Port Hacking Protection Society

Jetski issues – a Summary of Studies

In response to a proposal to restrict jetski use in Port Hacking, the jetski lobby has circulated an anonymous document purporting to present the scientific data on jetskis. That document purports to cite a number of 'scientific' studies that are alleged to show minimal adverse effects of jetskis on the environment or on other users.

These 'studies' are typically not referenced, or where they are, the source is one of the many boating/jetski lobby organizations. From a search of jetski lobby sites, it is clear that many of these 'studies' are anecdotal and put together for public relations purposes. They do not provide a balanced and objective scientific assessment.

A number of the arguments used by the jetski lobby are highly contestible, and many have been tested in US and European courts and found to be untenable.

In order to provide a more objective source of data, we have put together the attached summary of independent studies, and some of the counter arguments to the jetski case which have been found to be credible through a range of court cases and regulatory enquiries.

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Other studies - attached

The tactics used by the jetski industry and lobby are pretty much the same throughout the world.
They include

a. swamping the opposition with emails and letters and representations, often aggressively presented;
b. using false data to try to distort the debate, in particular by putting misleading ‘science into the hands of their members, who argue the points with vehemence
c. setting up straw-men cases to dispute, and arguing that once these myths are refuted, the whole case against jetskis disappears.
d. Setting up a false issue of equity – the claims that “most jetskiers are responsible” is juxtaposed on an assumption that all uses are equally legitimate, without taking into account the fact that most uses can continue without disruption to others, but some (jetskis in particular) by their nature are disturbing to others, and therefore of their nature require a different kind of management regime.

Hidden in Waterway’s Authority Boating Draft Plan of Management for Port Hacking is the startling fact that jetski use on Port Hacking is growing at a rate exceeding 50% per annnum. This is prior to the banning of jetskis on Sydney Harbour and the Parramatta River, which must significantly increase the growth pressure on Port Hacking. Even the proponents of jetskis acknowledge that Waterways has been ineffective in its own policing. We are faced with an avalanche of jetskis, with no effective mechanisms for their management.

It is not the performance of the individual jetski as a device, nor the behaviour of the most responsible, that is at issue. The key management question is ‘given an estimated number of users of these machines, and the typical patterns of use, will the outcome for non-jetski users and the environment be the outcome we want for Port Hacking?” The answer to this, given far larger numbers of jetski users than even the present flood, must be “no”. More effective management, including banning of these craft where their use will reduce the amenity to non-jetski users, must be a core demand if we are to have sustainable and equitable use of Port Hacking.

The existing regulations (see attached) are honoured in the breach more than the observance, with ‘offensive noise’ and illegally jetski races, manouevering and waver jumping being the everyday exception on Port Hacking to the official rule of boating regulations. Rather than entertain ourselves with responding to the myths and the agenda set by the jetski lobby, it is worthwhile to focus on the specific issues and the available data.

Background – the delicate status of Port Hacking

Any consideration of the management of Port Hacking should take into account the increasingly vulnerable status of the estuary, and the threatened nature of its ecology.

- Seagrasses- the EXTENT of seagrass beds across the Port has declined by around 50% since around 1930, and around 75% in the main channels. Within this extent, there are further un-measured declines in intensity due to ecological pressures, such as water quality and (particularly) to mooring and anchoring[1]. The total decline in seagrass MASS is unmeasured, but would exceed 60% and could easily exceed 80% in the main channels[2].
- The water quality of the Port is severely compromised. A status report on the waters of Port Hacking[3] showed severe water quality deterioration, to the extent of shellfish failing health test guidelines 50% of the time in the upper reaches. This data is consistent with the Hacking River CMC Pollution Source Inventory, (1997) Coastcare monitoring, and the findings of Council's own "Heads of Bays" study [4].
- Of course, with the combination of these factors one would expect that there would be a significant reduction in biodiversity. Sadly the data is lacking to be able to discuss this issue (there are no starting benchmark studies, or current population studies, with which to work). However, the recent draft study on the Basin (West 2001) clearly shows the adverse impacts of these pressures in one of the sensitive areas of Port Hacking, and results in the conclusion that significant protective actions (including banning of jetski access) is urgent.
- The decline in foreshore biodiversity is identifiable from Council's own foreshore studies (unpublished as yet) which show a marked loss of vegetation from the foreshores.
- - Sediment contamination, including the presence of heavy metals in surprising concentrations, is pronounced. ([5])

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[1] Aquatic Conservation: Marine and Freshwater Ecosystems Volume 9, Issue 4, 1999. Pages: 391-400 *Effects of boat anchoring in Posidonia oceanica seagrass beds in the Port-Cros National Park (north-western Mediterranean Sea)*
Patrice Francour , Anne Ganteaume, Maxime Poulain
.Experiments on the effects of anchors on Posidonia oceanica seagrass meadows revealed that, on average, 34 shoots were destroyed during an anchoring cycle lock-in an retrieval), especially when the seagrass mat compactness is weak and the extent of rhizome baring is high.

[2] "A History of Change to the Estaurine Macrophytes of Port Hacking" by Williams and Meehan (extracts provided) July 2001

[3] 1998 Department of Lands and Water Conservation Draft Water Quality Guidelines for NSW Rivers

[4] Available from Council – ref Mike Rogers

[5] Port Hacking Tidal Delta Study 1999, for the Hacking River Catchment Management Committee, plus personal communications

All the identified studies show one thing – Port Hacking is under severe threat, and has suffered a measurable significant decline in its ecological health.

Sutherland Shire Council, through its commitment to Agenda 21 and the Sydney Regional Coastal Management Strategy (1998) as well as its own Plan of Management for Port Hacking, is committed to the principles of sustainability for the estuary, including the precautionary principle. The NSW government, through its own Estuaries policy is committed to the same approach.

In the face of demonstrated biophysical decline in the health of Port Hacking, stringent precaution is essential and justified.

Jetski noise

The PWC advocates put forward a case that jetskis do not create an untoward noise problem. The method which they use to create this case is to provide 'on-paper' comparisions of a single PWC operating in accord with best-use practice (the vessel running in a straight line, not wave-jumping, with a stable throttle pressure). They do not deal with the actual situation, viz multiple jetskis, wave jumping and racing, operating in otherwise peaceful conditions where the other users have sought out a quiet area which is being denied them by this activity. The approach used is designed to mask the compounding noise-nuisance effects of the following important matters:

a. the offensiveness of noise is a function of not only its level, but also its context and the state of mind or expectations of the listener. The qualitative impact of a machine noise is radically different when one is in a natural setting to which one has traveled to obtain relief from the pressures of an industrial setting, compared to the same noise experienced in a factory or main-road setting.
b. The sensitivity of listeners varies, both absolutely and in relation to context. Listeners who have expended substantial effort to escape from industrial settings (either by selecting to live away from these, or to go to the trouble to leave them) are going to be far more affected by imposed noise than those who are comfortable in industrial noise contexts. The latter will include those who seek out such noise settings (such as the users of jetskis).
c. Measures of the individual jetski's performance are quite misleading in situations where there are multiple jetskis in use at any point in time. In Port Hacking it is typically the case on a fine weekend that there may be as many as 10 of these craft in any particular area. The real noise management issue is the effect of
    i. A large number of these at any location at any point in time;
    ii. A rotating population at any point in time, such that as one or more leave, they are replaced with others (creating a constant and ceaseless stream of noise). There is no relief, which leads to a compounding psychogical effect.
    iii. The use-activities, which include racing and weaving, yelling as well as machine noise, and in the case of Port Hacking, lots of wave jumping in relatively close proximity to National Park and residential areas.
d. The jumping of a jetski out of the water has four noise-attenuation effects
    i. A jetski out of the water loses the muffling effect of the water
    ii. In leaving the water, the motor 'races', increasing the amount of noise to be muffled
    iii. The increased variability of pitch and volume makes the noise more offensive and apparent. It is estimated (see attached) that this factor alone adds 18dBA to the noise effect of a single jetski; and

iv. The physical ‘whump’ of the machine as it hits the surface (often accompanied by a yell from the user) compounds the sound problem.

Port Hacking is unusual in its shoaling patterns and their proximity to houses, and as a result there is a high proportion of uses in conditions which maximize this nuisance value.

The relevant legislation is the Reg 5 of Noise from Vessels Regulation. It is an offence for a vessel to emit offensive noise, which is defined to take into account the conditions under which the noise is emitted and the sensitivities of the user. These issues are not acknowledged as relevant considerations by the jetski lobby, though they are very clearly relevant to those adversely impacted by jetskis noise.

The attached extracts of a study conducted in the US (“Drowning in Noise”) clearly show that there is a real and measurable cost to non-jetski users of the users of jetskis, measured at around $US700 per jetski per annum. There is no justification for this penalty to be imposed on those least able to protect themselves by those who are most able to avoid causing this harm. There is no justification for requiring that those who are the victims ‘justify on some technical basis why they ought not be required to bear this harm, yet this is what the jetski lobby keep trying to require as if it were there right to cause harm and only be stopped when a victim is able to enagage in a technical engineering debate. The onus should be on the harm-doer to find the solution, not on the harm victim to do so.

Ecological impacts of jetskis

The pro-jetski lobby ignores all studies that frustrate its desire to believe that there is no adverse ecological impact from these machines. The forms of the ecological impact are multiple.

Jetskis directly disturb seabirds and other marine creatures, and cause direct physical harm to others. Attached is an extract of one US study. An Australian equivalent study shows that jetskis are as disruptive as disturbance by dogs to nesting seabirds[6].

Jetskis add significant petroleum contaminants into the waterway. The proponents are keen to cite studies where testing of large water volumes reduce the apparent effect, or studies which compare per-hour emissions. But these studies are selective in what they choose to measure.

i. It takes only small volumes of oil and contaminants to adversely impact on marine eco-systems or the experience of non-machine user. One has only to swim in an area where a PWC has been to taste the slick. The selective studies require that we ignore the evidence of our senses.
ii. Studies which compare per-hour emissions ignore the behaviour of the users, who use their vessels for many hours in a session. Whilst a standard 2 stroke boat may emit the same level, typically it will be used to go to a spot (for example a fishing hole) and then to return to base. The jetski will be used for hours of machine-intensive and polluting play.

Extracts: 2 stroke and marine environments[7]

Because two-stroke emissions are not discharged from a single source, such as an oil spill or leaky tank, but instead come from many smaller spills, there is no visible environmental damage. However, the high level of oil and fuel released is posing a serious threat to aquatic ecosystems, fish populations, municipal water supplies, and air quality.

Petrochemicals released from motorized boating float on the surface microlayer and settle within the estuarine and shallow ecosystems of bays, lakes, rivers, and seas, where marine life is youngest and most vulnerable. These areas are the base of the food chain, inhabited by fish eggs, larvae, algae, crab, shrimp, and zooplankton. In addition, large discharges tend to occur during warmer months at the height of the boating season, which is also when reproduction and early development takes place within these aquatic nurseries

Chromosomal damage, reduced growth, and high mortality rates of fish occur at extremely low levels of petrochemical pollution. In one study, researchers exposed fish and fish larvae (Perch, Sea trout, Rainbow trout, Adult flathead minnow, and Northern pike) to exhaust levels that reflected two-stroke emissions found in natural habitats. The study concluded "that emissions produced by two-

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[6] Disturbance Distances for Water Birds and the Management of Human Recreation with special reference to the Coorong Region of South Australia, David Paton, Mark Ziembicki, Peter Owen, Cybele Heddle, Final Report for the Migratory Waterbird Component of the National Wetlands Program may 2000

[7] Bluewater Network 2001

stroke engines contain substances that have a negative impact on the living fish. Disruption of normal biological functions has been observed at different levels of biological organisation including cellular and physiological functions.
According to Michigan State's Dr. John Giesy, one of the world's leading experts on the toxicological effects of marine hydrocarbon pollution, the true toxicity of two-stroke emissions released into the water is up to 50,000 times more toxic under field conditions in the presence of ultraviolet (UV) light in sunlight. This is due to polycyclic aromatic hydrocarbons (PAHs), substances contained in petrochemicals that form highly toxic and persistent compounds known to be: (1) ubiquitous contaminants that bioconcentrate; (2) carcinogenic to mammals; and (3) acutely photo-toxic to aquatic organisms in a few minutes to a couple of hours.
Through controlled experiments, Dr. Giesy found that it takes .05 ppb (parts per billion) of PAHs in water to cause a 10% decrease in zooplankton and as little as 5 ppb (parts per billion) to kill all zooplankton in a 30 minute test period. Sampling has found PAH levels substantially in excess of 5 ppb during recreational boating activity. PAHs are considered so dangerous that the N.Y. State Department of Environmental Conservation now regulates PAHs on the same toxicity level as PCBs.
In addition to aquatic pollution, marine motors are one of the largest overall contributors to ambient hydrocarbon pollution.
The Clean Air Act forced the automobile industry to dramatically reduce harmful emissions, however, until recently, marine emissions have gone unnoticed and unregulated. Like automobiles, marine motors pollute the air with hydrocarbons, nitrogen oxides, carbon monoxide, particulate matter, other toxic compounds, and smoke causing ground level ozone, smog, and acid rain, as well as premature deaths from cancer and emphysema. There is tremendous potential to build on the gains already made in improving air quality by extending strong emissions regulations to marine motors.

Jetski damage to seagrasses

Jetskis also disturb seagrasses. Jetski users claim continually that they do not go across seagrasses, because of the harm that these beds do to their machines if sucked up into the jets. PHPS members have reported specific instances of jetskis ploughing channels through the seagrasses at Bonnie Vale, and have previously forwarded photographic evidence of this harm. This is not an abberant observation, as it is noted throughout the world wherever jetskis are used.
The following commentary from Kenneth Smith from Florida (who is studying clam harvesting impacts on seagrasses) from a seagrasses site, is of interest
The impacts from PWCs (personal watercraft) have not been investigated to the extent that a refereed journal article has been produced. Anecdotally, I have seen the 3/4 meter wide and deep "blow-outs" that PWCs cause when they jump up on plane on shallow seagrass beds in Rookery Bay (Collier County, FL). Where these water craft are frequently operated in shallow seagrass systems, impacts to seagrass systems can be severe. In Sunset Cove in the upper Florida Keys, I have also seen turtle grass blow-outs where the Thalassia rhizome mat

has been peeled back by the force of PWCs operating in the area. I witnessed a jump start, where the operator throttles to maximum and the craft attains a vertical aspect, that peeled back a 1.5 meter segment of rooted turtle grass and left it hanging in midwater, but still attached to the larger grass bed. This is especially deleterious in areas where seagrasses grow on a thin veneer of sediment such as the calcareous sediments overlying limestone bedrock in the Florida Keys.

It may be argued that the responsible jetskiers do not engage in such activity. In Port Hacking, the state of seagrasses is so threatened that we ought not take the chance, for the actual amount of seagrass that is removed with each such irresponsible action is very substantial – it only takes a small number of irresponsible users to irreversibly harm the paltry residue of seagrasses that are left in Port Hacking.

Safety and perceptions of safety.

Virtually every study into the failures of control of jetskis cite the disproportionate safety impacts and disproportionate rate of illegality associated with their use. The recent banning in Sydney Harbour is just one more such instance.

Understanding built-in anti-social design of jetskis

Jet skis are designed to operate at high speed in shallow water, to wave jump and even skid up beaches . It is only reasonable then to expect that operators will wish to use them according to their design. What is created is akin to allowing a racing car or oversize vehicle (ie vehicle unsuited by their design) to use public roads and highways –a foreseeable danger-on the roads, with no constraint on the safety risk except for some voluntary constraint by the individual. This is is not acceptable except under the most stringent control(management) to ensure risks to safety are minimised.

It seems that the design capacity of jetski creates a foreseeable danger and that Waterways regulations do not adequately address this. Waterways Authority clearly does not have the capacity to enforce compliance. The obvious safety argument is that both Council and Waterways Authority are negligent if they do not remove the risk of these craft by excluding them from waterways where there is a foreseeable safety risk created by their use.

The absence of reliable complaints data

In the case of Port Hacking it is not possible to get reliable data on complaints, incidents and the like, because Waterways Authority have, notwithstanding repeated complaints about their failure, instigated a reporting and complaints system designed to minimize the apparent problems whilst doing nothing about the actual (increasing) problems.

The situation at present is that:

a. there is no out-of-hours number for jetski complaints;
b. if you are persistent enough to obtain the Waterways Authority switchboard number , the automatic referral system will indicate only that you can obtain information on boating licenses etc. There is no indication of where or how to complain;
c. If you do persist, you will be discouraged from lodging a complaint (with the indication being that unless you have the vessel registration number you cannot make a complaint); and
d. If you persist, no action will be taken.

Under such circumstances, is it any wonder that it takes only the most aggrieved individual with the most extreme complaint to lodge any complaint at all.

PHPS is aware of four major risk incidents in the last 2 or so years. Only two of these were even recorded by Waterways.

We are also aware from observations that many (particularly migrant) families are seriously threatened by the presence of jetskis, and will remove their children from the water.

The jetski strategy – reverse the onus of proof

The proponents of jetskis try to push the line that it is up to those who have such concerns to 'prove' that injuries have actually occurred, and that it was the fault of the jetskier. Where problems are proven, they take the position that the low impact users should be 'protected' by setting aside limited safety zones for swimming.

This is intrinsically the wrong way around. The common law is that those who introduce a harm should be responsible for its removal. The potential victim should be free to continue with their harm-free activities unhindered.

Port Hacking has been a low impact use waterway, safe for swimmers, kayakers, picnickers and the like. That is the way it should be perceived, and it should be managed to protect these use values.

The growth in liability risk

Recent cases make two points increasingly clear

a. local government is liable for the safety risk to individual swimmers etc who are attracted to an area by the promise of safe low-impact use[8]. The case law indicates strongly that once a council is aware of the potential risk, if it does nothing to prevent the harm it will be liable for the injuries even if the actual cause was an irresponsible use of a vessel within the waterway.

b. A recent case suggests that the defence of non-feasance has now been removed, which means that Council has a positive duty to act (and cannot get out of liability just because of inaction).

The possibility of direct economic costs to Council now that it is fully aware of the risk, and for so long as it does nothing about it, is strong.

[8] THE COUNCIL OF THE MUNICIPALITY OF WAVERLEY v. BLOOM [1999] NSWCA 229

The law-abiding majority myth

The constant argument is that it is only a law-breaking minority which is causing all the problems for jetski users. This is a deceptive argument for a number of reasons.

Why is it that nowhere has it been possible to create a jetski use regime where this ‘minority’ has been effectively controlled? If it is indeed a minority, is it the case that this minority is intrinsically linked to the activity of jetski-ing such that only by getting the activity out of an area, you can get rid of these people? Or is it that the activity is of such a harmful character that it only takes a very small, intermittent ‘break-out’ from some accepted code of conduct, as to create major problems? Or is it the case that the activity requires such extensive policing that it can be made acceptable only by the extensive application of funds to its management, such that it is uneconomic for society to permit this activity? Regardless of the line taken, the issue of the irresponsible minority is so inter-mixed with the nature of the activity that it cannot be filtered out, even by the law abiding participants (who constantly rail at the inability of the regulators to get the trouble makers under control).

Second, the question remains ‘if there is this element in the sport, who should bear the costs of their irresponsibility?’ and this question is even more pronounced when the costs of such control and the likelihood of its failing are both so substantial. The jetskiers clearly believe that the risks and costs should fall on the shoulders of the non-jetskiing community. It makes more sense in both a practical and justice sense that it falls on the shoulders of those who are advocating the activity that brings the problem.

The economic contribution myth

The strongest proponents of jetskis are, of course, those who benefit economically from this activity which takes place at the cost of many others. They propogate the myth of an industry, making economic contribution.
This requires selective counting. What is counted is the economic activity of the marketers of these devices, and those who make their living from the maintenance of them.
What is not counted is the raft of economic disbenefits.

a. In low-impact use estuaries like Port Hacking, the main economic contributors from the waterway to the local economy comes from the majority low impact users. Typically these arrive by public transport or private car. They shop in the local food or swimwear shops, and they spend in a myriad of low-key activities. Jetski intimidation and loss of amenity reduce the appeal of an area to these users, thereby leading to a reduction of these diverse economic contributions.
b. Jetskis are disproportionately costly on the public purse, because of the additional policing and administrative demands which they place on the system. This represents a reallocation of funds away from more positive uses including schools, hospitals, community facilities and the like.
c. Jetskis are imported. The bulk of the economic activity takes place in Japan or the USA, with the consequent adverse impacts on not only our local environment, but also our international trade and currency markets.
d. Jetskis cause ecological and social costs which have a measurable economic value.

There are no studies available which provide a net balance of the economic effects of jetskis, after taking into account the major disbenefits which they create. It is anticipated that the net economic result would be a major economic loss, with the public subsidizing the users of these machines to a very large degree, and with the commercial operators effectively paratising the general community to obtain their short term profit.

What the community wants

There is a myriad of survey evidence on what the community wants from Port Hacking. They want effective management to protect the ecological values of Port Hacking, and they want to continue to use it as a low-impact use area.

What do Sutherland Shire residents think? (1998)

Environmental concerns loom large in the thinking of Sutherland residents. The surveys conducted for Sutherland Shire Council by the Hunter Valley Research Foundation find that the environment figures in 6 out of the top 10 issues for residents surveyed.

The top three issues overall were: water pollution, waterways/beaches/wetlands, and air

pollution. Kerbing, guttering and pot holes do not make an appearance until the 25th ranking.

This is in line with State-wide trends. Attitudes across the State (1997) found that residents in NSW now do many things to make their home and work environmentally-friendly. The community is more concerned about the limits of natural resources and the detrimental effects that humans have on the delicate balance of nature. The EPA survey reports that water and air pollution are the two issues of highest priority for the NSW Government to address, with freshwater pollution (followed by beach/ocean pollution) and vehicle emissions (followed by industrial emissions) as the major focus of concern. There is a greater appreciation of the need to provide a healthy environment for a productive economy, rather than one at the expense of the other. There is also strong support for strengthening regulations on industry

The Sydney Coastal Zone (1996)

The Sydney Coastal Councils Group surveyed the community in September 1996 as part of the development of its coastal management strategy.

The survey identified 7 key coastal issues. The top five rankings across the survey area (in order of priority) were: water quality, conservation of natural heritage, sewage treatment and disposal, ecologically sustainable development (ESD) and development. The rankings across the Hacking varied to the overall rankings: ESD (1), sewage treatment and disposal (2), conservation of natural heritage (3), coastal dynamics (4), development (5

Shire residents' attitudes to Port Hacking (1985)

Attitudes to Port Hacking have not shifted much in over a decade. A 1985 study of Shire residents to determine attitudes to Port Hacking found strong support for the development of a policy or management plan to look at the future of the Port, what it has to offer and how it can best accommodate the needs of users.

The majority of respondents favoured controlled dredging in the major navigational channels, but within an environmental protection framework.

Residents were aware that competing and conflicting waterways uses will be an increasing issue with the increasing population. They also wanted improved access to the water from the foreshores.

Foreshore Residents views (1997)

The Hacking River Catchment Management Committee (HRCMC) published the results of a survey of foreshore residents. The survey found that the ecological health of the estuary is the dominant concern of respondents, with residents of the southern shores showing significantly higher concern for the protection of the estuary's natural qualities.
Residents were more concerned about visual impacts than with boating safety concerns and noise impacts. However a substantial proportion of respondents were also concerned about noise associated with small motorised craft such as jet skis, power boats and tinnies. These concerns were very strong on the Southern side of Port Hacking notably at Bundeena and Maianbar.

Extracts from “Drowning in Noise: Noise Costs of Jet Skis in America”

A Report for the Noise Pollution Clearinghouse
by Charles Komanoff & Howard Shaw, Ph. D.
APRIL 2000
Full report at http://www.nonoise.org/library/drowning/index.htm

3. Jet Ski Noise Is Different

Less than two decades since they were introduced, jet skis have become ubiquitous on U.S. waterways. Sales of jet skis currently run at around 150,000 a year; older models are being scrapped at only a third of that rate, and an estimated 1.3 million “personal watercraft” are now operating on the nation’s bays, lakes, rivers and oceans.

In reaction to the nearly constant intrusion of jet ski noise on thousands of beaches and shorelines, organizations of anglers, canoeists, nature-lovers and beachgoers have campaigned strenuously to limit jet ski use. Prodding by national and local citizens’ groups has resulted in the banning of jet skis from more than two dozen units of the National Park
Service, including Yellowstone, Everglades and Grand Canyon National Parks, and from dozens of prized lakes from Lake Tahoe in the Sierra Nevada range to the Stockbridge Bowl in western Massachusetts.(4)

Vermont now bans jet skis from lakes and ponds smaller than 300 acres, effectively limiting them to lakes at least a half-mile across,(5) and the machines have been barred from waterways of the San Juan Islands of Washington State and of Marin County, north of San Francisco. Some jurisdictions, including San Francisco County and south Florida’s Monroe County, require jet skis to keep a considerable distance — in some instances, almost a quarter-mile — from shore.(6)

Yet bans or operating limits are still exceptional. Restrictions have been adopted piecemeal, and only over bitter resistance by jet ski manufacturers and user groups. For the most part, following America’s laissez-faire tradition toward motorized recreation, jet skis have been permitted to proliferate, almost as-of-right, while objectors must bear the burden of proving harm and seeking redress. Throughout the 1990s, in fact, while citizens were scrambling to marshal facts and mount grassroots campaigns, the jet ski industry and user groups were cultivating influence and entering mainstream culture.

Manufacturers and users insist that jet ski noise is little different from noise generated by other motorized watercraft.(7) But their arguments appear to ignore fundamental differences between jet skis and motorboats. While jet skis can sometimes be observed operating no more loudly than motorboats, as a general

rule jet skis are considerably noisier and more disturbing. Three differences stand out:
1. Jet skis are designed and used differently from motorboats, in ways that typically make them far more annoying to other people in the same environment.

With their small size and shallow draft, jet skis can venture closer to shore than motorboats. Moreover, whereas motorboats are used for many different reasons, from excitement to relaxation, jet skis are designed and marketed for only one reason: the thrill of speed. Jet skis are not used for fishing or cruising; a jet ski is seldom driven at less than full throttle. Motorboaters as often as not head for a fishing or picnicking spot, then douse the engine when they get there. But jet skiers seldom have a destination in mind. Rather, they use their vehicles continuously as a recreational end in themselves.

2. The heart of the difference between jet skis and motorboats, and the crux of the jet ski noise problem, is that jet skis continually leave the water. This magnifies the noise in two ways. First, without the muffling effect of the water, the engine's exhaust is much louder — typically by 15 dBA; an airborne jet ski has the same noise impact on a listener at the water's edge as an in-water jet ski 8 times closer, or the same as 32 identical in-water jet skis at the same distance. Second, each time the jet ski re-enters the water, it smacks against the surface with an explosive "whomp" — sometimes with a series of them.

Leaving the water is central to the fun of jet skiing. For many jet skiers, the ultimate thrill is to take to the air and bounce off the water repeatedly. This is easily accomplished — by jumping the wake from a passing motorboat, or from another jet ski (often in a duet of mutual wake creation and riding), or from one's own machine. But jet skis don't have to deliberately jump to leave the water: because of the short hull, a jet ski ridden fast on even a slightly choppy surface will lift out of the water naturally, eliminating the water's sound-muffling action and creating the jarring whomp. So whether by the operator's intent or the vehicle's design or both, jet skis wind up "out of the water" much of the time — certainly far more than all but the occasional (and also annoying) "cigarette" boat to which jet skis are sometimes likened. And not only does this raise the jet ski's instantaneous noise emission by a very considerable 15 dBA on average; the effect is vastly compounded by the variable nature of the noise.

An established finding of psycho-acoustics is that rapidly varying noise is much more annoying than constant noise — even a constant noise that is equal in intensity to the loudest instantaneous noise in a series. This is a truth known by experience to anyone who has been repeatedly startled or disturbed by a loud but intermittent sound, like a jackhammer at a construction site. A varying noise commands the hearer's continuous attention, making it especially bothersome. This ensures that jet skis' whirring and whomping noises, varying from moment to moment, will be much more annoying than the relatively constant sounds

produced by other watercraft. (For quantification of this annoyance, see sidebar, “Variable Noise is More Disturbing,” on p. 21.)

3. The final characteristic that distinguishes jet skis from motorboats is their rapid maneuvering and frequent speed changes. In addition to jumping wakes, jet skis are designed and marketed for weaving, sharp turning, spinning doughnuts and generally erratic throttle use. As a result of these maneuvers, the jet impeller has no consistent water “throughput,” and thus, no consistent load on the engine. Consequently, the engine’s speed rises and falls from moment to moment with each maneuver. The result is a penetrating whining sound, rising and falling rapidly in pitch like a dentist’s drill and demanding the attention of anyone within earshot.(8)

We estimate that jet skis are operating “out of the water” or in the rapid maneuvers just described, around 20% of the time. Both involve not only elevated noise emission levels but also varying — hence, unusually annoying — sounds.

Understanding noise

Noise is a complex phenomenon, not least in its basic unit of loudness, the decibel (dBA), which is the logarithm of a physical quantity, acoustic power (see sidebar on previous page). Nor is it usual to see the impact of noise expressed in dollars. Accordingly, this section outlines and explains jet ski noise estimation and costing step by step. (Readers interested in a more detailed account of the technical nuances may refer to the Appendix.)

It will be helpful to keep the following points in mind:

Laws of Noise

Noise from a “point source” such as a jet ski diminishes rapidly over distance, with the sound intensity declining in proportion to a power of the intervening distance. Based on measurements which we discuss in Part 1 of the Appendix, we assume that this decline is in proportion to the 1.661-th power over water, and to the 1.993-th power over land. This corresponds to a decline of 5 dBA per doubling of distance over water (6 dBA over land). See Fig. 1.

In measuring and discussing noise from jet skis it is important to distinguish between measurements taken at the source (a jet ski) and those taken at the position of a hearer (a beachgoer). When two simultaneous noise sources combine, the combined loudness is not simply the sum of the two dBA values. Rather, the dBA values must be converted back to raw acoustic power values; these are added and the logarithm of this sum, multiplied by 10, gives the dBA value for the combined noises. This implies that the louder source contributes much more to the combined loudness than a comparison of the two dBA values would suggest. Whenever the jet ski is louder than the background noise level, the combined noise level experienced by the beachgoer will be only slightly more than that of the jet ski alone. Informally, we can say that quieter sounds (the

background noises in this case) are almost “swamped” or overwhelmed by louder. See Fig. 3.
The noise increment due to an additional noise (from the jet ski) is calculated by subtracting the background noise level from the combined noise level discussed above (the additional noise combined with the background noise).
Fluctuating noise is much more annoying than steady noise; this “psycho-acoustical” phenomenon helps explain the exceptionally disturbing effect of the repeated noise surges when a jet ski leaves the water. This is quantified by Robinson’s Formula (see sidebar, next page, and Fig. 5).

Understanding the effect of noise variation

Variable Noise is More Disturbing: Robinson’s Formula

Researchers of humans’ perception of noise have long observed that varying noise is generally more disturbing than a steady noise — even when the steady noise is louder (contains more sound power) than the loudest of the varying noises. The reason, in a nutshell, is that varying noise demands the hearer’ continuous attention; it can’t be “tuned out.”

In 1970, British acoustician Douglas Robinson gave a precise analysis of this phenomenon with the empirically derived relationship LNP = LEQ + 2.56 x Sigma.

Here LNP is the Noise Pollution Level, or “effective” noise level — that is, the level at which a constant noise would be as annoying as the varying noise in question).

LEQ is the mean noise power intensity converted to dBA; and Sigma is the standard deviation of the noise intensity in decibels. (All noise levels are as experienced by the beachgoer.)

Through Robinson’s Formula, we can quantify the extent to which jet skis’ intermittent whirring and whomping noise profile is more annoying than other watercraft’s more constant sounds. This is no small matter, as the examples here of a jet ski operating 160 feet from a beachgoer on a secluded beach show.

In Fig. 5, LEQ = 73.9 dBA (this is the mean noise power intensity, converted into dBA, when the instantaneous noise intensity is 67.9 dBA four-fifths of the time, and 80.0 dBA for the remaining one-fifth), and the standard deviation is 4.8 dBA. “Robinson’s Formula” then yields LNP = 73.9 + 2.56 x 4.8, or LNP = 86.3 dBA. In other words, a jet ski that continually leaves and then smacks against the water from 160 feet away will raise a 45 dBA background noise level to more than 86 dBA — a stunning 41 dBA impact.

By comparison, in Fig. 3, the same jet ski would have raised the 45 dBA background noise level by just 20 dBA, to 64.9 dBA, if it had remained in the water the entire time. The difference in impacts is only partly due to the higher emission level when the jet ski is out of the water; the fluctuation in the noise level is as influential, if not more so.

To a considerable extent, then, the power of jet skis to disturb is rooted in people’s sensitivity to varying noise signals. Jet ski manufacturers claim that their vehicles are no more disturbing than ordinary motorboats, but Robinson’s Formula, a fundamental result in psychoacoustics, clearly reveals the falsity of

this claim. Perhaps even more importantly, it gives researchers the ability to quantify the actual noise impacts and costs.

Understanding the effects of jetski clustering

Now we need to account for jet ski "clustering." Many jet skis are driven in pairs or in larger groupings. We assume that the average jet ski is part of a cluster of 1.6 jet skis (a statistical artifact akin to the proverbial "2.1-child-family"). This has the effect of adding just over two decibels (2.04 dBA, to be exact) to the 80 dBA mean emission level we have assigned to a single jet ski.(14)

(14) The 2.04 dBA increment is derived as 10 x log (1.6). This calculation is conservative since it assumes identical sound profiles for each jet ski in a cluster.

Conflict resolution in coastal waters: The case of personal watercraft

Burger, J; Leonard, J
Marine Policy [Mar. Policy], vol. 24, no. 1, pp. 61-67, Jan 2000
The number of personal watercraft (PWC) used in coastal and inland waterways has increased recently, potentially disturbing people, fisheries activities, and wildlife and recreational resources. In 1997 we 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 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. Although these measures did not eliminate the problem, they reduced the disturbance to the birds in 1998 and 1999, allowing increased reproductive success, representing a successful co-management program.

For local data see Disturbance Distances for Water Birds and the Management of Human Recreation with special reference to the Coorong Region of South Australia, David Paton, Mark Ziembicki, Peter Owen, Cybele Heddle, Final Report for the Migratory Waterbird Component of the National Wetlands Program May 2000 (attached) which shows the effects of jetskis on roosting waterbirds to be of the highest magnitude of disturbances (equivalent to a human plus dog entering a roost area)

BLUEWATER NETWORK AND NATIONAL PARK SERVICE REACH AGREEMENT OVER JET SKI LAWSUIT

Settlement clears way for jet ski ban throughout entire park system by Fall of 2002

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FOR IMMEDIATE RELEASE

Tuesday, December 20, 2000 -- San Francisco, CA

Today, Bluewater Network a national environmental organization, reached a settlement with the National Park Service (NPS) and the Department of Justice (DOJ) regarding personal watercraft (PWC) use in the National Park System. PWC, better known by the trade name jet ski, have been shown to cause significant damage to air and water quality, visitor enjoyment, public health and safety, natural quiet and wildlife. The settlement, which was worked out by Bluewater Network's lawyers at Meyer and Glitzenstein, is a major victory in Bluewater's campaign to prohibit PWC from the entire park system.

In March of this year, the NPS adopted regulations which banned PWC operation from approximately two-thirds of all national parks that permit motorboat activity, including parks such as Olympic, Yellowstone and the Everglades. However, the rule exempted 21 parks from this ban including Glen Canyon and Lake Mead National Recreation Areas and Cape Lookout National Seashore. In August, Bluewater Network filed suit claiming that the Park Service's jet ski regulations violated federal law which requires the NPS to leave park resources unimpaired for future generations.

As a result of today's settlement, these 21 parks will now be required to ban jet skis, unless they undertake a rulemaking process which must comply with environmental reviews as required by the National Environmental Policy Act as well as the Park Service's own legislative and administrative mandates. The settlement also provides the public an opportunity to comment on PWC use at any park that wants to authorize the craft. In the past, the public has consistently and overwhelmingly supported protecting the parks from jet ski damage. Jet ski operation may continue in these 21 parks while the NPS undergoes the rulemaking process, however the settlement stipulates that the entire process must be completed no later than the fall of 2002.

"We believe this settlement will expand the protection of park resources and wildlife from jet ski damage," said Sean Smith, Public Lands Director for

Bluewater Network and a former park ranger. "The days of jet skis tearing through our national heritage are numbered."

States affected by settlement: Arizona, California, Colorado, Georgia, Florida, Indiana, Massachusetts, Maryland, Michigan, Mississippi, Montana, Nevada, North Carolina, New Jersey, New York, Oklahoma, Pennsylvania, Texas, Utah, Virginia, Washington

Parks affected by settlement:

Glen Canyon National Recreation Area (AZ/UT)
Lake Mead National Recreation Area (AZ/NV)
Whiskeytown National Recreation Area (CA)
Curecanti National Recreation Area (CO)
Cumberland Island National Seashore (GA)
Gulf Island National Seashore (FL/MS)
Indiana Dunes National Lakeshore (IN)
Cape Cod National Seashore (MA)
Assateague Island National Seashore (MD/VA)
Pictured Rocks National Lakeshore (MI)
Bighorn Canyon National Recreation Area (MT)
Cape Lookout National Seashore (NC)
Delaware Water Gap National Recreation Area (NJ/PA)
Fire Island National Seashore (NY)
Gateway National Recreation Area (NY)
Chickasaw National Recreation Area (OK)
Amistad National Recreation Area (TX)
Lake Meredith National Recreation Area (TX)
Padre Island National Seashore (TX)
Big Ticket National Preserve (TX)
Lake Roosevelt National Recreation Area (WA)

There are extensive jetksi bans throughout the world, as the realization grows that these machines are both environmentally harmful, and anti-social in their use.

1995: Jervis Bay Marine Park Authority survey of users on issues

The following data are an objective indication of the nature of the concerns raised by community about jetskis in natural settings.

5.11 Conflicting Uses of the Marine Park

In discussions with people who use the marine park, staff members have been made aware of a number of activities which occasionally conflict with each other or with the environment. To obtain further information on potential conflicting activities, a question was asked on this subject in the ***Help Us Plan Jervis Bay Marine Park*** survey. The most common responses are reported in Figure 13. Many of these conflicts have been discussed in other sections of this paper.

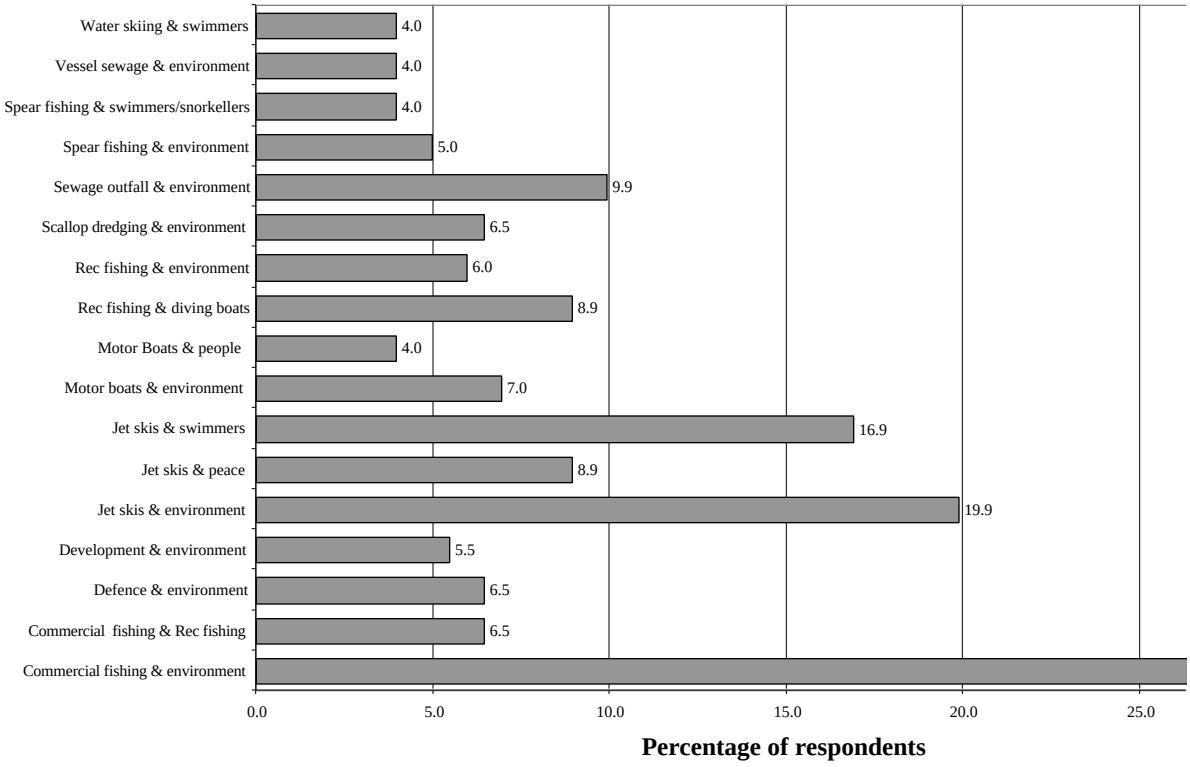

Figure 13. Conflicting Use in Jervis Bay Marine Park Responses from the 1004 returned ***Help Us Plan Jervis Bay Marine Park*** surveys

5.11.1

Fairness is in favour of bans

Jetski advocates typically raise the issue of ‘fairness’ in how their members are treated by jetski bans. But that is a distortion of the underlying principles of fairness.

Accepting that the rights of any user is equal to those of any other, it must be that the enjoyment of one low impact user is no less significant than the enjoyment of one higher impact user (and vice versa). If the pleasure for one user causes a loss of pleasure for other, the person achieving enjoyment is doing so at the cost of the other. If the pleasure of one user is achieved at the distress of a greater number there is an unfairness, which ought be corrected. The loss to the many is far greater than the benefit to the one.
A Catchment Management Committee study of foreshore residents (1998) clearly shows that uses which require good environmental conditions (swimming, kayaking etc) are more common than are those activities which do not require the same pristine conditions. Visitor numbers to Port Hacking also bear out the same message – for the greatest number, it is environment conditions that are the key to their pleasure. “Fairness” and protection of the natural unspoilt conditions, are pretty much aligned in the management of Port Hacking

Focusing on one of the contentious issues, the use of high speed vessels close to foreshores, one user (or a group in the case of PWCs) can cause distress to a larger number of others who are seeking to enjoy peace and quiet, unspoiled natural conditions, or who are concerned for their or their children's safety in the water. The user creating the noise is taking away the pleasure of the larger number. This is a substantial unfairness, more so because it is the person creating the harm who is getting all the benefit, and the larger number who are unable to do anything to prevent it who are bearing all the loss.

It is a sound principle that those who have the capacity cause a loss to others ought be responsible for preventing it. It is also reasonable to expect that those who have the capacity to reduce the harm take the steps to do so.
Many of the uses which can cause a loss of pleasure for other users require only open water (not unspoilt natural conditions), or they use the water and the Park as a scenic backdrop for activities that do not depend on their natural condition, or merely use the water as a “road” to get from one place to another. They do not depend on being close to the shore, or in quiet natural areas, for their enjoyment. Powered vessels in particular are highly mobile, compared with swimmers, canoeists, fisherpersons or residents, or the biodiversity resources of the waterways. It is easy for them to move to another place, without any significant loss of their amenity.
Requiring that some of these users adjust their use in order to reduce the risks to biodiversity, or to prevent the loss of opportunities for peaceful low impact use valued by others, is not in the least unfair. By any logical analysis, it is about one of the most fair expectations which one part of a community can place on others.

And indeed, many of the power boating users of Port Hacking adopt the responsible attitude of enjoying their recreation well away from those whose pleasure will be reduced by the side-effects of that recreation. It is the PHPS position that this informal best practice should be reflected in the way in which uses of the Port are reflected. This is not to restrict the use by those who are responsible, but to ensure that those who are less concerned about others are obliged to live up to that best practice. In this way, the responsible users will not have their reputations tarnished by the uncaring, and all users will be able to continue to enjoy Port Hacking in the knowledge that everyone else is acting fairly and responsibly.

Boating regulations that are typically violated by PWC users in Port Hacking

Marine (Boating Safety Alcohol and Drugs) Act 1991
Section 6 (1) operate vessel on any waters while under the influence of alcohol operate vessel under influence of alcohol

Section 6 (1) operate vessel on any waters while under the influence of drugs operate vessel under influence of drugs

Maritime Services Act 1935
Section 13SA personal watercraft or other vessel exceed by not more than 10 knots the speed limit specified by notification published in the Gazette PWC/non-PWC vessel exceed specified speed by not more than 10 knots

Water Traffic Regulations N.S.W.
Regulation 3 navigate a vessel on any navigable waters recklessly navigate recklessly

Regulation 3 navigate a vessel on any navigable waters at speed likely to cause annoyance or nuisance navigate at speed likely to cause annoyance or nuisance

Regulation 5 whilst using vessel on navigable waters, cause annoyance to any person cause annoyance to person

Regulation 5 whilst using vessel on navigable waters, cause nuisance to any person cause nuisance to person

Regulation 8 conduct a race for vessels on navigable waters otherwise than in accordance with an aquatic licence conduct race otherwise than in accordance with aquatic licence

Regulation 15 (3) navigate a vessel on navigable waters at a speed of or exceeding 10 knots within 30 m from vessel navigate vessel at speed within 30 m from vessel

Regulation 15 (4) (a) navigate personal watercraft at a speed of or exceeding 10 knots within 60 metres of a vessel of 4 metres or less, or a canoe or kayak, that does not have means of mechanical propulsion, or a rowing shell fast PWC near small vessel/canoe/kayak/rowing shell

Regulation 15AA (a) drive personal watercraft on navigable waters in a designated surf zone or swimming area drive PWC in surf zone/swimming area

Regulation 15AA (1) (b) drive personal watercraft on navigable waters within 60 metres of boundary of designated surf zone or swimming area drive PWC near surf zone/swimming area

Noise from Vessels Reg.
Reg 5 - Offensive Noise from vessels. (being defined as noise which is offensive to any person by virtue of its nature, the context or the sensitivities of those who hear that noise)

Jet Skis Position Paper

Go to Jet Skis Campaign Home

Personal Watercraft

Personal watercraft (PWC), also known as Jet Skis®, Waterbikes ®, and Sea-Doos ®, are aquatic craft propelled by a water jet drive which are capable of achieving planing speeds. Produced by manufacturers of all-terrain vehicles and snowmobiles, ***PWC are fundamentally different from conventional boats in terms of design, operation and use.*** Their shallow draft design allows PWC to be operated at high speeds in shallow areas close to shore, unlike other motorized boats. Highly maneuverable and capable of speeds exceeding 65 mph, PWC are marketed as "thrill" vehicles. Common practices include: weaving between vessels, jumping wakes, spinning doughnuts, and radical changes of course.

PWC are the one of the fastest growing segments of the boating industry in the U.S. and now account for one third of all boat sales. The $1.4 billion PWC industry sells approximately 100,000 units per year. Cumulative sales have topped 1.2 million units as of 1998, and are climbing rapidly.

PWC are multiple impact machines. They have an unprecedented effect in terms of noise pollution, marine pollution, wildlife harassment, and safety on the waterways. The specific problems associated with PWC have resulted in calls for strict regulation or bans.

Noise Pollution

Marine users, shoreline hikers and wildlife enthusiasts complain that the high-pitched, chainsaw-like whine of PWC ruin their outdoor experience. PWC produce noise levels in the range of 85-102 decibels (dB) per unit--levels at which the American Hospital Association recommends hearing protection (above 85 dB). By comparison, a busy city street produces about 85 dB. Furthermore, the design of PWC results in noise that is particularly disturbing. The jet drive emerges from the water every time a PWC goes over a wave which causes the engine noise to increase in loudness and pitch; this continual change in loudness and pitch during normal use make PWC much more disturbing than the constant sounds of conventional motorboats.

A controlled study of PWC in the San Juan Islands (Washington state) by the Woods Hole Oceanographic Institute concluded that PWC, which lack a low-frequency long distance sound, do not signal surfacing birds or mammals (including humans) of approaching danger until they are almost on top of them. [1] The high frequency sounds PWC produce in both air and water also startle birds and other wildlife. [2] Joanna Burger of Rutgers University in New Jersey, found that fast and noisy PWC traffic sent almost 200 birds flapping into the air, more than six times that of ordinary motorboats. [3] Tom Wilmers, a U.S. Fish and Wildlife Biologist at Key Deer National Wildlife Refuge, reported that he saw a jet ski repeatedly flush an Osprey from its nest site eleven times in less than one hour. [4] Wilmers also noted that PWCs' tendency to circle continuously in one location for extended periods of time exacerbates the disturbance factor because it reduces opportunities for displaced birds to return to feeding or nesting areas. [5]

In addition, a recent report by the Noise Pollution Clearinghouse finds that jet skis will wreak an estimated $900 million in noise annoyance costs on beachgoers this year, as well as hundreds of millions of dollars of additional costs to water recreationists and shoreline property owners. The report also documents that minimum-distance rules are only modestly

effective, while supposedly quieter new models won't put much of a dent in the noise burden. (A copy of this report can be obtained from Bluewater Network).

Wildlife Impacts: Disruption & Displacement

Wildlife biologists throughout North America have testified on the existing and potential impacts of PWC use. In California, marine mammal experts have voiced their concern that PWC activity near seals, sea lions, and elephant seals disturbs normal rest and social interaction, and causes stampedes into the water that can separate seal pups from adult mothers. [6] According to Judy McIntyre, researcher and director of the North American Loon Fund, PWC are the greatest current threat to breeding loon populations. [7] Florida's Game and Fresh Water Fish Commission concluded that fast moving watercraft near shorelines, a normal pattern of PWC use, produce larger flushing distances* of water fowl. [8] Joanna Burger, author of a Rutgers University PWC study, observed PWC's skimming the edge of islands, and running over Common Tern nests containing eggs or chicks. Burger's study confirms that waterfowl respond "significantly more" to PWCs compared to motorboats. [9] Officials at the Washington State Department of Fish and Wildlife's Ecosystem Management Program have gone on record to report that they are becoming "increasingly concerned with the effect of motorized personal watercraft... particularly jet skis, on both nesting birds and spawning salmon." [10] And, the state of Hawaii classified PWC as "thrill craft," imposing strict areas of use for the vehicles in order to protect migrating humpback whales. [11]

* Flushing distance refers to how far away a PWC has to be to cause birds to fly up and away from a giving point.

Polluting the Aquatic Environment

Jet skis are far more polluting than other conventional two-stroke powered motorboats. Two-stroke engines (which power all PWC) run on a mixture of oil and gasoline, and discharge as much as one-third of this mixture unburned into the water. An average two-hour "thrill" ride on a PWC can dump between 3 and 4 gallons of gas and oil into the water. [12] PWC have twice the hourly annual usage rate of other water vessels, double the load factor (rpm, payload, etc.), and significantly more horsepower than a typical two-stroke outboard. [13] For these reasons, PWC emit twice as much pollution as an equivalently powered motorboat. [14] The California Air Resources Board also reported that a days ride on a 100 horsepower jet ski emits the same amount of smog-forming air pollution as driving 100,000 miles in a modern passenger car. [15]

The threat of two-stroke engine pollution from PWC is particularly troubling because of where and how the machines are used. PWC are capable of traveling in shallow and remote areas where water and other wildlife are most prevalent and most sensitive to environmental pollution. Hydrocarbons in gas and oil released from two-stroke motors float on the surface and settle within the shallow ecosystems of water bodies. These areas are home to many organisms at the base of the food chain: fish eggs, algae, shellfish, and zooplankton. Scientists have determined that hydrocarbon pollution can bioaccumulate within the complex food web, posing a serious threat to the marine environment. [16]

Safety Concerns

Accident rates for PWC are disproportionate compared to their numbers on the water. An article in the ***Journal of the American Medical Association*** (JAMA) stated that while the number of PWC tripled during the first half of the 1990s, injury rates involving their use quadrupled. [17] PWC injury rates were 8.5 times higher than injury rates for motorboats. [18] In addition, actual jet ski-related injuries and deaths are four times higher than Coast Guard data indicates, at over 12,000 accidents per year. [19]

Even the Coast Guard's under-reported figures are disturbing: in the state of California, there were 391 PWC accidents encompassing 276 injuries and eight deaths during 1997. Most of the accidents were blamed on excessive speed and operator inexperience. According to Officer Danny Lopez of the San Francisco Police Department's Marine Patrol, "They're very easy to purchase and very dangerous to operate." [20]

For inexperienced PWC riders (those who most commonly operate the craft), [21] steering poses a particular problem. PWC have no brakes or clutch to aid maneuvering and are extremely difficult to steer at high speeds and impossible when the throttle is cut. When operators let up on

the throttle to avoid a collision--something people are conditioned to do with bicycles and cars--they go straight, essentially becoming uncontrollable.

Never have such a small proportion of boats had such a negative impact on a large number of users. Injuries and deaths often involve inexperienced riders who collide with other vessels on the water. Normal PWC use, such as following other boats to jump their wakes, endangers other marine users, resulting in disproportionate numbers of warnings from marine enforcement officers and complaints from other marine enthusiasts. [22]

Increasing Regulation

High accident rates have led to a wave of new state safety laws regulating PWC use. It is often common practice for high-paid industry lobbyists to pressure governmental officials and land mangers to support legislation which removes authority over local waterways from county and municipal governments. In the states where the PWC industry has failed to get authority to regulate removed from local citizens the industry often leans on local and state regulators to adopt tame, "model" regulations, which do not address any problems specific to PWC use or design. These regulations suggest setting a minimum age of 16 for PWC operation, prohibiting nighttime use, and requiring an emergency shut-off switch, but they ignore more pervasive problems. For example, U.S. Coast Guard statistics indicate that the largest number of PWC injuries are to people between the ages of 23 and 29 years old, not 12 and 22 years old as the PWC industry contends. [23] The industry's legislation is minimal at best and represents an attempt to placate the publics concerns associated with these craft.

Some local communities are attempting to establish regulations which address common concerns surrounding PWC activity: safety, conflicts with other recreational users, excessive noise, marine and air pollution, and wildlife harassment. These regulations include laws that alleviate noise problems, prevent wildlife disruption and displacement, reduce the tremendous pollution from PWC two-stroke motors, and augment the safety laws proposed by the industry. Some areas of effective regulation:

- Include large buffer zones or "special use areas" (where PWC are prohibited) that keep PWC users far away from the shoreline as well as from swimmers, divers, surfers, wildlife, and other boaters
- Limit PWC access to waterways except within specific areas to be designated by local communities through city ordinances. Limit access to narrow, 5 mph corridors
- Prohibit PWC behavior that endangers other marine users (e.g. jumping wakes, spinning doughnuts)
- Require PWC riders to carry liability insurance and an identification card
- Include citizen nuisance suit provisions in legislation (citizens can file a private nuisance suit if harassed by PWC activity)
- Define PWC as "thrill craft." (Differentiate PWC from other traditional boats due to their high impact, high performance characteristics.)

Enforcement Issues

It has been suggested that stricter enforcement of existing laws would be sufficient to prevent much of the problems for which PWC users are held responsible. This assumption poses a number of problems: First, many of the problems associated with PWC are a direct result of the way the machines are designed and marketed. PWC advertisements use phrases such as "hard-charging," "aggressive handling," and "speed is everything." [24] Marine patrol officers say augmenting enforcement will only solve part of the problem. PWC are "musclecraft"[25] machines designed to be used in a certain way--they open the door to reckless operation. [26] Unfortunately, the craft are being used exactly the way the industry intends them to be used--aggressively. Because PWC invite irresponsible behavior, only severe zoning restrictions or bans may, as a practical matter, be enforceable.

Second, while increased enforcement may mitigate some problems associated with PWC, it comes at a cost to citizens. Taxpayers carry the burden for augmenting marine enforcement in order to deal with the effects that one minority recreational activity imposes upon the majority of other recreational users. No amount of enforcement will completely eliminate the safety problems, noise, air and water pollution, and wildlife harassment that comes with high performance, high impact PWC operation. These are the inevitable effects of PWC activity.

Finally, the industry often donates PWC to enforcement agencies, allegedly for lifesaving or monitoring capacities (Kawasaki Corporation donates over 1,000 PWC annually to federal, state, and local law enforcement agencies; retail values for this loan program are estimated to be $5,000,000). [27] In reality, such gifts undermine agency opposition to proliferation of such craft. This amounts to divided loyalties within law enforcement when it comes to PWC regulation or bans. [28] In addition to careful consideration about whether PWC are necessary and safe for law enforcement on specific waterways, donations should be limited to search and rescue and lifesaving purposes only.

PWC Use Is Incompatible with Certain Waterways

As accident, injury, and sales rates of PWC continue to rise, local communities and government agencies, both state and federal, are considering whether PWC belong at all in their jurisdictions. For example, San Juan County in Washington state voted to ban PWC in 1995. Citizens in the San Juans contend that PWC jeopardize the unique attributes of a pristine area, including peaceful recreation and the viewing of diverse wildlife such as sea otters, loons, orca whales, and eagles. The PWC industry challenged the County's ban, but it was upheld by the Washington State Supreme Court in July of 1998. PWC are also banned on smaller lakes and rivers across the country. Some states, such as Vermont and Maine, have banned PWC on lakes smaller than a designated size (300 acres and 200 acres, respectively). Maine also allows citizens to file private nuisance suits if harassed by PWC activity.

Some local communities who have partially or completely banned PWC use include:

- San Juan County, Washington
- Mendocino County, California
- Monroe County, Florida
- San Francisco County, California
- Pacifica, California
- City of Malibu, California
- Walton County, Florida

Legal Issues

A number of different legal strategies are employed by the industry to attempt to impede strong regulations. These legal strategies and some suggestions for addressing them are detailed below. It should be noted that lawsuits are commonly used by the industry to delay or prevent meaningful PWC regulations from being implemented. Industry almost always litigates to avoid precedent-establishing regulations from being implemented elsewhere.

- ***Definition of PWC*** : The industry suggests the following definition for PWC:

  > ***'Personal Watercraft' shall mean a vessel which uses an inboard motor powering a water jet pump as its primary source of motive power and which is designed to operated by a person sitting, standing, or kneeling on the vessel, rather than the conventional manner of sitting or standing inside the vessel.*** [29]

  This definition, however, excludes PWC which carry two or more people, and jet boats, craft with many of the same characteristics of PWC. Jet boats, though slightly larger, share many of the problems unique to PWC and should be included in any regulation of these craft. The following definition, if not in conflict with a state's Harbors and Navigation Code, is more appropriate:

  > ***Personal watercraft refers to a vessel, usually less than 16 feet in length, which uses an inboard, internal combustion engine powering a water jet pump as its primary source of propulsion. The vessel is intended to be operated by a person or persons sitting, standing or kneeling on the vessel.***

- **FASFRA (*Federal Aid in Sport Fish Restoration Act, a.k.a., Wallop-Breaux funds*)**: In 1995 a U.S. Appeals court ruled that any public boat launch ramp built with FASFRA funds must allow access to all craft within similar given horsepower sizes, including PWC (***Patrick Buckley; Personal Watercraft v. City of Redding, California:*** 66 F.3d 188; 1995 U.S. App. LEXIS 33286). The court concluded that communities cannot prevent PWC from launching at these boat launch ramps. This ruling has been used by the industry to thwart community efforts to reign in PWC.

However, in 1999 a case out of Florida may blunt the industry's use of this case. In ***Kissimme River Valley Sportsman Association v. The City of Lakeland*** (60 F. Supp. 2d 1289) the United States District Court in Florida ruled that FASFRA does not create a federal right to equal access for boats of common horsepower ratings at boat launch facilities constructed or maintained under the Act.

Based on Bluewater's legal research, we believe that communities may prohibit PWC regardless of whether they have taken FASFRA funds to construct boat launches and facilities.

- ***"Class A vessel" definition*** : Industry often argues that the U.S. Coast Guard recognizes PWC as "Class A vessels," just like other traditional boats, and regulates them equally. According to the Commandant of the Coast Guard, "The term Class A vessel has no meaning insofar as Coast Guard regulations are concerned, except with regard to the fire extinguisher regulations." [30]

- ***Singling Out PWC*** : In 1995 the National Oceanic and Atmospheric Administration (NOAA) banned PWC within the Monterey Bay National Marine Sanctuary based on evidence that these vessels harmed the marine environment of the sanctuary. The Personal Watercraft Industry Association (PWIA) sued the Department of Commerce, arguing that NOAA's prohibition was unconstitutional because it singled out PWC.

  On March 3, 1995 the District of Columbia Circuit Court of Appeals upheld NOAA's PWC restrictions. In ***PWIA vs. the Department of Commerce*** (48 F3D 540, 310 U.S.APP.D.C. 364) the court found that although NOAA's restrictions did indeed single out PWC, the agency's actions were not "arbitrary and capricious" and therefore constitutional. More importantly the court ruled that when a resource management agency regulates to protect the environment it does not need "to make progress on every front before it makes progress on any front."

  However, it is very important to demonstrate substantive rationale for enacting PWC legislation. This is accomplished by legally distinguishing PWC from other craft by emphasizing their unique design and use patterns (traveling in packs, continuous circling in one location, extremely high speeds, jumping wakes), safety problems, incompatibility with numerous other forms of aquatic recreation, wildlife harassment, and excessive noise and marine pollution. When designing a regulation, be sure to include a severability clause in case a portion of your ordinance is overturned.

- ***Right of access to public waterways*** : PWC operators and industry argue that because they pay licensing and boat registration fees, they have a right to access public waterways. On July 9, 1998, the Washington State Supreme Court upheld a local PWC ban in San Juan County, Washington. In ***John Weden et al vs. San Juan County et a*** l (Docket number 96-2-00376-6) the court ruled that when a PWC rider obtains a boat registration or buys a license it is nothing more than a precondition to legally operating a PWC. Just as purchasing a hunting license doesn't permit hunting of endangered species, the court made it clear that registration does not confer an unconditional right of access.

- ***Harbors and Navigation Code*** : The Harbors and Navigation Code varies from state to state, but some codes contain provisions specific to PWC which prohibit activities like wake jumping, speeding, and reckless or negligent operation. Local regulation may legally fill the gaps in state regulation. In other words, local communities can generally restrict PWC use based on time-of-day operation, speed limits, special use districts, and sanitation and pollution concerns, but must avoid duplicating state law. San Francisco chose to establish a "special use area" where PWC would not be allowed to operate due to growing concern over their operation in areas of high activity close to the shoreline.

- ***Federal Navigation Channels:*** When a federal navigation channel runs through county waters (common it port cities/waterways like San Francisco Bay, Los Angeles Harbor, etc.), the Port and Waterways Safety Act, the Federal Boat Safety Act, and other federal laws designate certain powers of regulation specifically to the U.S. Coast Guard. These Coast Guard regulations may, in some cases, preempt a state or local PWC regulation. However, in ***U.S. vs. Locke (000 U.S. 98-1701 (2000)*** , the U.S. Supreme Court explained the provisions of federal preemption of state or local law. In sum, a state or locality may regulate as it pleases under two conditions: 1) the U.S. Coast Guard has not already regulated those

waters, and 2) the new local/state regulation addresses some local peculiarity. When enacting your local regulation, make sure to explore the presence and existing regulations of federal navigation channels, and make sure to write your ordinance is such a fashion to address "local peculiarities." A good example of this is the Marin County, CA, ordinance.

Inappropriate Recreation on Public Lands and Waterways

Adequate regulation does not obscure the fact that PWC use is not compatible with the basic values of certain waters. Federal agencies whose jurisdictions span a wide range of areas recognize the unique impact of jet skis and have regulated them accordingly. These agencies include the National Oceanic and Atmospheric Administration, Fish and Wildlife Service, and the National Park Service. PWC activity is inappropriate given the respective mandates of these government agencies to protect the public lands and waters under their care from severe damage by one unique form of recreation. The substantial impact PWC have on other visitor experiences has also compelled those overseeing these areas to limit or ban their use.

More and more, those on and off the water see a need to recognize that thrills for a few should not become a safety and environmental hazard for the majority.

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[9] Joanna Burger, ***Effects of Motorboats and Personal Watercraft on Flight Behavior Over a Colony of Common Terns*** , Nelson Biological Laboratories, Rutgers University, 1998.

[10] "Testimony and Exhibits Submitted to Board of County Commissioners Regarding Restrictions on Use of Jet Skis in San Juan County," ***Superior Court of Washington for Whatcom County*** , Exhibit 22, Jan. 31, 1996.

[11] Department of Land and Natural Resources, Division of Boating and Recreation. Act 140, 1995.

[12] According to ***Personal Watercraft Illustrated,*** 2000 model year PWC on average burn 15.1 gallons per hour at wide open throttle. According to the Environmental Protection Agency and several other government agencies, PWC two stroke engines dump between 25 and 30 percent of their gas and oil mixture unburned. Multiplying 15.1 by .25 and .3 reveals that PWC can dump between 3.79 and 4.53 gallons of fuel into the environment every hour.

Statistics taken from "Proposed Regulations for Gasoline Spark-Ignition

Marine Engines, Draft Proposal Summary." Mobile Source Control Division, State of California Air Resources Board; June 11, 1998, p. 2: Average 77 horsepower (Hp) PWC emits 8,427 grams hydrocarbons (HCs)/hour; 8,427 g HCs/hr. Ö 454g/lb. = 18 lbs./hr; 18lbs./hr. Ö 6 lbs./gallon = 3 gallons HCs/hr.; The average 77 Hp PWC emits 3 gallons of gas and oil per hour of use.

[13] Ibid; Federal Register, Air Pollution Control; Gasoline Spark-Ignition Marine Engines; 40 CFR Parts 89,90,91, October 4, 1996; California Air Resources Board staff (Mark A. Carlock, Chief), "Proposed Pleasure Craft Exhaust Emissions Inventory," July 7, 1998, pp. 4-9.

[14] Draft Proposal Summary, California Air Resources Board. (June 11, 1998) op.cit, p. 2.

[15] Watercraft SIP Team. "Overview of ARB's Spark-Ignition Marine Engine Regulations." July 9, 1998, pp. 2-3.

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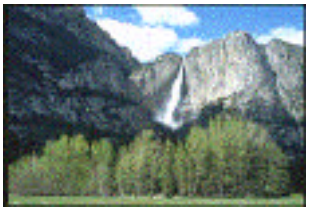

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Bluewater Network is a project of Earth Island Institute.

National Park Service

Water Resources Division
Mark VanMouwerik
Matt Hagemann
May 27, 1999

Water Quality Concerns Related to Personal Watercraft Usage

Introduction

Nearly all personal watercraft (PWC) utilize conventional two-stroke engines. As much as 30 percent of the fuel used by these engines is discharged unburned into water [1]. The combustion process discharges additional toxic compounds into water. As a result, the use of PWCs has resulted in measurable water quality degradation in the nation's lakes and reservoirs.

The following components of the fuel are discharged to the receiving water: benzene, toluene, ethyl benzene, xylene (collectively called BTEX), and methyl tertiary butyl ether (MTBE). Polycyclic aromatic hydrocarbons (PAHs) are discharged to water in small amounts as part of the unburned fuel and in much larger amounts as part of the exhaust from engine combustion. Because of its chemical characteristics, BTEX readily transfer from the water to air whereas MTBE and PAHs do not. MTBE and PAHs have been found in lakes and reservoirs with PWC usage, sometimes at levels in excess of human health and ecologic risk standards.

This report has been written to:

- document concentrations of MTBE and PAHs found in lakes and reservoirs in the U.S. as a result of recreational watercraft usage;
- identify the risks that MTBE and PAHs pose to humans and aquatic organisms;
- describe management strategies that have been taken by other agencies to address concerns posed by these contaminants;
- interpret the results of these studies to determine the water quality concerns related to PWC usage; and
- provide a list of helpful references on this topic.

Combustion Process

Conventional Two-Stroke Engines

Also known as "two-cycle" engines, these motors intake a mixture of air, gasoline, and oil into the combustion chamber while exhaust gases are being expelled from the combustion chamber. Since the intake and exhaust processes are occurring at the same time, it is unavoidable that some of the unburned fuel mixture will escape with the exhaust. This expulsion of unburned fuel is the reason for the elevated levels of hydrocarbon emissions from conventional two stroke engines.

Hydrocarbon emission levels for conventional two-stroke outboard or PWC motors range from approximately 100 grams/kw-hr to more than 300 grams/kw-hr [2]. Based on average use, a typical conventional two-stroke outboard or PWC will expel as much as 30% of the incoming fuel mixture, unburned, via the exhaust. At common fuel consumption rates, an average two-hour ride on a PWC may discharge three gallons of the gas-oil mixture into the water.

Direct-Injection Two-Stroke Engines

These new engines also have concurrent intake and exhaust processes; however, unlike the conventional two-strokes, the intake charge is air only (no fuel is mixed into the intake charge). The fuel is injected directly into the combustion chamber only after the exhaust process has finished. This means that no unburned fuel escapes with the exhaust. This results in a four-fold decrease in smog-forming pollution in a typical 90-horsepower engine when compared to a conventional two-stroke [1]. However, these emissions from direct-injected two-strokes are still four times higher than four-stroke engines with the same horsepower [1].

Regulatory Requirements

In December 1998, the California Air Resources Board adopted new emission regulations for gasoline-powered marine engines, including outboard, PWC, and some jet boat engines [1]. The regulations apply only to new marine engines manufactured for the 2001 model year and later. There is no requirement to retrofit pre-2001 model year watercraft or engines.

Under California Air Resources Board's new regulations, a typical marine engine will become 75% cleaner by 2001 and 90% cleaner by 2008. The reduction in pollution will be achieved, in part, through the use of direct-injection two-stroke engines with catalytic converters.

Direct-Injection Engine Availability

PWC manufacturers are currently in the process of introducing direct-injection engines. The first direct-injection PWCs debuted late in the 1998 model year. It is expected that most manufacturers in the U.S. market will offer a full range of direct-injection outboard and PWC engines by approximately 2002, partly in response to the demands imposed by California and Federal regulators.

Contaminants

MTBE

Background

The addition of oxygenates, such as MTBE and ethanol, to gasoline has become more common in recent years. These oxygenates enhance octane level, increase burning efficiency, and reduce the emission of atmospheric pollutants. The most frequently used oxygenate is MTBE which is used in 17 states to meet air quality standards [3]. According to EPA's Office of Mobile Sources, about 30% of U.S. gasoline currently contains some form of oxygenate for air quality improvement purposes at levels up to 15% by volume. More than 10 billion kg of MTBE were

used in U.S. gasoline in 1996 [4], making MTBE the second-most widely produced chemical in the U.S. [5].

MTBE is difficult to remove from contaminated water because of its high water solubility and low volatility. Most water treatment plants would have little or no effect in reducing MTBE concentrations from the raw water supply without expensive system upgrades.

MTBE can contaminate surface water through point-source releases such as underground storage tank leaks. MTBE can also contaminate surface water through non-point releases such as stormwater runoff. The contamination of lakes and reservoirs with MTBE has been documented where PWCs are used. The recreational use of two-stroke motors has been identified as a primary cause of this contamination. In general, lakes and reservoirs with greater degrees of recreation show higher concentrations of MTBE, particularly in the summertime and in upper water layers [6].

The State of California has adopted a secondary drinking water standard of 5 µg/L (microgram per liter or part per billion) for MTBE on the basis of taste and odor [7]. California has also proposed a primary, health-based drinking water standard of 13 µg/L for MTBE [7].

MTBE in Surface Water

The Metropolitan Water District (MWD) of Southern California has conducted an extensive MTBE monitoring program in six surface water reservoirs of varying recreational activity [6]. The occurrence of MTBE correlated with the general pattern of recreational use by motorized watercraft. These investigators determined seasonal trends at Lake Perris and found that concentrations of MTBE reached as high as 25 µg/L at the lake surface in the summertime, a level exceeding California's primary drinking water standard of 13 µg/L. MTBE was found in concentrations up to 8 µg/L in Lake Perris in the fall and winter as the lake mixed vertically, a level exceeding the 5 µg/L California secondary maximum contaminant level (MCL) [6].

Concentrations of MTBE in and around marinas, or in other areas expressly used for boating, can be much higher [8]. In Shasta Lake, a large hydropower and recreational-use reservoir in northern California, concentrations ranged from 9-88 µg/L over the Labor Day 1996 weekend. Maximum values were associated directly with large boats entering a docking area or with engine exhaust from these same vessels. MTBE was also measured in a temporary lake constructed in southern California for a jetski event in the summer of 1996. After the three-day event, concentrations ranged from 50-60 µg/L and were well mixed in this shallow water body. Concentrations of MTBE at Lake Tahoe in the vicinity of boating activity were often within the range of 20-25 µg/L, with a single maximum measured value of 47 µg/L [8].

Since March 1997, one of the most extensive efforts to monitor MTBE to date has been conducted at Donner Lake, California [8]. The ongoing research at Donner Lake has indicated the following:

- Of the 470 samples analyzed to date, MTBE concentrations have ranged from 0.09 to 12.1 µg/L;

- Concentrations of MTBE appear to be uniformly distributed throughout the entire surface area of the lake;
- Residual concentrations carried over from 1996 to 1997 are in the range of 0.1-0.2 µg/L;
- Beginning in early May, and coincident with the onset of the summer boating season, MTBE concentrations in the surface waters increased from a low value of 0.1 µg/L on April 24th to approximately 2 µg/L just prior to the 4th of July weekend;
- Sampling on July 7 showed a dramatic six-fold increase of MTBE in surface water from 2 to 12 µg/L. This increase is most likely the result of increased fuel exhaust into Donner Lake from 2-stroke engine watercraft since rainfall and urban runoff was negligible at this time, and since stream flow was nearing its seasonal minimum;
- MTBE in the upper and warmer portion of the lake (0-35 feet deep) was uniformly high as the result of natural wind mixing of these waters. Below approximately 50 feet in the colder uncirculated waters, MTBE was always less than 0.5 µg/L. This distinct distribution results from the formation of a stable density boundary in the lake which prevents mixing between the surface and bottom waters; and
- During March and April, before boating activity increased on the lake, it was calculated that Donner Lake contained 45-65 pounds of MTBE. By July 1, this had increased to 250 pounds with a sharp increase to a maximum of 815 pounds shortly after the July 4th holiday. Over the September Labor Day weekend, MTBE also increased but much less dramatically (i.e., approximately a 100-pound increase).

PAHs

Background

PAH molecules contain two to seven benzene rings. Their environmental fate, persistence, and toxicity are related to this molecular structure and to the number and configuration of attached alkyl groups (such as methyl (CH_3-) or ethyl (CH_3CH_2-) groups). The smaller and lighter (i.e., two- and three-ringed) compounds are generally more water-soluble, more biodegradable, and more volatile. Their solubility makes them more bioavailable (and more of a risk) to aquatic life, but their low persistence also reduces exposure times. The larger and heavier (i.e., four- through seven-ringed) compounds are generally much less water soluble, bind more strongly to sediment and tissue of exposed organisms, and don't biodegrade or volatilize as easily. PAHs (light or heavy) with alkyl groups attached are more persistent and more likely to bind to sediment and tissue than the non-alkylated "parent" PAH compounds. The lighter PAHs are generally thought to be more of an immediate (acute) threat to organisms in the water column, while the heavier PAHs (including the alkyl PAHs) tend to be a longer-term (chronic) threat to sediment-dwelling organisms. Recent studies (as discussed herein), however, are showing a wider range of PAHs (including the heavy and alkyl PAHs) to also be in the water and be a risk to aquatic life. Some consider the possible effects of a PAH-contaminated sediment accumulating in the benthic zones of lakes/reservoirs to be a more serious, but currently less understood, risk to aquatic life. (This paper, however, does not specifically address sediment; for more on PAHs, alkyl PAHs, and PAHs in sediment, see the NPS "Contaminants Encyclopedia" at http://www.aqd.nps.gov/toxic.)

PAHs in Surface Water

PAHs in unburned ("petrogenic") two-stroke fuel mixture are rare, with the possible exception of naphthalene and acenaphthene. The combustion process of the two-stroke engine, however, creates several different combustion ("pyrolytic") PAHs (including alkyl PAHs) that have been found in the water.

At least three different studies have linked motorboat usage to PAH contamination of water. One study found PAHs in the Occoquan Reservoir, a drinking-water source east of Washington, D.C. [9]. Total PAH concentrations in the water column (5-25 ft. deep) were as high as 4.12 µg/L. The most common PAHs were phenanthrene, pyrene, chrysene/benzo(a)anthracene, benzo(a)pyrene, and acenaphthene. A sample from the surface of the water at a marina was also taken which found 11 different PAHs, including those listed above plus naphthalene, acenaphthylene, anthracene, flourene, and flouranthene. This sample had a total PAH concentration of 18.86 µg/L; naphthalene, acenaphthylene, and acenaphthene were each at about 1 µg/L, and phenanthrene, pyrene, chrysene/benzo(a)anthracene, and benzo(a)pyrene were each at 2.3 µg/L or more. The PAH compounds found in the reservoir were mostly indicative of burned fuel, although some PAHs associated with unburned fuel were also present.

These PAHs were found during the month of June when boating activity was highest, and no PAHs were found at the same sample sites in October when boating activity was low, thus indicating their association with motorboats [9]. This is in agreement with another study at Lake Metigoshe, North Dakota, which found the highest hydrocarbon concentrations in July, a time of peak boating activity, and the lowest concentrations in October, a time of low boating activity [9]. Additionally, a 1997 study of motorboat pollutants in Lake Tahoe, CA/NV, found good correlation between peak boating activity and lake PAH concentrations [10].

Human Health Risks

MTBE

California has adopted a Public Health Goal (PHG) of 13 µg/L for MTBE in drinking water [7]. The PHG is a concentration of a contaminant in drinking water that does not pose any significant risk to health. The PHG for MTBE is based on carcinogenic effects observed in experimental animals. California Department of Health Service will consider the PHG in establishing a primary drinking water standard (maximum contaminant level, or MCL) by July 1, 1999 and will probably set the MCL at the level of the PHG, if technical feasibility and costs allow. The U.S. EPA adopted an advisory level of 20-40 µg/L for drinking water in 1997 [7].

California's secondary MCL for MTBE is 5 µg/L and was made effective January 7, 1999 [7]. Secondary MCLs address "aesthetic" qualities of drinking water supplies. In the case of MTBE, the purpose of the secondary MCL is to protect the public from exposure to MTBE in drinking water at levels that can be smelled or tasted.

PAHs

Of the PAHs found in the Occoquan Reservoir [9], benzo(a)anthracene, benzo(a)pyrene, and chrysene are probable human carcinogens [11]. On this basis, U.S. EPA has established an MCL for benzo(a)pyrene of 0.2 µg/L. MCLs for other PAHs have not been established.

For some of the PAHs associated with two-stroke engines (e.g., those observed in the Occoquan Reservoir study [9]), U.S. EPA has established the following water quality criteria for the protection of human health from exposure to PAHs in drinking water and in the tissue of edible aquatic organisms (e.g., fish) [12]:

Contaminant	Consumption of water and organisms (e.g., fish) (µg/L)	Consumption of organisms (e.g., fish) only (µg/L)
Anthracene	9,600	110,000
Flourene	1,300	14,000
Acenaphthene	1,200	2,700
Benzo(a)anthracene	0.0044*	0.049*
Flouranthene	300	370
Pyrene	960	11,000
Chrysene	0.0044*	0.049*
Benzo(a)pyrene	0.0044*	0.049*

* based on a one-in-a-million chance of getting cancer

Assuming the Occoquan Reservoir PAH concentrations are indicative of concentrations in other water bodies, some of the above criteria are probably being regularly exceeded in many other water bodies at least several months out of the year.

Ecologic Risks

MTBE

There is little known about the ecologic risk to aquatic organisms from MTBE. One of the most thorough studies to date [13] found:

- There is little toxicity of MTBE to aquatic organisms, with the most sensitive taxonomic group tested being green algae;
- Fish accumulate MTBE to about 1.5 times the concentration of MTBE in the water column;
- The most conservative hazard quotients for rainbow trout exposed to MTBE in two selected surface waters range from 1×10^{-3} to 6×10^{-3}, well below the level that indicates potential adverse ecological effects; and
- Adverse effects on rainbow trout are not expected until concentrations of MTBE in the water column reach 4,600 µg/L to 4,700 µg/L. These levels are much greater than the human health standards for MTBE in drinking water supplies.

This study, which was a screening-level risk assessment, identified several areas for further research, including: the potential ecological risk to benthic invertebrate communities from

MTBE; the combined toxicity from MTBE and other common constituents of gasoline to aquatic organisms; long-term investigations of MTBE toxicity; and other fish tissue studies that include species in addition to trout.

PAHs

Since there are no U.S. EPA National Recommended Water Quality Criteria (neither acute nor chronic) for PAHs [12], one must turn to the literature for concentrations that pose a risk to aquatic life.

One of the more prominent studies [10] found that ambient levels of PAHs in two-stroke motorboat emissions had significant negative impacts on fish growth and zooplankton survival and reproduction in Lake Tahoe. Lake PAH levels ranged from 0.005-0.070 µg/L. The study found that the toxicity of about half of the 15 or so PAHs measured in the water increased in the presence of sunlight. No-observed-effect-concentrations (NOEC) for these PAH phototoxins were calculated as follows: 0.009 µg/L for fish (fathead minnow) growth; 0.007 µg/L for zooplankton (Ceriodaphnia dubia) survival; and 0.003 µg/L for zooplankton reproduction. Although samples for the study were collected at a depth of three meters (m), the study predicts that PAH toxicity at these levels could be found as deep as 20 m in Lake Tahoe. This is not necessarily true for most lakes/reservoirs, however, since Lake Tahoe is highly oligotrophic and has a high degree of clarity (low turbidity).

> NOTE on phototoxicity: Much of the PAH toxicity data from the literature that resource managers compare field data to (e.g., PAH concentrations measured in a water body) do not take into account phototoxicity. The toxicity of certain PAHs in the presence of sunlight or UV light can be hundreds of times greater than would be the case in the absence of photo sources [14,15,16]. Giesy states that the toxicity of some PAHs found in two-stroke exhaust is as much as 50,000 times more toxic in field (sunlit) conditions than in laboratory (unexposed to UV light) conditions [17]. The phototoxic effect is very important to consider when determining safe/acceptable levels of PAHs in water. The results from the Lake Tahoe study [10], therefore, are especially informative because they were attained using field conditions—like sunlight (UV) and water samples from the Lake—for their toxicity tests. Other studies also have documented the phototoxicity (to the zooplankton Daphnia magna) of several PAHs [18].

Two studies by Tjarnlund, et al., exposed fish to two-stroke motor exhaust levels that would be found in or near the wake of such a boat. All exhaust components—not just PAHs—were included in these studies. One study found several different morphological disturbances in fathead minnows, and elevated levels of DNA-adducts in the blood, liver, and kidneys of perch [19]. The other study found disruption of biological functions in rainbow trout at different levels of biological organization including cellular and subcellular processes (DNA-adduct levels and enzyme activity) and physiological functions (carbohydrate metabolism) [20].

Two other recent studies measured the toxicity of PAHs from crude oil to fish. Some of the PAHs involved in these studies also have been found in the burned-fuel component of two-stroke

discharge. In the first, total PAH concentrations (from weathered crude oil) of 0.7 µg/L caused malformations, genetic damage, mortality, decreased size, and inhibited swimming in Pacific herring eggs; concentrations of 0.4 µg/L caused sublethal responses such as yolk sac edema and immaturity consistent with premature hatching [21]. In the second, experiments with Pink salmon embryos led the authors to conclude that water quality standards for total PAHs above 1.0 µg/L may fail to protect fish embryos; they suggest a standard of only 0.010 µg/L (includes a safety factor of ~100x) [22].

> NOTE: It is important to note that this suggested standard be based on both "parent" PAH *and* alkyl PAH measurements. Most total PAH analyses do not use laboratory methodologies that detect the alkyl PAHs, thus underestimating—often grossly so—true total PAH concentrations and the risk they pose. To use standards or criteria that are based on both "parent" and alkyl PAHs properly would require analyzing water samples (or sediment, soil, or tissue) for the same PAHs. This discrepancy between the PAHs that are actually out in the environment and those that usually are actually measured or used to calculate standards and criteria is a growing controversy among environmental toxicologists. This explains why many in the field require that the so-called "expanded" PAH scan be conducted when measuring PAH concentrations in environmental samples. (See reference [23] for a description of this analytical method.)

Actions by Water Management Agencies

On the basis of concerns for contamination of water supplies used for human consumption, at least five water management districts have banned or restricted the use of motor boats, including PWCs, on reservoirs in California [24]. These agencies include Metropolitan Water District (MWD) of Southern California, East Bay Municipal Utility District (East Bay MUD), Contra Costa Water District, Santa Clara Valley Water District, and Tahoe Regional Planning Agency. East Bay MUD has proposed to ban all two-stroke engines, including direct-injection, by January 1, 2000.

Some of the current restrictions include selective bans on PWCs in the summer and fall months. The banning of PWC usage as opposed to other types of watercraft is based on studies that show PWCs impart a disproportionate amount of pollution to water. Data from one study of PWCs and outboard motorboats show that PWCs emitted 80% of the hydrocarbons while representing one third of the watercraft [25]. PWCs use more fuel and discharge more pollution to water than other watercraft with outboard two-stroke engines because they are designed and operated differently. PWCs have a narrow hull that rides low or sinks in the water. To get the hull to plane more efficiently on the surface of the water, operators commonly open the throttle fully to "give it gas." Additionally, PWCs tend to sink when performing common stunts at lower speeds and the throttle must be fully opened to complete the maneuvers.

Water management agencies are also selectively drawing water from depths below those where the highest MTBE concentrations are found. This is only an option at lakes where depth-specific intake structures have been constructed and where MTBE is concentrated in the upper part of the water column [6]. MWD has documented MTBE to be uniformly distributed throughout the

water column at 4 µg/L in Lake Perris in Southern California. If motorboat usage were to increase at that lake, it is possible that the secondary MCL of 5 µg/L could be exceeded, no matter what the intake depth. Typical water treatment plants have little or no effect in reducing MTBE concentrations from the raw water supply.

Conclusions

- The use of two-stroke engines, including PWCs, has resulted in the contamination of lakes and reservoirs. MTBE and PAHs are commonly observed two-stroke contaminants and pose the most serious threats to human and ecological health. Concentrations of MTBE in lakes in California routinely exceed State human health standards and taste and odor thresholds. At drinking water intakes in these lakes, concentrations of MTBE have, on occasion, exceeded the taste and odor threshold. Water treatment facilities are generally ineffective in reducing MTBE concentrations. Therefore, with increasing motorboat use, unacceptable tastes and odors as well as health risks could be posed to drinking-water consumers. Aquatic ecologic communities do not appear to be threatened by observed concentrations of MTBE; however, more research is needed to reinforce this conclusion.

- PAH concentrations in lakes and reservoirs with high motorboat activity have been found at levels dangerous to aquatic organisms. The concentrations causing adverse effects can be extremely low (parts-per-trillion range) due to PAH phototoxicity, especially in oligotrophic waters where sunlight penetration is high. Some are concerned about possible adverse effects from PAHs bound to sediment, especially in waters higher in suspended solids; this phenomenon is currently poorly understood. PAH concentrations in lakes and reservoirs with high motorboat activity also have been found at levels dangerous to human health where humans are drinking the water and/or consuming the fish from these waters. Although PAH concentrations have not been widely measured, there is no reason to believe that the concentrations quoted from the studies above are not widespread in lakes or reservoirs with high motorboat activity.

- Management strategies adopted by other agencies include outright bans on PWC and restricted use of two-stroke motors. The exclusive use of the newly introduced and less polluting, direct-injection two-stroke engines has also been examined by water management agencies. Other strategies include drawing relatively uncontaminated water from deeper intervals to supply drinking water.

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EXCELLENT ORDINANCES

Excellent Local Jet Ski Ordinances

Lake Tahoe, California: Because of concern regarding the effects of gas and oil pollution from two-stroke engines on Lake Tahoe, the Tahoe Regional Planning Agency enacted an ordinance which phases out carbureted two-stroke engines by 1999. The ordinance also establishes a "No-Wake Zone" within 600 feet of the waterline of Lake Tahoe.

City of Malibu, California: Prohibits operation of jet skis within 300 yards of the shoreline of any beach, except in authorized areas. Stated reasons for prohibition: "Personal motorized watercraft [jet skis] present a nuisance and a hazard if used in close proximity to beaches — they are hazardous to swimmers and other recreational users of the ocean, they are extremely noisy and they spew gasoline fumes. The public health, safety and welfare requires that a clear separation be maintained between motorized watercraft users and beach-goers."

Mendocino County, California: Jet skis are banned on all coastal estuaries, this includes their bay from headland to headland and their rivers for a distance of seven miles inland from the mouth of the rivers.

Monroe County, Florida: This ordinance prohibits the operation of jet skis within 1200 feet of the shoreline in specified areas of the county. It also includes a provision that allows citizens to petition for adoption of new "personal watercraft prohibited zones" within the County.

San Francisco County, California: Jet ski use is banned within 1200 feet of the entire shoreline of San Francisco County — known as a "special use area" — including the east part of Angel Island and all of Alcatraz and Treasure Islands. An "access corridor" allows jet skis to launch from the public boat ramp and travel out to Bay waters beyond the special use area. The ordinance also includes a provision which allows citizens to file a private nuisance suit if harassed by jet ski activity.

San Juan County, Washington: San Juan County has banned jet ski use on all waters within the exterior boundaries of the County. On July 9, 1998, the Washington State Supreme Court upheld this local jet ski ban in San Juan County, Washington. In ***John Weden et al. vs. San Juan County et al.*** (Docket number 96-2-00376-6) the court ruled that when a PWC rider obtains a boat registration or buys a license it is nothing more than a precondition to legally operating a PWC. The court made it clear that registration does not confer an unconditional right of access.

Walton County, Florida: Prohibits the operation of jet skis within certain areas of the County. Jet skis are not permitted within 750 feet of the shoreline except in a designated "vessel corridor." While in the vessel corridor they cannot operate in excess of idle speed.