped to zero for Western Grebe and declined for the other species.

Fishing success was observed to drop to zero when personal watercraft used the same waters. Recovery time was reported to be 1-2 hours after personal watercraft left the area. The potential effects of noise on Florida flats fishing, marine mammals, and fish in general have been noted recently (see Appendix B).

The noise and physical intrusion from the repeated use of a limited water area by powerboats of unlimited size was noted as probably responsible for a decline in waterfowl production and a decline in wildlife diversity at Ruby Lake National Wildlife Refuge. Rather constant disturbance from powerboats, especially those towing water skiers, caused repeated separation of hens from ducklings, forcing broods out of brooding areas and increasing their vulnerability to predators in her absence. Noise and physical intrusion are thought responsible for reducing the reproductive success of late nesting and re-nesting hens.

B. HUMAN INTRUSION/TRAFFIC

The potential adverse impacts associated with human intrusion and personal watercraft "traffic" which should be considered are: interruption of activity, alarm, and flight; avoidance and displacement; permanent loss of habitat; decreased reproductive success; interference with movement; direct mortality; interference with courtship; and alteration of behavior.

As with conventional motorboat use, collisions between personal watercraft and marine wildlife are possible. Motorboat collisions with marine wildlife are well documented. Only one record of an accident between wildlife, a whale, and a personal watercraft could be found. However, it is estimated that less than 10% of all personal watercraft accidents are reported, including collisions with wildlife.

Some resource managers observe that collisions between wildlife and personal watercraft are more likely because of the operators limited visibility. The machines are highly maneuverable and thought to be more confusing to fleeing wildlife than conventional motorboat use.

Personal watercraft users are observed to get carried away running a circuit, jumping wakes, and forgetting to pay attention to their surroundings resulting in potential harm to wildlife or themselves. Species at risk in Everglades N.P. would include sea turtles, alligators, crocodiles, and manatees.

Wakes generated by personal watercraft may result in bank or shoreline erosion similar to that of conventional motorboats, and possibly more severe. An increase in severity would be the result of the personal watercraft being able to run at higher rates of speed while closer to shore.

Erosion from motorboats is well documented but information is unavailable for personal watercraft. Again, the repeated use of a limited area by personal watercraft, not unlike motorboat use of Buttonwood Canal or certain creeks and passes, must also be considered.

Wakes may also flood shore nesting birds. Equipment can be purchased and installed on personal watercraft which increases the height and amount of spray ("rooster-tails") generated, adding to the disruptions from noise, visual stimuli, and wakes.

C. ALTERATION OF VEGETATION AND SOIL

The physical forces associated with boating activity include wash, turbulence, propeller action (cutting effects), and direct contact. These forces all interact and their relative importance varies according to habitat, size of the water body, time of year, and direction of travel. Information on the physical forces associated with personal watercraft were not available.

The primary impacts associated with an alteration of vegetation/soil which should be considered are: permanent loss of habitat; and a change in community structure.

The mechanical cutting action of motorboat propellers on aquatic vegetation and increased turbidity caused by turbulence has been reported to decrease vegetative productivity at Ruby Lake NWR, and is suspected in other study areas.

Prop scaring is well documented on the seagrass beds of Everglades N.P. Personal watercraft are not capable of prop scaring as most have a shielded impeller. Limited personal observation and communication with resource managers indicates very little damage to seagrasses and other bottom vegetation attributable to personal watercraft.

Personal watercraft are capable of damaging or removing emergent vegetation. This has been documented as a result of conventional motorboat use. Damage to emergent vegetation from personal watercraft use is considered more likely and possibly more severe given their ability to run faster while closer to shore than conventional motorboats.

Personal watercraft do increase turbidity and probably redistribute benthic invertebrates, as do motorboats. However, these impacts may be prolonged as a result of repeated use by multiple machines in a limited area.

Researchers have reviewed the effects of recreation on freshwater plants and animals. They note that the power to drive a boat is dissipated in the surrounding water and in turn is directed to lake beds and banks. Under certain circumstances this can cause severe erosion. The energy transmitted by a water vehicle's wash depends on the speed and power of the vehicle, the shape of its hull and its displacement.

In a study of the creation of wash by pleasure craft the British Transport Docks Board noted that transom sterns will create large transverse waves when the boat is over-powered or run at high speeds. Tunnel sterns enclosing a propeller driven from an inboard engine cause less wash.

The wash from boats can cause considerable erosion to plants. Wash is thought responsible for damage to reed beds when boats enter gaps and turn close to the plants.

Personal watercraft are thought to generate less wash than conventional watercraft. However, because of their ability to run in shallow water closer to shore at higher speeds, the wash they do generate may transfer more energy to banks and shoreline vegetation than conventional craft running farther out. Managers have expressed concern over the potential for personal watercraft to erode the soil from around mangrove seedlings.

In 1972 Frank Craighead reported that the wash of boats at low tide tears out the mud binder among the shell substrate and loosens prop roots of mangroves in Everglades National Park. He observed many mangrove islands disappearing along the much travelled canals and the Intracoastal Waterway.

Motorboats and personal watercraft create turbulence in the water. Increases in turbidity have been reported as a result of recreational boating and observed for personal watercraft by several recreation and resource managers. It is possible that increases in

localized turbidity as a result of personal watercraft use may be significant because of their habit of running multiple circuits in the same area.

The impacts of increased turbidity are not clear. Some researchers have found no recordable increase in turbidity due to the effects of outboard motors in experimental ponds, although there was movement of bottom sediments. They also noted redistribution of benthic invertebrates, but not damage. Others noted no strong correlation between turbidity and boat use, but felt opacity was due to phytoplankton.

Propellers have been observed to remove about 10cm from the top of the submergent Myriophyllum spicatum. Research has found that an outboard motorboat driven through a patch of Nuphar lutea will cut through the petioles and prolonged use of an outboard motor boat, operating in 75cm of freshwater, with the propeller 35cm from the bottom, removed all plants from a path 1.5m wide and that silt had been washed to the sides of the path leaving sand and gravel in the center.

Observers have reported on the effectiveness of motorboat propellers in cutting swaths through seagrass beds on the mud flats of Florida Bay. Personal observation and aerial photographs show this impact as common in certain areas. Attempts have been made to investigate the persistence of these cuts, but the results are not conclusive.

Most personal watercraft have shielded impellers and are not capable of the cutting impacts as described above. Resource and recreation managers interviewed report very little damage to vegetation by personal watercraft while in operation. Running in shallow water where engine damaging sand and vegetation might be sucked through the jet pump is not recommended by watercraft mechanics and generally avoided by knowledgeable users.

The impacts to marginal and bank vegetation by direct contact with boats have been reported by several investigators. Shallow-rooted species at the mouths of creeks and on gravel bars in the Ozarks have been disrupted or locally eliminated by the launching and beaching of boats. Personal watercraft have the potential for similar impacts, particularly given the habit of running close to shore at high speeds. Also, their use typically involves multiple launching and beaching from the same beach location.

D. HARMFUL SUBSTANCES

The primary impacts associated with harmful substances, which include spills and emissions, are: permanent loss of habitat; and direct mortality.

No information on emissions specific to personal watercraft was available. It is assumed that emissions from personal watercraft would be similar to those of outboard motors. Studies indicate that a substantial amount of unburned fuel may enter the water, but it rapidly becomes dispersed through the mixing action of propellers.

There is little quantitative information on what substances actually appear in the aquatic environment during the operation of outboard motors. It is suggested that

water vapor, carbon oxides, nitrogen and sulfur are emitted from the combustion chamber, and lead compounds in the unburned fuel and partial oxidation products are discharged below the water surface.

A water quality study on the Northwest coast of Florida estimated a discharge of both volatile and nonvolatile oil to be 6 grams per liter of fuel consumed per boat. It has been estimated that the total discharge of hydrocarbons from one outboard engine, running for one day, would be equivalent to the waste material (sewage) produced by a population of 400 people. These emission rates are generally reported as insignificant.

However, no conclusive data were available on the direct effects of outboard motor emissions on wildlife.

SUMMARY OF POTENTIAL EFFECTS FROM ENVIRONMENTAL DISRUPTIONS

Tables 1 and 2 summarize the primary and secondary impacts potentially resulting from the environmental disruptions associated with the use of personal watercraft. The existence and severity of an effect is site-specific and depends on such factors as the sensitivity of the species involved, the nature of the disruption, characteristics and importance of the affected habitat, and the availability and condition of alternative undisturbed habitat.

There were no studies available specific to personal watercraft. The reviews of the potential effects on natural resources resulting from motorboat use were provocative, suggesting the need for further study, yet generally inconclusive in part for the reasons stated above.

TABLE 1. Primary impacts potentially resulting from environmental disruptions associated with the use of personal watercraft.

	ENVIRONMENTAL DISRUPTION			
PRIMARY IMPACT	Noise	Human intrusion/ traffic	Alteration of vegetation/ soil	Harmful substances
Interruption of activity/ alarm/flight	X	X		
Avoidance/displacement	X	X		
Permanent loss of habitat use		X	X	X
Decreased reproductive success		X		
Interference with movement	X	X		
Direct Mortality		X		X
Interference with courtship	X	X		
Alteration of behavior	X	X		
Change in community structure			X	
Nest/den abandonment	X	X	X	X

TABLE 2. Secondary impacts which may occur as consequences of primary impacts.

SECONDARY IMPACT	PRIMARY IMPACTS: Interruption of activity/alarm/ flight	Avoidance/ displacement	Permanent loss of habitat	Decreased reproductive success	Interference with movement
Decreased use/temporary desertion of traditional areas		X			
Shift in range		X			
Change in distribution		X			
Overutilization/ove-population of adjacent habitat		X	X		
Use of marginal habitat		X			
Gradual range abandonment		X			X
Inefficient use of habitat	X	X	X		X
Mortality		X			
Reduced feeding efficiency	X	X			
Change in activity patterns	X	X			
Interference with/alteration of movements		X			
Decreased availability/ elimination of food source			X		
Inadequate nutrition					X
Insufficient energy reserves for migration					X
Reduction in numbers			X		
Adverse physiological effects	X		X		X
Disruption of social structure and group composition		X			X
Reduced reproductive potential/success	X		X		X
Nest desertion		X			
Decrease in nest density/ sites			X		
Delay/failure to den/nest					X
Nest/den displacement		X			
Decreased survival/loss of young			X		X
Increased use of alternate nests		X			
Decrease in aquatic productivity			X		
Human injury/property damage					
Delay/failure to reach traditional range					X
Ease of travel					X
Increased vulnerability to predators					X
Interference with mating synchrony					X

TABLE 2. Secondary impacts which may occur as consequences of primary impacts (cont.).

	PRIMARY IMPACTS				
SECONDARY IMPACT	Direct mortality	Nest/den abandonment	Interference with courtship	Change in community structure	Alteration of behavior
Decreased use/temporary desertion of traditional areas					
Shift in range					
Change in distribution					
Overutilization/ove-population of adjacent habitat					
Use of marginal habitat					
Gradual range abandonment					
Inefficient use of habitat					
Mortality			X		
Reduced feeding efficiency					
Change in activity patterns					
Interference with/alteration of movements					
Decreased availability/ elimination of food source	X				
Inadequate nutrition					
Insufficient energy reserves for migration					
Reduction in numbers					
Adverse physiological effects					
Disruption of social structure and group composition					
Reduced reproductive potential/success					
Nest desertion					
Decrease in nest density/ sites					
Delay/failure to den/nest					
Nest/den displacement					
Decreased survival/loss of young					
Increased use of alternate nests					
Decrease in aquatic productivity					
Human injury/property damage					X
Delay/failure to reach traditional range					
Ease of travel					
Increased vulnerability to predators					
Interference with mating synchrony					

ENERGETICS OF DISTURBANCE

Environmental disruptions associated with the use of personal watercraft, motorboats, aircraft, etc., may have an additional subtle but important effect on wildlife often overlooked by resource managers. Any changes in an animal's "normal" routine will have some effect on the energy and nutrient budgets of the individual. The biological significance of these effects depends on the type and amount of costs incurred.

Adverse effects of environmental disruptions (such as flight, avoidance, or interference with movement) raises the energy cost of living at the expense of energy needed for reproduction and growth. This increased cost results from:

1. The cost of physiological excitement preparing the animal for exertion.

2. The cost of locomotion incurred when an animal attempts to escape a disruption, is forced to deviate from traditional migration routes, etc.

3. The cost of lost food intake.

4. The cost of suboptimal habitat selection.

If an animal is unable to compensate for such increases in its cost of living, reproduction, growth, and survival may be adversely affected. The costs from environmental disruptions associated with personal watercraft use and recreational boating are unknown.

APPROACHES FOR MINIMIZING NEGATIVE EFFECTS

Most existing use restrictions directed at personal watercraft are applied to all motorized craft, e.g. no wake zones, horsepower limitations, seasonal limitations, motorless areas. Some areas have restricted, or are proposing to restrict, the use of personal watercraft to certain bays or coves to segregate perceived incompatible uses e.g. fishing, canoeing, shoreline camping. Others have restricted direction of travel and "stunts", for reasons of boating safety.

A. INDIRECT TECHNIQUES

1. RESOURCE ALTERATIONS

a. Habituation

The behavior of some animals is influenced by their ability to learn. Habituation to humans allows wildlife to efficiently use habitat near human recreational activity, without expending large amounts of energy in physiological stress and fear responses.

Habituation ability varies among wildlife species and is influenced by the species' learning ability, perceptive abilities, and sensitivity threshold, and by the type of stimulus.

Three types of harassing stimuli might be (1) those that are not familiar or predictable, (2) those involving sharp contrasts or sudden changes in the environment, for example, quick movements, sudden loud noises, and (3) those to which an animal responds innately with alarm, such as a close and direct approach which might be associated with predators.

Habituation by wildlife to human recreational activities, if desirable, might be able to be encouraged by (1) avoiding or minimizing fear-provoking stimuli such as direct approaches, stalking, loud noises, quick movements, etc. during human-wildlife encounters, (2) controlling the time, frequency, and intensity of human activities to make them more regular, and therefore more predictable, and (3) minimizing the frequency and intensity of human-wildlife encounters during times when wildlife are particularly sensitive to disturbance.

The habituation ability of wildlife to personal watercraft use is unknown.

2. INFORMATION DISPERSAL

The personal watercraft industry is investing considerable time and money in encouraging users to ride their vehicles responsibly and safely. A video tape on the subject intended for clubs and dealers is available from Yamaha, and examples of

pamphlets are in Appendix B. The Personal Watercraft Industry Association is working on materials directed at rental operations.

3. ELIGIBILITY REQUIREMENTS

Several states require the personal watercraft operator be of a certain age and/or have a boating certificate from an approved course of instruction (Appendix C). Kawasaki Motors Corp. recommends that any personal watercraft operator have a valid motor vehicle operator's license, as an indicator of maturity, judgement, and responsibility. The Florida Marine Patrol is proposing that operators under the age of 15 be under direct parental supervision, and that rental to persons under the age of 15 be prohibited.

B. DIRECT TECHNIQUES

1. INCREASED ENFORCEMENT

After adopting "no wake" zones in the Imperial National Wildlife Refuge, managers rigorously enforced them with citations. They believe this to be very effective, although difficult to do, in restricting the use of personal watercraft.

The Florida Marine Patrol is entertaining the need to tighten up their definitions of reckless operation so it will be clearer when enforcement actions on personal watercraft users are needed. They also note that a $35 ticket for running mud flats is no where near the deterrent that a $600 repair bill is resulting from running grit through the pump.

2. ZONING

a. Spatial management

Limiting where personal watercraft may be used appears to be an increasingly popular management technique. The State of New Hampshire did this on a statewide basis approving their use on only one lake. The State of Hawaii limits their use to certain areas including a certain maximum distance from shore. Lake Mead National Recreation Area is contemplating regulations restricting personal watercraft use to certain bays or coves. This in an effort to segregate incompatible uses e.g. fishing, beach camping, etc. The Florida Marine Patrol considered prohibiting their use in the main channel of the Intercoastal Waterway.

b. Temporal management

Limiting recreational use to certain times of the year is a management technique Everglades National Park applies to all boating for the protection of certain bird rookeries.

Ruby Lake National Wildlife Refuge responded to resource damage from recreational boating by adopting restrictions on motor size (10 hp or less) during part of the year, and allowing only motorless boats or boats with electric motors during the rest of the year. This occurred after the Defenders of Wildlife sued contending that boating regulations violated the Refuge Recreation Act of 1962 (Appendix D).

The Florida Marine Patrol is proposing to limit the operation of personal watercraft to daylight hours only.

3. RATIONING USE INTENSITY

Glen Canyon National Recreation Area is proposing to control the use of their waters by enforcing a boating capacity which would apply equally to all types of boats including personal watercraft. But in general personal watercraft would not be restricted in where they can be used.

4. RESTRICTIONS ON ACTIVITIES

Imperial National Wildlife Refuge's response to their resource concerns has been to make all backwater lakes "no wake" zones and rigorously enforcing with citations.

At Puddingstone Reservoir in Southern California personal watercraft are restricted, along with other boats, to traveling in the same direction along a buoy marked route. Freestyling is not permitted.

Concern over the safety of personal watercraft users around a marina where the vehicles are rented, led managers of Glen Canyon NRA to adopt a number of "no wake" zones.

The Florida Marine Patrol is proposing that operators must wear their personal flotation device.

Virgin Islands National Park is considering strengthening its regulations to ensure that personal watercraft are not used in bays frequented by endangered green sea turtles.

The City of Hollywood, Florida, in response to concern over possible resource damage at West Lake from motorboats and personal watercraft passed an ordinance prohibiting the use of all fossil fuel powered vessels (Appendix E).