						yes/no				
Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Water Quality Impacts	The effects of powerboat emissions on the water quality of Loch Lomond.	Bannan, M. 1999. The effects of powerboat emissions on the water quality of Loch Lomond. Ph.D. Dissertation, Glasgow University, Scotland.	Hydrocarbon analysis of exhaust-polluted water	exhaust	unspecified	no	yes	yes	no	This study shows that hydrocarbon pollution from a relatively small number of inefficient powered recreational craft using a Scottish lake poses a potential environmental threat to water chemistry and zooplankton communities.
Water Quality Impacts	Stirring up trouble: Resuspension of bottom sediments by recreational watercraft.	Beachler, M.M., and D.F. Hill. 2003. Stirring up trouble: Resuspension of bottom sediments by recreational watercraft. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1):15-25.	Experimental and theoretical study of the hydrodynamic impacts of recreational watercraft in shallow waterbodies	turbulent prop or jet wash	unspecified	yes	yes	yes	no	Through a combination of field experimentation and mathematical modelling, thes study illustrates the mechanism of bottom stirring by recreational watercraft (inboard, outboard, and jet propulsion). A relationship for boat speed and maximum bed velocity for several different depths was modelled. Also noted that PWC with their expectionally shallow drafts has increased traffic in regions of water bodies which have historically seen little boating.
Water Quality Impacts	The direct physical, chemical and biotic impacts on Australian coastal waters due to recreational boating.	Burgin, S., and N. Hardiman. 2011. The direct physical, chemical and biotic impacts on Australian coastal waters due to recreational boating. Biodiversity and Conservation 20(4): 683-701.	Recreational impacts on of boats on aquatic ecosystems	physical, chemical, biotic	unspecified	no	yes	no	yes	Physical impacts: disturbance due to movement of craft in shallow water (turbulence), effects of anchoring/drag, and noise/interference/collision with wildlife. Chemical impacts: pollution from fuels and oils, defouling treatments, and human waste. Biotic impacts: introduction and spreading of non-native species. Impacts of recreational boating can be lessened with the support of governments to guide, engage, and educate the boating fraternity.
Water Quality Impacts	MTBE in southern California water.	Dale, M.S., B. Koch, and R.W. Losee, RW. 2000. MTBE in southern California water. Journal of the American Water Works Association 92(8):42-51.	Water quality monitoring of California reservoirs that allow recreational boating	MTBE	humans	no	yes	yes	no	Methyl tertiary butyl ether (MTBE) is a common fuel oxygenate used in motor vehicle fuels to control emissions and boost octane. MTBE has been identified as a surface water contaminant, and major contributions of MTBE are from two-stroke engine watercraft. Precipitation and runoff seemed to be minimal contributors of MTBE to the reservoirs evaluated in this study.
Water Quality Impacts	Potential impacts of emissions from outboard motors on the aquatic environment: A literature review.	Depree, C. 2007. Potential impacts of emissions from outboard motors on the aquatic environment: A literature review. NIWA Project ELF07201/Client Report HAM2007-026. Prepared for West Coast Regional Council. National Institute of Water & Atmospheric Research Ltd., New Zealand.	Boat derived contaminants on water quality (environmental toxicity and drinking water criteria)	sub-surface exhaust emissions	unspecified eggs/larvae	yes	yes	yes	no	Normal levels of motorized recreational boating activity does not have a significant impact on water quality with respect to toxicity. The main contaminants of concern are BTEX compounds, PAHS, and the fuel additive MTBE. These can negatively impact plankton productions and the environmental microlayer where eggs accumulate and larvae feed. Also noted: PWC release disprportionately large amounts of fuel emissions into the water in shallow waters that otherwise would not be disturbed by other forms of boating.

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Water Quality Impacts	Physical and chemical characteristics of Knowles, Forgotten, and Moqui Canyons, and effects of recreational use on water quality, Lake Powell, Arizona and Utah.	Hart, R.J., H.E. Taylor, R.C. Antweiler, G.G. Fisk, and G.M. Anderson. 2004. Physical and chemical characteristics of Knowles, Forgotten, and Moqui Canyons, and effects of recreational use on water quality, Lake Powell, Arizona and Utah. Scientific Investigations Report. 2004-5120. U.S. Geological Survey.	Results of a 2-year water sampling program at site on Lake Powell before and after the high-use season	volatile organic compounds (VOCs), wastewater, byproducts of fuel-based contaminants	unspecified	yes	yes	yes	no	Concentrations of many chemical contaminants were higher during the high-use period than during the low-use period. Report illustrates specific temporal and spatial water-quality deterioration caused by visitor use.
Water Quality Impacts	VOC loading from marine engines to a multiple-use lake.	Heald, P.C., S.G.R. Schladow, and B.C.Allen. 2005. VOC loading from marine engines to a multiple-use lake. Lake and Reservoir Management 21(1):30-38.	A boating survey to quanitfy daily MTBE and BTEX loading from recreational boating on N. Cal multi-use lakes	VOCs	unspecified	yes	yes	yes	no	MTBEs have greater resistance to microbial degradation and persist in the waters longer than BTEX compounds. Study makes clear that aside from eliminating gasoline-fueled engines and MTBE in gasoline, phasing out the use of older technology 2-stroke engines is the single most effective means of controlling MTBE and BTEX inputs to lake and reservoirs.
Water Quality Impacts	Polycyclic aromatic hydrocarbon (PAH) ecotoxicology in marine ecosystems.	Hylland, K. 2006. Polycyclic aromatic hydrocarbon (PAH) ecotoxicology in marine ecosystems. Journal of Toxicology and Environmental Health-Part A-Current Issues 69(1-2):109-123	Carcinogenic effects of PAH on marine organisms	PAH	molluscs, flatfish, perch	no	yes	no	yes	PAH inputs to the marine environment derived from incineration processes (pyrogenic) and from fossil fuels (petrogenic). This report primarily focuses on pyrogenic effect from the smelter industry and offshore activities in Norway. Also noted: The exhaust from outboard engines used with leisure vessels may contribute sufficient PAHs to induce adverse effects in some coastal areas (Tjarnlund et al 1996).
Water Quality Impacts	Health & environmental assessment of MTBE: Report to the Governor and Legislature of the State of California as sponsored by SB 521.	Keller, A., J. Froines, and C. Koshland. 1998. Health & environmental assessment of MTBE: Report to the Governor and Legislature of the State of California as sponsored by SB 521. Volume 1: Summary & Recommendations. University of California, Santa Barbara	Reformulated gasoline air quality benefits vs human health and ecological efffects of MTBE	MTBE	humans	no	yes	yes	no	RFG is intended to reduce engine pollutant formation and air toxic emissions. Added gasoline oxygenates promote more efficient combustions by converting carbon monoxide to carbon dioxide. Improvements in newer engines also significantly reduce emissions of air pollutants, and MTBE and other oxygenates were found to have no significant effect on exhaust emissions from these newer vehicles. Report recommends phasing out MTBE over serveral years to allow refiners to develop and produce non-oxygenated RFG.
Water Quality Impacts	Underwater emissions from a two-stroke outboard engine: a comparison between an EAL and an equivalent mineral lubricant.	Kelly, C.A., G.A. Ayoko, and R.J. Brown. 2005. Underwater emissions from a two-stroke outboard engine: a comparison between an EAL and an equivalent mineral lubricant. Materials & Design 26(7):609-617.	Characterizing and quantifying pollutants in water column from 2-stroke engine	PAHs and VOCs	unspecified	no	yes	yes	yes	Emission rates of PAHs and VOCs were determined for 2-stroke engine when using a mineral and equivalent environmentally adapted lubricant (EAL). Results show little difference in emissions rates of pollutants with either lubricants in salt and fresh water.

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Water Quality Impacts	Gasoline-related compounds in Lakes Mead and Mohave, Nevada,	Lico, M.S, and B.T.Johnson. 2007. Gasoline-related compounds in Lakes Mead and Mohave, Nevada, 2004-06. Scientific Investigations Report 2007-5144. U.S. Geological Survey	Sampling of lake waters to determine distribution of man-made organic compounds related to use of gasoline powered engines	PAHs, MTBE, VOCs (BTEX)	unspecified	no	yes	yes	no	Every site sampled detected compounds contained in raw gasoline (BTEX) and those produced by combustion of gasoline (PAH). MTBE was detected in 2004, although concentrations decreased most likely due to the removal of MTBE from gasoline purchased in California. Evidence indicates that motorized watercraft are the principal source of BTEX and PAH in lakes.
Water Quality Impacts	Assessing environmental impacts of two-stroke outboard motor lubricants using tank testing and simple dispersion model.	Loberto, A.R., R.J. Brown, and C.A. Kelly. 2003. Assessing environmental impacts of two-stroke outboard motor lubricants using tank testing and simple dispersion model. Pages 3-12 in: 2nd International Conference on Tribology in Environmental Design, Bournemouth Univ., Poole, England, Sept 8-10, 2003.	Experimentally investigate the spread of emissions by the boat wake and its propeller	exhaust	unspecified	yes	yes	yes	yes	Mixing action of the propeller is extensive resulting in relatively low concentrations of the emitted pollutants. The propeller of a boat mixes more extensively than that of a jet.
Water Quality Impacts	MTBE and gasoline hydrocarbons in ground water of the United States.	Moran, M.J. J.S. Zogorski, and P.J. Squillace. 2005. MTBE and gasoline hydrocarbons in ground water of the United States. Ground Water 43(4):615-627	The occurrence and distribution of MTBE and gasoline hydrocarbons in national samples of ground water over 10 year period	MTBE	humans	no	yes	yes	no	Although relatively infrequently detected in ground water sampling, the detection frequency of MTBE rivals or surpasses other VOCs that have been produced and used for a much longer period of time. The potential long-term human health effects of low-level concentrations of MTBE in drinking water are not well understood.
Water Quality Impacts	Seasonal increases in polycyclic aromatic hydrocarbons related to two-stroke engine use in a small Alaskan lake.	Rice, S.D., L. Holland, and A. Moles. 2008. Seasonal increases in polycyclic aromatic hydrocarbons related to two-stroke engine use in a small Alaskan lake. Lake and Reservoir Management 24(1):10-17	The role of boating activity on the presence of PAHs through interannual sampling with passive samplers	PAHs	fish	yes	yes	yes	no	Seasonal increases of PAHs coincide with spatial and temperal increases in the use of 2-stroke powered jet skis and skiffs. PAH loads indicate a chronic exposure issue for aquatic residents of lakes and are cause for concern for the long-term water quality needs of fish and wildlife.

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Water Quality Impacts	Analysis, occurrence and fate of MTBE in the aquatic environment over the past decade.	Rosell, M., S. Lacorte, and D. Barcelo. 2006. Analysis, occurrence and fate of MTBE in the aquatic environment over the past decade. Trends in Analytical Chemistry [TrAC] 25(10): 1016-1029.	Updated overview of the analytical techniques, environmental occurrence and fate of MTBE in studies over past decade	MTBE	humans, aquatic life	yes	yes	yes	no	Fuel oxygenate MTBE is nearly ubiquitous in the worldlwide environment. The use of motorized watercraft was the major contribution as a source of MTBE, whereas neither highway run-off nor precipitation contributed significantly. Restrictions of highly emitting 2-stroke engine types should be considered.
Water Quality Impacts	Concentrations, sources, and fate of the gasoline oxygenate methyl tert-butyl ether (MTBE) in a multiple use lake.	Reuter, J.E., B.C. Allen, and R.C. Richards. 1998. Concentrations, sources, and fate of the gasoline oxygenate methyl tert-butyl ether (MTBE) in a multiple use lake. Environmental Science & Technology 32(23):3666-3672.	MTBE measurements on multi-use lake at 9 individual depths on 16 dates	MTBE	humans	yes	yes	yes	no	Recreational boating was the msot important source of MTBE, neither highway runoff nor precipitation contributed significantly. Peaks of MTBE in early July, minimum occurred in January. Thermal stratification slows MTBE transportation to deeper depths.
Water Quality Impacts	A personal watercraft-based system for coastal ocean mapping.	Webb, B.M. 2012. A personal watercraft-based system for coastal ocean mapping. Journal of Ocean Technology 7(2):48-68	Use of PWC as a platform for coastal mapping			yes	no	no	yes	A novel PWC-based system for coastal ocean mapping has been developed, field-tested, and deployed in Alabama's coastal waters to measure tidal currents, hydrography, and near-surface water characteristics in shallow water.
Water Quality Impacts	Jet ski provides platform for collecting water quality data in bay studies.	Werblow, S., and B. Webb. 2012. Jet ski provides platform for collecting water quality data in bay studies. Sea Technology 53(8):45+.	Use of PWC as a platform for coastal mapping			yes	no	no	yes	Jet ski deployed to measure hydrocarbons and investigate coastal dynamics in coastal waters.
Noise	The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (Micropterus salmoides).	Graham, A.L., and S.J. Cooke. 2008. The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (Micropterus salmoides). Aquatic Conservation-Marine and Freshwater Ecosystems 18(7):1315-1324.	Physiological measurement (cardiac output) of bass under three types of boat noise	boating noise	Largemouth bass	no	yes	yes	no	Cardiac output, an indicator of fish stress, increases in magnitude from exposure to canoes, trolling motors, and combustion engines. Results demonstrate that fish experience sublethal physiological disturbances in response to the noise propagated from recreational boating activities.

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Noise	Underwater noise of small personal watercraft (jet skis).	Erbe, C. 2013. Underwater noise of small personal watercraft (jet skis). Journal of the Acoustical Society of America 133(4):EL326-EL330.	PWC noise measurements with undewater acoustic recorders to be used for environemental impact studies	PWC noise		yes	no	no	yes	Although quieter underwater than boats, the sound pressure level might not be a good indicator of the bioacoustic impact on marine fauna.
Noise	Drowning in noise, noise costs of jet skis in America	Komanoff, C. and H. Shaw. 2000. Drowning in noise-Noise costs of jet skis in America. Noise Pollution Clearinghouse. Montpelier, VT.	Report on noise pollution, charterization of noise and report of human perception of monetary cost of PWC noise	PWC noise	humans	yes	no	yes	yes	Biggest difference between noise from PWC and motorboats is that the former continually leave the water, which magnifies noise in two ways. Without the muffling effect of water, the engine noise is t ypically 15 dBA louder, and the smacking of the craft against the water surface results in a loud "whoop" or series of them. With the rapid maneuvering and frequent speed changes, the impeller has no constant "throughput" and no consistent load on the engine. Consequently, the engine speed rises and falls, resulting in a variable pitch. This constantly changing sound is often perceived as more disturbing than the constant sound of motorboats. Estimates costs of PWc noise in terms of perceived loss of value by nearshore human users.
Legal, Manage-ment & Policy	Acadia bans PWCs on lakes.	Daerr, E.G. 1998. Acadia bans PWCs on lakes. National Parks 72(9/10):45	The first legislative ban of PWC in a National Park			yes	no	yes	no	With invovlement from NPAC, National Parks and Conservation Association, Acadia National Park in Maine becomes the first national park to legislatively ban PWC from lakes and ponds.
Legal, Manage-ment & Policy	The National Park Service's proposed ban: A new approach to personal watercraft use in the national parks.	D'Antuono, K. 2000. The National Park Service's proposed ban: A new approach to personal watercraft use in the national parks. Boston College Environmental Affairs Law Review 27(2):243.	An examination of the legality of NPS ban on PWC use	safety concerns, pollution, noise, habitat disruption, wildlife disturbance	aquatic flora and fauna, water bodies, and humans	yes	yes	yes	yes	NPS invoked its regulatory powers under Organic Act to propsoe a System-wide ban of PWC, citing safety concerns, adverse environmental impacts, and harming wildlife. The author views that the System-wide ban is both a legal and effective remedy, and that exemptions from the ban should be granted on a limited basis.
Legal, Manage-ment & Policy	PWCs banned from towns at Cape Cod.	Dougherty, R. 2002. PWCs banned from towns at Cape Cod. National Parks 76(3/4):16	NPCA successfully lobbies Massachusetts to bans PWCs from waters surrounding four seaside towns			yes	no	no	yes	Ordinance approved by Massachusetts officials banning PWC in four towns surounding Cape Cod Natinoal Seashore. These local waters are contiguous with federal waters, considered ecologically sensitive.

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Legal, Manage-ment & Policy	PWCs banned most of park system.	Dougherty, R. 2002. PWCs banned most of park system. National Parks 76(5/6):14.	NPCA highlights PWC usage debate in National Park System			yes	no	yes	yes	Timeline from 1998 - 2002 highlighting ban on PWCs within National Park System. At time of printing PWC is allowed at 16 out of 87 park units, which are conducting environmental assessments for PWC management.
Legal, Manage-ment & Policy	The sounds of silence: Trends in the regulation of personal watercraft.	Dudiak, T.A. 2003. The sounds of silence: Trends in the regulation of personal watercraft. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1):45-54.	An overview of boating regulatory authority with discussion of recent court decisions in PWC regulaton.			yes	no	yes	yes	With the regulatory precedent set by the NPS banning PWC, local and state entities are following the trend that imposes access limitations for recreation that may threaten resources and public safety.
Legal, Manage-ment & Policy	Taking PWCs to task.	Jacobs, I.L. 1998. Taking PWCs to task. National Parks 72(3/4):49-50.	Powerbost industry CEO opinion PWC vs. Boats			yes	yes	N/A	N/A	Powersports CEO does not think PWC should be treated the same as boats due to different operating parameters and driver behavior, which diminishes boating experiences and perception of boating community.
Legal, Manage-ment & Policy	Managing recreational use on the Yahara Lakes.	Jones, S.A. 2003. Managing recreational use on the Yahara Lakes. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1):35-44.	Dane County, WI, description and evaluation of growth of lake based recreation and balancing resource use			yes	yes	yes	no	Increase in the multi-use of popular recreational lakes has driven up conflict within user groups. Regulatory and educational practices are used to manage recreational use. An increase in comprehensive data analysis and thorough public input can help management resolve conflict and achieve balanced resource use.
Legal, Manage-ment & Policy	PWCs: Out of place in parks.	Katherine, H.M. 1997. PWCs: Out of place in parks. National Parks 71(3/4):17.	A pre-NPS Ban on PWC in parks discussion			yes	no	yes	no	outdated - A plan on zoning a portion of Lake Crescent in Olympic National Park for PWC before NPS ban on PWC in Park System.
Legal, Manage-ment & Policy	NPCA demands final PWC rule.	MacKay, K. 1998. NPCA demands final PWC rule. National Parks 72(7/8):18.	Request to issue moratrorium on PWC in national parks			yes	no	yes	yes	outdated
Legal, Manage-ment & Policy	PWC rule issued by park service.	MacKay, K. 1998. PWC rule issued by park service. National Parks 72(11/12):20.	Report that NPS has released a proposal to regulate PWC in national parks			yes	no	yes	yes	outdated

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Legal, Manage-ment & Policy	Jet skis hit bumpy water.	Morgan, K. 1997. Jet skis hit bumpy water. Earth Island Journal 12(4):9.	Report on environmental problems caused by PWC in USA			yes	no	yes	yes	outdated
Legal, Manage-ment & Policy	Use of personal watercraft banned.	O'Connell, K.A. 1996. Use of personal watercraft banned. National Parks 70(7/8):25	Report on the decision of officials of the Glacier National Park in Montana for temporary ban on PWC			yes	no	yes	no	outdated
Legal, Manage-ment & Policy	Assessment of recreation activity and its application to integrated management and spatial planning for Cork Harbour, Ireland.	O'Mahony, C., J. Gault, and V. Cummins. 2009. Assessment of recreation activity and its application to integrated management and spatial planning for Cork Harbour, Ireland. Marine Policy 33(6):930-937.	A study to create and implement an integrated management strategy for recreation in a coastal setting			yes	yes	no	yes	A collaborative effort for linking scientific research to policy and planning involving participation for marine recreational activities. Data required involves level of use and activities and how users interact with each other and the wider environment.
Legal, Manage-ment & Policy	Making waves (cover story).	Whiteman, L. 1997. Making waves (cover story). National Parks 71(7/8):22-25.	An introduction of PWC lead to plans banning them in Park System			yes	no	yes	yes	outdated
Legal, Manage-ment & Policy	UK personal watercraft management: A user perspective.	Whitfield, R., and R. Roche. 2007. UK personal watercraft management: A user perspective. Marine Policy 31(4): 564-572.	A study examines the role of PWC clubs in effecting better managmenet of the sport			yes	no	no	yes	Along with statutory framework, PWC Clubs in England are playing an increasingly important role in the management of PWC activity. Membership could be expected to altar behavior through peer eduction, and with input from coastal managers working with local clubs.
Legal, Manage-ment & Policy	Code of Federal Regulation for PWC		Federal code establishing emission standards for PWC at Lake Mead, Mojave, and Powell	air pollution		yes	no	yes	no	36 CFR §7.48 (f)(3) - After December 31, 2012, no one may operate a personal watercraft (PWC) that does not meet the 2006 emission standards set by EPA for the manufacturing of two-stroke engines. A person operating a personal watercraft that meets the EPA 2006 emission standards through the use of direct-injection two-stroke or four-stroke engines, or the equivalent thereof, is not subject to this prohibition and will be allowed to operate.

						yes/no				
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Legal, Manage-ment & Policy	Code of Federal Regulation for PWC		Federal code establishing emission standards for PWC at Lake Powell	air pollution		yes	no	yes	no	36 CFR §7.70 (e)(3) - After December 31, 2012, no one may operate a personal watercraft (PWC) that does not meet the 2006 emission standards set by EPA for the manufacturing of two-stroke engines. A person operating a personal watercraft that meets the EPA 2006 emission standards through the use of direct-injection two-stroke or four-stroke engines, or the equivalent thereof, is not subject to this prohibition and will be allowed to operate.
Legal, Manage-ment & Policy	Padre Island National Seashore Personal Watercraft Use-Environmental Assessment	NPS (National Park Service). 2006. Padre Island National Seashore Environmental Assessment. February 1, 2006. NPS, U.S. Department of the Interior, Padre Island National Seashore, Texas.	National Park Service NEPA assessment for regulations to manage or prohibit PWC in Padre Island National Seashore	disturbance from traffic, noise, potential pollution	fish, birds, submerged aquatic vegetation	yes	no	no	yes	Assessment of impacts to National Seashore from 3 alternatives: 1) remain closed to PWC 2) allow limited use of PWC 3) Allow PWC only in boat channel. Identifies projected potential use of PWC and identified adverse negiligible to moderate impacts to park resources and users, but does not identify any long term impacts to productivity. Final determination was not to open the area to PWC use.
Injury	Brief report personal watercraft injuries on noncoastal waterways.	Doering, H.B., S.D. Helmer, and J.G. Ward. 2012. Brief report personal watercraft injuries on noncoastal waterways. American Surgeon 78(9):1005-1007.	A retrospective review of PWC trauma registry from 1/1200 to 12/31/2008	PWC	Humans	yes	no	yes	no	In 2009, PWC accounted for 22 percent of all boating accidents in the US, while they only made up 10 percent of the recreational boating fleet. Head injuries were the most common and with appropriate education and increased emphasis on safety mechanisms and equipment, many PWC accidents can be prevented.
Injury	The increasing threat of personal watercraft injuries.	Latch, R, and D.H. Fiser. 2004. The increasing threat of personal watercraft injuries. Clinical Pediatrics 43(4):309-311.	Trend of increasing number and severity of injuries associated with rise of popularity of PWCs	PWC	Humans	yes	no	yes	yes	With the increasing prevalence of PWC use and injury, recommendations to reduce morbidity and mortality including using US Coast Guard approved PFDs, limiting use of PWC to trained adults, and improving recognition of significant PWC injury by medical personnel.
Injury	Human error in recreational boating.	McKnight, A., J. Becker, W. Wayne, and A.J. Pettit. Human error in recreational boating. Accident Analysis and Prevention 39(2):398-405.	Per-boat accident rates and causes from all types of recreational boats	Human error	Humans	yes	yes	yes	yes	PWC have the highest of all per-boat accident rates. Operating too close to other boats and land showing a large number of collisions. Alcohol plays a very small role in PWC accidents.
Injury	Epidemiology of Personal Water Craft Injuries	Gill, R.S., K.A. Whitlock, A.S. Jawanda, S.S. Gill and S. Karmali. 2012. Epidemiology of Personal Watercraft Injuries. Journal of Trama Treatment 1:112. doi:10.4172/2167-1222.1000112 .	Summary of PWC injuries	PWC	Humans	yes	no	yes	yes	Major causes of PWC related injuries are blunt trauma collisions. However, there is increasing recognition of rare injuries to the perineum and lower abdomen. In order to curb the high accident rates, industry and regulators will heed recommendations for protective safety equipment including helmets and wetsuits bottoms combined with improved operator education.

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Injury	Personal Watercraft Steering, Braking, and Testing	Kamen, P. 2010. Personal Watercraft Steering, Braking and Testing. Second Cheasepeake Power Boat Symposium, The Society of Naval Architects and Marine Engineers. https://www.well.com/user/pk/spa/PWC-steering.pdf (accessed April 2017).	Informal summary of braking and steering technology in PWC	technology improvments	Humans	yes	no	n/a	n/a	Description of evolution of off-throttle steering and emergency stopping equipment in PWC from 1955 to 2009, in the context of assessing accidents and improving safety. Early safety problems with PWC resulted in part from operators unable to compensate for long stopping distances and jet-based steering (rather than rudders or props). Various types of modifications to PWC to improve handling are reviewed; computer-aided throttle managment for steering and reversing is the most recent and promising, though "boat" based technologies are applicable.
Effects on Other Wildlife	Impact of recreational power boating on two populations of northern map turtles (Graptemys geographica).	Bulte, G., M.-A. Carriere, and G. Blouin-Demers. 2010. Impact of recreational power boating on two populations of northern map turtles (Graptemys geographica). Aquatic Conservation-Marine and Freshwater Ecosystems 20(1):31-38.	Assessing the vulnerability of fresh water turtles to direct effects of boating activities	boat strikes	Northern map turtle	no	yes	yes	no	Recreational power boating is a serious threat to northern map turtles, even under moderate boat traffic. Adult females are at a higher risk of being hit by boats due to differences in habitat use, movement patterns, and basking behavior. Conservation measures such as restricting speed or prohibiting powerboats in critical habitats could reduce injuries and mortality.
Effects on Other Wildlife	Impacts of Human Recreation on Brown Bears (Ursus arctos): A Review and New Management Tool.	Fortin, J.K., K.D. Rode, G.V. Hilderbrand, J. Wilder, S. Farley, C. Jorgensen, and B.G. Marcot. 2016. Impacts of Human Recreation on Brown Bears (Ursus arctos): A Review and New Management Tool. PLOS One 11(1): http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0141983	Potential population-level effects of recreational activities and the tools to aid managers in making decisions about recreational activies in brown bear habitats	anthro-pogenic recreational activites	Brown bears	no	yes	yes	no	Primary mechanism which brown bears are affected by recreation is via displacement. Most impactful during hyperphagia, when bears dramatically increase their food intake in preparation for hibernation. Decisions that managers make about regulating recreational activities in time and space have important consequences for bear populations.
Effects on Other Wildlife	Measuring the effects of water-based recreation on the spatial ecology of eastern musk turtles.	Laverty, J.F., B. Korol, and J.D. Litzgus. 2016. Measuring the effects of water-based recreation on the spatial ecology of eastern musk turtles. Copeia 104(2):440-447.	Comparison of turtle spatial ecology and health in human impacted and non-impacted sites	water-based recreation	Eastern musk turtles	no	yes	yes	no	Water-based human recreation had minimal effect on the spatial ecology of turtles. No differences in injury and mortality rates were found between impacted and non-impacted sites. Data suggested higher occurrences of mortalities at impacted site, larger sample size required.

						yes/no				
Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Other Wildlife	Recreational boats and turtles: Behavioral mismatches result in high rates of injury.	Lester, L.A., H.W. Avery, and A.S Harrison. 2013. Recreational boats and turtles: Behavioral mismatches result in high rates of injury. PLOS ONE 8(12) http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0082370	Measuring the rate of terrapin injuries due to boat strikes and determining whether terrapins behaviorally respond to boat sounds *in situ* .	boat strikes	Diamondback terrapins	no	yes	yes	no	Boat injuries were found in 11% of captured terrapins, killed terrapins not included in injury rate. Terrapins do not behaviorally respond to playback recordings of boat engine sounds (possibly because of they are habituated to the sounds produced by boat engines). Conservation measures are needed to protect viability of terrapin populations.
Effects on Other Wildlife	Animal reactions to oncoming vehicles: a conceptual review.	Lima, S.L., B.F. Blackwell, and T.L. DeVault. 2015. Animal reactions to oncoming vehicles: a conceptual review. Biological Reviews 90(1):60-76.	Providing insight into reactions of animals to oncoming vehicles when collisions might be imminent	auto, boat, or aircraft strikes	variety of taxa	no	yes	yes	no	Avoiding a collision requires successful vehicle detections, threat assessment, and evasive behavior; failures can occur at any of these stages. Much behavioral work on animal-vehicle collisions remains to be done across a wide variety of taxa.
Effects on Other Wildlife	Ungulate flight responses to human disturbance: A review and meta-analysis.	Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. Biological Conservation 141(9):2159-2173.	Types of disturbance stimuli and ungulates reactions	anthropogenic disturbance	ungulates	no	no	no	no	Environmental factors, and experience with humans and their recreational activities have significant impacts on ungulate behavior. Testable management predictions about flight responses generated from analysis that can enhance wildlife fitness and human experiences.
Effects on Marine Mammals	Behavioural responses of harbour seals to human-induced disturbances.	Andersen, S.M., J. Teilmann, and R. Dietz. 2012. Behavioural responses of harbour seals to human-induced disturbances. Aquatic Conservation-Marine and Freshwater Ecosystems 22(1):113-121.	Experimental disturbances conducted on seal reserve in Denmark	boats / pedestrians	Harbor seal	no	yes	no	yes	Harbor seals respond to approaching boats at a significantly greater distance compared with pedestrians.
Effects on Marine Mammals	Harbor seal behavioral response to boaters at Bair Island Refuge.	Fox, K. S. 2008. Harbor seal behavioral response to boaters at Bair Island Refuge. M.S. Thesis, San Jose State University.	Documentation of seal and boat interaction in San Fransisco Bay	boats	Harbor seal	no	yes	no	yes	Harbor seals demonstrate habituation to current boater traffic passing haul-out site, although a correlation was found between multiple boat events and lower total seal numbers at haul-out.
Effects on Marine Mammals	Evaluation of Boater Compliance with Manatee Speed Zones along the Gulf Coast of Florida.	Gorzelany J.F. 2004. Evaluation of Boater Compliance with Manatee Speed Zones along the Gulf Coast of Florida. Coastal Management 32:215-226.	Manatee speed zone compliance surveys in presence and absence of law enforcement	boats	Florida manatee	yes	yes	no	yes	Relative proportion of compliant boaters decreased with decreasing vessel size with lowest proportion of compliance observed among PWC. Overall compliance increases with presence of law enforcement.

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Effects on Marine Mammals	Long-term observations of a harbor seal haul-out site in a protected cove in Casco Bay, Gulf of Maine.	Harris, D. E., B. Lelli, and S. Gupta. Long-term observations of a harbor seal haul-out site in a protected cove in Casco Bay, Gulf of Maine. Northeastern Naturalist 10(2):141-148.	Seal haul-out trends over four year period	boats	Harbor seal	no	yes	no	yes	Observations of seals on molting ledges show an obvious 12-month periodicity corresponding to yearly cycles in seal behavior. The number seals at a haul-out site can vary greatly within a year and from year to year. Decreasing trend in fraction of days each month that seals were present probably not caused by increased boat activity during summer months.
Effects on Marine Mammals	Bottlenose dolphins increase breathing synchrony in response to boat traffic.	Hastie, G.D., B. Wilson, and L.H. Tufft, LH. 2003. Bottlenose dolphins increase breathing synchrony in response to boat traffic. Marine Mammal Science 19(1):74-84.	Behavioral changes of dolphins in presence of boats, short term escape responses	boats	Bottlenose dolphin	no	yes	no	yes	Synchronous breathing patterns of bottlenose dolphin increase in the presence of boat traffic; such short-term behavioral responses by dolphins may potentially accumulate to produce longer-term consequences for both individuals and whole population.
Effects on Marine Mammals	Geostatistical analyses of interactions between killer whales (Orcinus orca) and recreational whale-watching boats.	Jelinski, D.E., C.C. Krueger, and D.A. Duffus. 2011. Geostatistical analyses of interactions between killer whales (Orcinus orca) and recreational whale-watching boats. Applied Geography 22(4):393-411.	Geographic information system (GIS) analysis of recreational boats and killer whales, reserve boundary violations	boats	Killer whales	no	yes	no	yes	Reserve violations are high among all user groups, vessel behavior is associated with vessel size and method of propulsion, resulting in short-term changes in killer whale movement. This study supports recommendations of Erbe (2002) for killer whale-watching, based on acoustic analysis, where vesssels should be turned off and approach no closer than 50m to avoid hearing loss and change of behavior. Cruising speed of about 10km/hr when within a few hundred meters.
Effects on Marine Mammals	Combined physiological and behavioral observations to assess the influence of vessel encounters on harbor seals in glacial fjords of southeast Alaska.	Karpovich, S.A., J.P.Skinner, J.E. Mondragon, and G.M. Blundell. 2015. Combined physiological and behavioral observations to assess the influence of vessel encounters on harbor seals in glacial fjords of southeast Alaska. Journal of Experimental Marine Biology and Ecology 473: 110-120.	Heart rate recorder attached to harbor seals for physiological response to incidental traffic and experimental disturbances	boats	Harbor seal	no	yes	no	yes	From monitoring heart rates in seals, disturbances from boats can cause direct energetic costs to harbor seals and has implications associated with the conservation of marine mammal populations that inhabit areas with vessel traffic.
Effects on Marine Mammals	Haul-out disturbance on harbor seals (Phoca vitulina) on glacial ice in Tracy Arm, Alaska.	Mathews, E.A., L.A. Jemison, G.W. Pendleton, K.M. Blejwas, K.E. Hood, and K.L. Raum-Suryan. 2016. Haul-out disturbance on harbor seals (Phoca vitulina) on glacial ice in Tracy Arm, Alaska. National Marine Fisheries Service Fishery Bulletin 114(2): 186-2002.	Randomized observerations to determine frequency at which seals entered water in presence and absence of vessels	boats	Harbor seal	no	yes	no	yes	Odds of seal entering water due to presence of vessel over 2 times as high as baseline, undisturbed rate. 3.7 times as high when vessel within 100m. Tour and power vessels were th most common types of vessels, but seals were most sensitive to cruise ships and kayaks.

						yes/no				
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Effects on Marine Mammals	Immediate response of Atlantic bottlenose dolphins to high-speed personal watercraft in the Mississippi Sound.	Miller, L.J., M. Solangi, and S.A. Kuczaj, II. 2008. Immediate response of Atlantic bottlenose dolphins to high-speed personal watercraft in the Mississippi Sound. Journal of the Marine Biological Association of the United Kingdom 88(6):1139-1143.	Opportunistic surveys of PWC and dolphins conducted over two years from research vessel	PWC	Bottlenose dolphin	yes	no	no	yes	Passing of high speed PWC significantly increased dolphin dive duration, group cohesion, and breathing synchrony. 47% of the encounters of dolphin group's had changes in behavior within one minute of PWC interaction, including increase in travelling behavior and decrease in feeding behavior.
Effects on Marine Mammals	Haul-out selection by pacific harbor seals (Phoca Vitulina Richardii): Isolation and Perceived Predation Risk.	Nordstrom, C.A. 2002. Haul-out selection by pacific harbor seals (Phoca Vitulina Richardii): Isolation and Perceived Predation Risk. Marine Mammal Science 18(1): 194-205.	Predator avoidance behavior of terrestrial predators	terrestrial predators	Harbor seal	no	no	no	yes	Harbor seals select isolatated sites to reduce exposure to terrestrial carnivores.
Effects on Marine Mammals	Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida.	Nowacek, S.M., R.S. Wells, and A.R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. Marine Mammal Science 17(4):673-688.	Specific behavioral response assessment of individual dolphins to boat traffic	boats	Bottlenose dolphin	yes	yes	no	yes	Dolphins had longer interbreath intervals (IBI) during boat approaches compared to control periods (no boats within 100m). They also decreased interanimal distance, changed heading, and increased swimming speed in response to approaching vessels compared to control periods. Changes in behavior were more likely to occur in response to a PWC than to an outboard at slow and fast speeds. PWC are not acoustically detectable at the same distances as are other types of watercraft (Evans et al 1992) and lack of predictability translates into greater disturbance and possibly danger potential.
Effects on Marine Mammals	Manatee behavioral response to approaching boats.	Rycyk, A. 2013. Manatee behavioral response to approaching boats. Ph.D. Dissertation, Florida State University.	DTAG and GPS tagging of manatees mapped along with boat trafic in SE Florida	boats	Florida manatee	no	yes	no	yes	Evaluation of the type and range of manatee behavioral reponse to approaching boats. Manatee behavior during boat passes is influenced by boat distance and speed, manatee behavior, and environmental factors. Behavioral changes specifically influenced by sound level and its rise rate.
Effects on Marine Mammals	Variability in reactions of Pacific harbor seals, Phoca vitulina richardsi, to disturbance.	Suryan, R.M. and J.T. Harvey. 1999. Variability in reactions of Pacific harbor seasl, Phoca vitulina richardsi, to disturbance. Fishery Bulletin 97(2): 332-339	Quantifying the variablity in response to disturbance among individuals and locations	boats	Harbor seal	no	yes	no	yes	Distance at which powerboats caused harassment ranged from 28 to 260 meters. Boating regulations near harbor seal haul-out sites should address speed and approach angle of vessel in addition to distance from animals. Boats that traveled slowly, parallel to the haul-out site, and made no abrupt move or changes in speed caused minimal disturbance.

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Effects on Marine Mammals	California sea lion (Zalophus californianus) and Steller sea lion (Eumetopias jubatus) interactions with vessels in Pacific Rim National Park Reserve: Implications for marine mammal viewing management.	Szaniszlo, W.R. 1999. California sea lion (Zalophus californianus) and Steller sea lion (Eumetopias jubatus) interactions with vessels in Pacific Rim National Park Reserve: Implications for marine mammal viewing management. M.S. Thesis, University of Victoria, (Canada).	Determining kind and level of behavioural response of sea lions to vessel activity to evalute effectiveness of Park Guidelines in preventing sea lion disturbance	boats, aircraft, terrestrial	California and Steller sea lion	yes	yes	no	yes	Disturbance to sea lions is minimal when following the prescribed distances and speed restrictions. PWC elicited a major disturbance response by sea lions. Personal Watercraft are not appropriate for viewing sea lions.
Effects on Marine Mammals	Harbor seal vigilance decreased over time since haul out.	Terhune, J.M. and S.W. Brillant. 1996. Harbor seal vigilance decreased over time since haul out. Animal Behavior 51: 757-763.	High level of viligance support an anti-predator function of harbour seal gropuing on haul-out sites	human disturbance	Harbor seal	no	yes	no	yes	Initial scanning time of newly hauled-out harbor seals during the first 3 min after haul out decreased as group size increased. The scanning times of individual seals significantly decreased over time since haul out.
Effects on Marine Mammals	Influences of boat traffic and noise on behaviors and vocalizations of bottlenose dolphins (Tursiops truncatus) in the Indian River Lagoon, Florida.	Williams, C.R. 2009. Influences of boat traffic and noise on behaviors and vocalizations of bottlenose dolphins (Tursiops truncatus) in the Indian River Lagoon, Florida. Ph.D. Dissertation, Florida Institute of Technology.	Hydrophone arrays used to measure vessel noise and dolphin vocalization. Dolphin behaviors observed before, during and after boats passed	boats	Bottlenose dolphin	yes	yes	no	yes	Dolphins are significantly reacting to boats at greater distances (mean of 185 m) than suggested by the MMPA and the general 50 m approach distance should be extended to mitigate the current levels of anthropogenic disturbances specific to Sebastian inlet.
Effects on Marine Mammals	Human and boat interactions with common bottlenose dolphins (Tursiops truncatus) in the waterways around Savannah, Georgia.	Wu, C. 2013. Human and boat interactions with common bottlenose dolphins (Tursiops truncatus) in the waterways around Savannah, Georgia. M.S. Thesis, Savannah State University, Georgia.	Surveys conducted to gauge observations and attitudes of recreational and commercial boater - dolphin interactions	boats	Bottlenose dolphin	no	yes	yes	yes	Recreational boaters and commercial fisherman contribute to the high occurance of human-dolphin interactions in the Savannah GA area by conditioning the animals through illegal feeding. Regulatory measures are already in place but enforcement is lacking. Education programs recommended to improve knowledge within user-groups.

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Effects on Marine Mammals	Effects of Vessels on Harbor Seals In Glacier Bay National Park.	Young, C., Gende, S.M., and J.T. Harvey. 2012. Effects of Vessels on Harbor Seals In Glacier Bay National Park. Tourism in Marine Environments 10(1-2):5-20	Evaluation of effectivenss of harbor seal-related vessel regulations in Glacier Bay National Park	boats	Harbor seal	no	yes	no	yes	Vessel regulations might be variably effective due to biological irrelevance, noncompliance, or environmental factors. Marine protected area (MPA) regulations should be evaluated to ensure achievement of conservation objectives.
Effects on Fish	Impoverishment of YOY-fish assemblages by intense commercial navigation in a large Lowland river.	Huckstorf, V., W.-C. Lewin, and T. Mehner. 2011. Impoverishment of YOY-fish assemblages by intense commercial navigation in a large Lowland river. River Research and Applications 27(10):1253-1263.	Comparison of young of years fish assemblages in 3 river stretches with varying levels of boat traffic	navigation-induced physical forces (waves/ wakes, return currents, shoreline dewatering)	perch and roach primarily, 12 other species	no	yes	yes	no	YOY fish assemblage structure changed along the boat traffic intensity gradient, with both species number and total fish density reduced in the highest traffic intensity reach (6-41 boat passes/day). Intensive commercial navigation impoverished the fish assemblage in width-restricted waterways. Fish species using littoral areas as nursery habitat will have lower recruitment in with high boat traffic. 9Correlative study, minimal corrections for pollution/ behavioral reponses.)
Effects on Fish	Effects of outboard motor emissions on early development of the killifish Oryzias latipes.	Koehler, M.E., and J.T. Hardy. 1999. Effects of outboard motor emissions on early development of the killifish Oryzias latipes. Northwest Science 73(4):277-282.	Laboratory based experiment exposure fish embryos to two-stroke outoard motor emissions to document impacts on larval development.	motor emissions, PAHs	killifish	no	yes	yes	no	Larvae exposed to increasing concentrations of outboard motor exhaust during development displayed slower development, increased incidence of larval abnormalities (abnormal hearts, spines, eyes; absence of swim bladders and spleens) and higher mortality rates at higher concentrations. Gas chromotography determined concentrations of 4 PAHs in the water samples. These concentrations were used to estimate boat use hours on various sizes of lakes to reach lethal concentrations and concluded that heavy use on small lakes might reach that threshold.
Effects on Fish	Documented and potential biological impacts of recreational fishing: Insights for management and conservation.	Lewin, W.-C., R. Arlinghaus, and T. Mehner. 2006. Documented and potential biological impacts of recreational fishing: Insights for management and conservation. Reviews in Fisheries Science 14(4):305-367	recreational fish harvest	N/a						not relevant

						yes/no				
Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Fish	Physiological changes in prickly sculpin (Cottus asper) inhabiting a lake used by jet-propelled watercraft.	Moles, A., and G.D. Marty. 2005. Physiological changes in prickly sculpin (Cottus asper) inhabiting a lake used by jet-propelled watercraft. Bulletin of Environmental Contamination and Toxicology 74(6): 1151-1158.	Effects of PWC on sculpin bodu condition in lakes with heavy PWC use vs. boat/aircraft use use vs. minimal motorized use	PAHs in fuel/ exhaust	prickly sculpin	yes	no	yes	no	Prickly sculpin in Auke Lake are undergoing physiological changes (lower condition factor, lower gastrointestinal indices, lower lymphocyctes, more microscopic lesions associated with toxicity, and prevalence of different parasites) that have not been observed in sculpin from other lakes that are not as heavily used by motorized watercraft. The suspected source of the physiological changes is the chronic input of polycylic aromatic hydrocarbons (PAH's) in the summer from PWC use in the lake. The authors suggested that at the time of the study, the Auke Lake watershed was experiencing a decline in the number of returning salmon and there was concern that the quality of fish rearing habitat was declining due to human activities, with release of PAH's from PWC's at the top of the list.
Effects on Fish	Influence of motorboat use on thermal refuges and implications to salmonid physiology in the lower Rogue river, Oregon.	Reid, I.S. 2007. Influence of motorboat use on thermal refuges and implications to salmonid physiology in the lower Rogue river, Oregon. North American Journal of Fisheries Management 27(4):1162-1173.	Motorboat wake impact on thermal refugia, and consequently on salmonid physiology	thermal habitat disruption, startle responses	salmonids	no	yes	yes	no	Thermal imaging, temperature monitors, behavioral observations, and bioenergetics models were used to evaluate the effects of boat traffic on fish in thermal refugia in a riverine setting. Small sample number (10 boat passes) did not find significant changes in water temperarture from boat passes/wakes. Startle responses from juvenile Chinook salmon were not observed when boat was +3m away. Bioenergetics models indicated minimal negligible impact physiologically.
Effects on Fish	Boating and navigation activities influence the recruitment of fish in a Baltic Sea archipelago area.	Sandstrom, A., B.K. Eriksson, and P. Karas. 2005. Boating and navigation activities influence the recruitment of fish in a Baltic Sea archipelago area. Ambio 34(2):125-130.	Year of the year abundance sampling for three species to compare boat routes, marinas, and control areas.	boat traffic and dredging for navigation	Perch, pike and white bleak	no	yes	no	yes	Comparison of YOY abundance for multiple species in different coastal areas with boat traffic/dredging concludes that species with high preference for submerged vegetation were negatively influenced by boating and navigation activities and that species with low preference were positively influenced.
Effects on Fish	The effects of hydrocarbon pollution from a two-stroke outboard engine on the feeding behaviour of Lythrypnus dalli (Perciformes : Gobidae).	Shulman, P., and C.M. Pomory. 2000. The effects of hydrocarbon pollution from a two-stroke outboard engine on the feeding behaviour of Lythrypnus dalli (Perciformes : Gobidae). Marine and Freshwater Behaviour and Physiology 33(3):213-220.	Laboratory comparison of effects of different concentrations of two-stroke boat exhaust in water on gobie feeding behavior.	hydrocarbon pollution	Lythrypnus dalli	no	yes	no	yes	Gobie feeding time periods were increased in the presence of sub-lethal amounts of two-stroke engine exhaust in water. Indicates that presence of exhaust required more effort to sucessfully gain food. Alhtough statisically signifcant differences were only found at the highest pollution contreation of the trial amounts, behavior changes were noted for lower amounts.

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Effects on Fish	Impacts of recreational motorboats on fishes: A review.	Whitfield, A. K., and A. Becker. 2014. Impacts of recreational motorboats on fishes: A review. Marine Pollution Bulletin 83(1):24-31	synthesis of direct and indirect impacts of a wide range recreation boats on several species of fish	direct strikes, behavioral response to boat passage, noise, heavy metals, fuel and boat byproducts, invasive species introductions, indirect habitat components (infra-structure, other biota, waterbody size)	various	no	yes	yes	yes	Recreation boat traffic does have impacts on fish, though actual impacts can vary by species and fish size, esepcially in terms of behavioral responses. Fuel, fuel byproducts, and anti-fouling treatments are detrimental, particularily in small/low flushing systems, but regualtory restrictions on pollution are making these less serious. Inadequate research exists on pelagic fish eggs and larvae. Aquatic invasives (carried on boats) appear to currently be the greatest potential threat to aquatic ecosystems.
Effects on Birds	Bulrush Mediation Effects on Wave Action: Implications for Over-water Nesting Birds	Allen, J.H., G.L. Nuechterlein, and D. Buitron. 2008. Bulrush mediation effects on wave action: implications for over-water nesting birds. Waterbirds 31(3):411-416.	Natural and boat wake wave attenuation by vegetation, nest survival	wake	bulrushes, grebes	no	yes	yes	no	Study of emergent vegetation in shallow freshwater areas used by over water nesting birds. Increased density of stems relative to location of floating nests can attentuate both natural waves and boat wakes impacts on nests, creating better nesting habitat. Higher density vegetation reduces wave heights, and nests are less likely to sink.
Effects on Birds	Effect of human activities on bearded vulture behaviour and breeding success in the French Pyrenees.	Arroyo, B., and M. Razin. 2006. Effect of human activities on bearded vulture behaviour and breeding success in the French Pyrenees. Biological Conservation 128(2):276-284	Relationship between types of activities and distance to the nest with probability of nesting failure	anthropogenic activites, noise	bearded vulture	no	no	no	no	Human activites have a direct effect on vulture behavior, increasing the likelihood that nest areas would be unattended. An increased probability of nest failure occurred in those areas where disturbance was most frequent. The types of activities with strongest effects were very noisy activites and hunting. Conservation measures based on these results may minimize detrimental effects of human activities on vultures.
Effects on Birds	The impact of recreational boat traffic on marbled murrelets (Brachyramphus mamoratus).	Bellefleur, D., P. Lee, and R.A. Ronconi. 2009. The impact of recreational boat traffic on marbled murrelets (Brachyramphus mamoratus). Journal of Environmental Management 90(1):531-538.	Flushing reactions of marbled murrelets within vacinity of small boat traffic	boat traffic	marbled murrelets	no	yes	no	yes	Study shows that age, boat speed, and boat density significantly affected flushing response. Faster boats caused a greater proportion of birds to flush, at further distances. Management actions include speed limits, set back distances, and exclusion of boat traffic.

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Effects on Birds	Modelling the responses of wildlife to human disturbance: An evaluation of alternative management scenarios for black-crowned night-herons.	Bennett, V.J., E. Fernandez-Juricic, and P.A. Zollner. 2011. Modelling the responses of wildlife to human disturbance: An evaluation of alternative management scenarios for black-crowned night-herons. Ecological Modelling 222(15):2770-2779.	Application of SODA (Simulaton of Disturbance Activities) a spatially explicit individual-based model to example case study	human activites, noise	black-crowned night-herons	no	no	yes	no	SODA is a non-species specific spatially explicit individual-based model for exploring the effects of spatial and temporal patterns of anthropegenic disturbance on wildlife. Using a classification and regression tree (CART) procedure to analyse simulation output, authors explored the dynamics of multiple strategies in concert. Simulation modelling helps to evaluate complex circumstances that would be difficult to replicate and test empirically.
Effects on Birds	Jet skis jolt loons.	Bower, J. 1997. Jet skis jolt loons. Audubon 99(5):14.	Loon disturbances from increasing presence of PWC, nest damage	wakes, noise, blocking nest access	common loon	yes	no	yes	no	Report on the growing number of loon/PWC encounters on Michigan lakes. A call for a comprehensive study on the impact of PWC on loon populations.
Effects on Birds	Effects of motorized boat passes on the time budgets of New Zealand dabchick, (Poliocephalus rufopectus).	Bright, A., G.R. Reynolds, and J. Innes. 2003. Effects of motorized boat passes on the time budgets of New Zealand dabchick, Poliocephalus rufopectus. Wildlife Research 30(3):237-244.	Experiments conducted to examine effects of boat passes of different speeds and frequencies on behavior	wakes, noise	New Zealand dabchick	no	yes	yes	no	Boat passes change short-term behavior of dabchicks, becoming more pronounced as the number of boat passes increases. These behavioral changes may increase daily energy expenditure and reduce time available for feeding. There was no effect on boat speed (5 vs 10 knots) on the behavior of birds. The birds also demonstrated habituation to boat traffic in high-use recreational sites.
Effects on Birds	Correlations between human-made structures, boat-pass frequency and the number of New Zealand dabchicks (Poliocephalus rufopectus) on the Rotorua Lakes, New Zealand.	right, A., J.R. Waas, and J. Innes. 2004. Correlations between human-made structures, boat-pass frequency and the number of New Zealand dabchicks (Poliocephalus rufopectus) on the Rotorua Lakes, New Zealand. New Zealand Journal of Ecology 28(1):137-142.	Effect that human-made structures and human activities may have on the numbers and distribution of dabchick pairs, chicks and nests	structures, wakes, noise	New Zealand dabchick	no	yes	yes	no	Human-made structures and boating activites do not have a significant negative effect on the numbers and distribution of dabchicks on Rotorua lakes. However, little is currently known about dabchick life history or population dynamics, so findings need to be interpreted conservatively.
Effects on Birds	Effects of human activity on bald eagle distribution on the northern Chesapeake Bay.	Buehler, D.A., T.J. Mersmann, and J.D. Fraser. 1991. Effects of human activity on bald eagle distribution on the northern Chesapeake Bay. Journal of Wildlife Management 55(2):282-290	Bald eagle distribution within potential habitat identified by radio-tags	human activities	bald eagles	no	yes	yes	no	Eagle use of the shoreline was inversely related to building density and directly related to the development set-back distances. Few eagles used shoreline segmetns with boats and pedestrians nearby.

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Effects on Birds	Personal watercraft and boats: Coastal conflicts with common terns.	Burger, J. 2003. Personal watercraft and boats: Coastal conflicts with common terns. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1):26-34.	Observation of common tern behavior and reproductive success in response to motorboats and PWCs	wakes, noise	common terns	yes	yes	no	yes	Prior to study, reproductive success of terns had declined to zero. Terns respond with significantly more upflights to PWCs that raced by and circled the island, than to motor boats that travelled slowly and remained in the channel. Education, public meetings, increased signage, enforcement, and designated zones for PWCs resulted in the greatest increase in reproductive success.
Effects on Birds	Effect of approaching boats on nesting black skimmers: Using response distances to establish protective buffer zones.	Burger, J., M. Gochfeld, and C.D. Jenkins. 2010. Effect of approaching boats on nesting black skimmers: Using response distances to establish protective buffer zones. Journal of Wildlife Management 74(1):102-108.	Determining set-back distances based on timing of first responses to approaching boats, timing of initial flight, and time to return after disturbance	small boats	black skimmers	yes	yes	no	yes	The skimmer reproductive stage had the greatest effect on all responses, followed by direction of approach, number of adults present at colony, and number of nests. The distance at which skimmers first flew when a boat approached decreased from the pre-egg laying period to hatching, and then increased slightly later in the season. Recommendation for managers to use a set-back distance > 118 meters from the perimeter of the colony, which is the 95% percentile of the distance that skimmers first flew in response to approaching boats.
Effects on Birds	Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation.	Cardoni, D.A., M. Favero, and J.P. Isacch. 2008. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: Implications for waterbird conservation. Biological Conservation 141(3): 797-806.	Bird surveys performed in areas of high disturbance due to recreation (weekends) and without (weekdays)	terrestrial anthro-pogenic	waders, grebes	no	no	yes	no	Some species (waders) were more affected by human presence than others (grebes). Changes in the waterbird grouping and structure in relation to the presence of people on the shoreline was detected. The buffer area defined by the current Reserve management strategy is working properly.

						yes/no				
Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	A review of human disturbance effects on nesting colonial waterbirds.	Carney, K.M., and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds. 22(1):68-79.	Developing general guidelines for ecotourism and other forms of human visitation through literature review	anthro-pogenic disturbances	various	no	yes	yes	yes	A summary of reviewed articles, based on taxonomy, examining investigator, ecotourist, recreator, watercraft, and aircraft activity effects on physiology, reproductive behavior, reproductive success, and population trends of waterbirds. Goals of paper are to identify species/taxa most vulnerable to human disturbance, the times at which disturbance is most likely to cause adverse impacts, and precautions that can be taken to minimize adverse effects. Though most studies found significant negative effects, taking careful measures minimized impact on some species. Waterbirds are especially vulnerable to human activities because their size, animated behavior, and physical beauty tend to attract humans.
Effects on Birds	Response: Disturbance, habituation, and management of waterbird colonies.	Carney, K.M., and W.J. Sydeman. 2000. Response: Disturbance, habituation, and management of waterbird colonies. Waterbirds. 23(2):333-334	Response to criticism of literature review of human disturbance and colonial waterbirds	anthro-pogenic disturbances	various	no	yes	yes	yes	Although Nisbet (2000) highlights several differences between his conclusions and Carney (1999), perspectives are more often in common than in conflict. Agree that future studies should rigorously address how visitor activities affect waterbird colonies.
Effects on Birds	Set-back distances to protect nesting and roosting seabirds off Vancouver Island from boat disturbance.	Chatwin, T.A., R. Joy, and A.E. Burger. 2013. Set-back distances to protect nesting and roosting seabirds off Vancouver Island from boat disturbance. Waterbirds 36(1):43-52.	Developing rules with scientifically based guidelines for birdwatching from boats	boats	cormorants, oystercatchers, gulls, and guillemots, ducks	no	yes	no	yes	This study examines the effects of species sensitivity, vessel type, habituation and season on agitation distance. A general set-back guideline of 40 m was recommended to protect most nest and roost sites while allowing viewers to appreciate seabirds. Set-backs could be adjusted to protect locally sensitive sites or species.
Effects on Birds	Persistence and abundance of the western grebe (Aechmophorus occidentalis) in Alberta.	Erickson, M.E. 2010. Persistence and abundance of the western grebe (Aechmophorus occidentalis) in Alberta. M.S. Thesis, University of Alberta, Canada.	emergent vegetation, human developments, and prey availability affect grebe population	habitat loss, anthro-pogenic disturbances	western grebe	yes	yes	yes	no	Recreational activity can be a serious stressor to grebes, with the wakes from watercraft swamping nests and forcing adults to abandon their eggs. Recommends that shoreline vegetation be protected for the success of breeding grebes, and human activity around colonies should be kept to a minimum to curb further grebe decline.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Alert distance as an alternative measure of bird tolerance to human disturbance: implications for park design.	Fernandez-Juricic, E., M.D. Jimenez, and E. Lucas. 2001. Alert distance as an alternative measure of bird tolerance to human disturbance: implications for park design. Environmental Conservation 28(3):263-269.	Adapting alert distance from waterbirds to pedestrian approaches of four bird species in wooded parks	anthro-pogenic disturbances	sparrow, blackbird, woodpigeon, magpie	no	no	no	no	Alert distances varied among species, with large species being less tolerant of human disturbance than small ones. Alert distance appears to be a more conservative indicator of tolerance than flight distances, because it includes a buffer zone in which birds may adapt their reaction to the behavior of visiors. Minimum approaching distances can be estimated from alert distances, and implemented to reduce human-wildlife conflicts.
Effects on Birds	Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical assessment of minimum approaching distances and buffer areas for grassland birds.	Fernandez-Juricic, E., M.P. Venier, and D. Renison. 2005. Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical assessment of minimum approaching distances and buffer areas for grassland birds. Biological Conservation 125(2):225-235.	Assesses the effects of tangential and direct approaches on birds and evaluates methods to estimate buffer areas	anthro-pogenic disturbances	finch, cindclodes, miner, meadowlark, lapwing	no	no	no	no	Study finds that four out of the five species showed greater flight initiation distance response to tangential rather than direct approaches, and that the minimum approach distance and buffer area estimates for these species varied significantly. Estimations based on alert distances may be too simplistic.
Effects on Birds	Responses of nestling black-crowned night herons (Nycticorax nycticorax) to aquatic and terrestrial recreational activities: a manipulative study.	Fernandez-Juricic, E., P.A. Zollner, and C. LeBlang. 2007. Responses of nestling black-crowned night herons (Nycticorax nycticorax) to aquatic and terrestrial recreational activities: a manipulative study. Waterbirds 30(4):554-565.	Assesses the effects of the presence and frequency of canoe and pedestrian disturbance on multiple behavioral responses of heron nestlings in Chicago	pedestrians, paddlers	black-crowned night-herons	no	no	yes	no	Both pedestrian and canoers initiated behavioral responses of nestlings (scanning, freezing, sleeping, and walking). The recommendation of the authors is to restrict boating activites during the initial part of the breeding season to minimize nest abandonment. Pedestrians should be managed in such a way as to increase the distance between pathways and nests. A 50 m buffer zone around the colony is recommended based on the responses obtained from the colony.
Effects on Birds	Determining impacts on least tern (Sternula antillarum) breeding colonies along a gradient of human disturbance.	Fournet, B. 2015. Determining impacts on least tern (Sternula antillarum) breeding colonies along a gradient of human disturbance. M.S. Thesis, University of Charleston, South Carolina.	Observation of tern nests to assess the amount human disturbance and follow up surveys with pedestrians	pedestrians, dogs, crows	least tern	no	no	no	no	Terns showed a significant response to crows and people with dogs compared to people without dogs. Surveys showed that beachgoers did value beach-nesting birds and thought that protecting nesting birds is important, but lack the knowledge necessary to assess their own negative impacts.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Effects of motorized tourboats on the behavior of nonbreeding American flamingos in Yucatan, Mexico.	Galicia, E., and G.A. Baldassarre. 1997. Effects of motorized tourboats on the behavior of nonbreeding American flamingos in Yucatan, Mexico. Conservation Biology 11(5):1159-1165.	Flamingo disturbance observations from interactions with sanctuary tourboats	tourboats	American flamingos	no	yes	no	yes	Tourboats reduced feeding time and increased alert behavior of flamingoes in the Celestun Estuary. Conservation efforts shold focus on education of tour boat operators to reduce disturbance of flamingoes.
Effects on Birds	Effects of watercraft on bald eagles nesting in Voyageurs National Park, Minnesota.	Grubb, T.G., W.L. Robinson, and W.W. Bowerman. 2002. Effects of watercraft on bald eagles nesting in Voyageurs National Park, Minnesota. Wildlife Society Bulletin 30(1):156-161.	Assessment of the potential impact of watercraft on nesting bald eagles through quantification of behavioral responses	boats	bald eagles	yes	yes	yes	no	Observation of 9 active nests over a one year period yielded a response (alert posture or flying) frequency of 4.7% when watercraft passed within 800m of these nests. Authors used CART to explore and quantify conditions leading to bald eagle response, despite the species' low overall response rate. The model indicated that distance was the most critcial component of any potential watercraft disturbance, with responses decreasing at increasing distances. Unknown effects on prey delivery rates, adult nest attendance, physiological stress, site tenacity and long-term productivity warrant further study.
Effects on Birds	AvianBuffer: An interactive tool for characterising and managing wildlife fear responses.	Guay, P.-J.; W.F.D. van Dongen, F.D. Wouter, and R.W. Robinson. 2016. AvianBuffer: An interactive tool for characterising and managing wildlife fear responses. Ambio 45(7):841-851	Describes software that models alert distances of birds with various disturbances	anthro-pogenic disturbances	unspecified	no	no	no	no	Users can input bird species and determine an alert distance above which the species is predicted to not flee humans. Authors feel that this tool will be of interest to conservation managers, pest managers, policy makers, land-use planners, educators, animal welfare proponents, and wildlife ecologists.
Effects on Birds	Responses of wintering grassland raptors to human disturbance.	Holmes, T.L., R.L. Knight, and L. Stegall. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21(4):461-468.	Measurement of flushing responses and flush distance of 6 species of raptors exposed to walking and vehicle disturbances	pedestrians, vehicles	american kestrel, merlin, prairie falcon, rough-legged hawk, ferruginous hawk, golden eagle	no	no	no	no	Raptor response to disturbance varies among species and between populations, therefore management plans should be tailored to each species, habitat, and season. Buffer zones for wintering raptors could be effective if placed around sensitive foraging areas. Walking disturbances resulted in more flushes than vehicle disturbances for all species except prairie falcons.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Database of bird flight initiation distances to assist in estimating effects from human disturbance and delineating buffer areas	Livezey, K.B., E. Fernandez-Juricic, D.T. Blumstein, A.F. Livezey, and B. Kent. 2016. Database of bird flight initiation distances to assist in estimating effects from human disturbance and delineating buffer areas. Journal of Fish and Wildlife Management 7(1):181-191.	Database records various species of birds sensitivity to humans and their activities	pedestrian, watercraft, aircraft	various threatened and/or endangered bird species Anseriformes, Charadriiformes, Ciconiiformes, Falconiformes	no	yes	yes	yes	This database distinguishes between nesting and nonnesting situations. The database includes numbers for non-motorized and motorized watercraft along with the respective alert distances (distances at which birds exposed to an approaching human activity exhibit alert behavior), flight inititation distances (distances at which birds exposed to an approaching human activity initiate escape behavior), and minimum approach distances (distances at which humans should be separated from wildlife).
Effects on Birds	A systematic review of the effects of recreational activities on nesting birds of prey.	Martinez-Abrain, A., D. Oro, J. Jimenez, G. Stewart, and A. Pullin. 2010. A systematic review of the effects of recreational activities on nesting birds of prey. Basic and Applied Ecology 11(4):312-319.	Literatature review dealing with human recreational effets on nesting-site occupancy and breeding performance of diurnal and nocturnal raptor species	terrestrial anthro-pogenic	various raptors	no	no	no	no	Authors summarize that there is insufficient information to quantitatively meta-analyze this topic. The only situation appropriate to analysis was the influence on nest location of a number of anthropic structures, specifically the distance of nests to the closest paved roads. Big raptors nesting in trees exhibited great displacement distances from nests to roads than big raptors nesting in cliffs.
Effects on Birds	Oh, not those jet-ski things again!	Milius, S. 1998. Oh, not those jet-ski things again! Science News 154(7):107.	Observations of PWC disrupting breeding colonies of birds along coastal waterways	PWC	terns	yes	no	no	yes	Author reports that PWC disturb nesting terns even more than motorboats, noting that birds react most dramatically early in the breeding season. Recommends that PWC not be allowed within 100 meters of nesting colonies.
Effects on Birds	The effects of human disturbance on common loon and red-necked grebe breeding success in southcentral Alaska.	Mills, Tamara K. 2004. The effects of human disturbance on common loon and red-necked grebe breeding success in southcentral Alaska. M.S. Thesis, University of Alaska Anchorage.	Decade long observation on Mat-Su lakes of watercraft/human development and loons/grebes	watercraft, habitat loss	common loon, red-necked grebe	yes	yes	yes	no	Temporal and spatial changes in loon and grebe populations studied by comparing lake use from 1987 to 1999, utilizing canoe and aerial surveys. Lake occupancy for all species declined and shifted spatially, while productivity remained stable for loons.
Effects on Birds	The effect of human disturbance and flock composition on the flight distances of waterfowl species.	Mori, Y., N.S. Sodhi, S. Kawanishi, and S. Yamagishi. 2001. The effect of human disturbance and flock composition on the flight distances of waterfowl species. Journal of Ethology 19(2):115-119.	Waterfowl response to human disturbance and the factors that influence their behavior	small boat	11 waterfowl species	no	yes	yes	no	Flight distance seemed to be affected by usage of water area: flight distances tended to be longer for waterfowl species that use a water area for foraging than for those that use it primarily for resting. The behavior of activiely foraging species may be more affected by human disturbances than that of resting species.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Disturbance, habituation, and management of waterbird colonies – Commentary.	Nisbet, I.C.T. 2000. Disturbance, habituation, and management of waterbird colonies – Commentary. Waterbirds 23(2):312-332.	Critique of studies of effects of human disturbance on breeding colonial waterbirds, review of Carney (1999)	anthro-pogenic disturbances	terns, gulls, herons	no	yes	yes	yes	Author argues that many studies do not withstand critical scientific scrutiny, overstating the adverse effects of human disturbance. Also that there is little scientifically acceptable evidence that human disturbance causes substantial harm to terns, gulls, or herons. Recommends that controlled, deliberate disturbance, resulting in habituation, can be used as a management tool.
Effects on Birds	Using the risk-disturbance hypothesis to assess the relative effects of human disturbance and predation risk on foraging American oystercatchers.	Peters, K.A., and D.L. Otis. 2005. Using the risk-disturbance hypothesis to assess the relative effects of human disturbance and predation risk on foraging American oystercatchers. Condor 107(3):716-725.	Examination of how natural predation risk factors interact with human-disturbance stimuli	predation, boats	American oystercatcher	no	yes	no	yes	The risk-disturbance hypothesis asserts that animals perceive human disturbance similar to nonlethal predation stimuli. Observation of animals show relationship between vigilance behavior, predator density, and boat activity. Findings show some support for risk-disturbance hypothesis.
Effects on Birds	Wading bird response to recreational boat traffic: Does flushing translate into avoidance?	Peters, K.A., and D.L. Otis. 2006. Wading bird response to recreational boat traffic: Does flushing translate into avoidance? Wildlife Society Bulletin 34(5):1383-1391.	Examination the association between flushing and local site use among wading birds in tidal creeks	boats	herons, egrets	no	yes	yes	yes	Patterns of repsonse varied among species, and there was no clear relationship between flushing and site use. Flush rates may not adequately reflect the species sensitivty to human disturbance and should only be used as a management guide in conjunction with other indices such as spatial distribution.
Effects on Birds	Recommendations for protecting raptors from human disturbance: A review.	Richardson, C.T., and C.K. Miller. 1997. Recommendations for protecting raptors from human disturbance: A review. Wildlife Society Bulletin 25(3):634-638.	Guidelines for assessing spatial and temporal buffer zones for a variety of raptors	anthro-pogenic disturbances	raptors	no	no	no	no	Human activities are know to impact raptors by: physically harming or killing eggs, young or adults; altering habitats; by disrupting normal behavior. To be effective buffer zones should be based on empirical evidence of wildlife responses to disturbances.
Effects on Birds	Buffer-zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats.	Rodgers, J.A., and S.T. Schwikert. 2002. Buffer-zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats. Conservation Biology 16(1): 216-224.	Observation of flush distances of 23 species of birds to direct approach of PWC and motorboats	motorized watercraft	Pelecaniformes, Ciconiiformes, Falconiformes, Charadriiformes	yes	yes	yes	no	Authors detected considerable variation in flush distances among individuals within the same species and among species in response to both types of vessels. Eleven species showed no significant difference in flush distance between the rapid (30-40km/h) direct approach of PWC and outboard-powered vessels. Seven species were approached only with PWC, not motorboats. Data suggests that a single buffer-zone distance can be developed for both PWC and outboard-powered vessels. Specific buffer zone distances given for individual species to minimize their disturbance at sites in Florida are given in report.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida.	Rodgers, J.A., and S.T. Schwikert. 2003. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida. Waterbirds 26(4):437-443.	Observation of flush distances of 13 species of birds to different levels of airboat activity on lakes	airboat noise	Pelecaniformes, Ciconiiformes, Falconiformes	no	yes	yes	no	Authors detected considerable variation in flush distances among individuals within the same species and significant differences among species in response to an airboat. Larger species generally exhibited greater average flush distances. A comparison of flush distances with fast moving motorboat and an airboat indicated that all species exhibit a greater flush distances to the approach of an airboat. Recommended buffer zones given for each bird species.
Effects on Birds	Set-back distances to protect nesting bird colonies from human disturbance in Florida.	Rodgers, J.A., and H.T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology 9(1):89-99.	Observations of 15 species of colonial waterbirds exposed to three types of anthropogenic disturbances to elicit set-back distances	pedestrians, canoes, motorboats	Pelecaniformes, Ciconiiformes, Pelecaniformes	no	yes	yes	yes	Authors define set-back distance as a minimum distance of nonintrusion by humans measured from the perimeter of a colony that will preclude disturbances to nesting birds. Their recommended set-back distances was estimated using an empirical formula as a function of observed flushing distances. This distance of 100 meters for wading bird colonies and 180 meters for mixed tern/skimmer colonies are believed to be adequate to effectively buffer the studied sites from human disturbances caused by approach of pedestrians and motor boats.
Effects on Birds	Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida.	Rodgers, J.A., and H.T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25(1):139-145.	Observations of 16 species of colonial waterbirds exposed to four types of anthropogenic disturbances to determine buffer zones	pedestrians, ATVs, canoes, motorboats	Pelecaniformes, Ciconiiformes, Pelecaniformes, Charadriiformes	no	yes	yes	yes	Based on an empirical formula based on the mean plus 1.6495 standard deviations of the observed fishing distances plus 40 meters (buffer distance = exp [μ + 1.6495σ] + 40m), a buffer of about 100 meters should minimize disturbance to most species of waterbirds studied in Florida.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Management options to reduce boat disturbance on foraging black guillemots (Cepphus grylle) in the Bay of Fundy.	Ronconi, R.A., and C.C. St Clair. 2002. Management options to reduce boat disturbance on foraging black guillemots (Cepphus grylle) in the Bay of Fundy. Biological Conservation 108(3):265-271.	Observations of flushing behavior in relationship between boat characteristics, guillemot behavior, and environmental conditions	motorboats	black guillemots	no	yes	no	yes	The distance guillemots foraged from shore and the size, speed, and approach distance of boats were important factors predicting flushing probability. Flushing probability was greatest with fast boats and closer approach distances. Boat size was also a significant factor predicting flushing events, but the direction of the effect was inconsistent. Small boats were more likely to flush birds than medium-sized boats, but small boats were not significantly different from large boats. Small boats generally traveled faster than medium and large boats, and had closer approach distances to guillemots than medium or large boats, likely because small boats often approached the shoreline more closely. In sum, small boats travelling fast and close to shore were more disruptive to the guillemots. Report recommends a set-back distance of 600 meters from shore with a speed limit of 25 km/hr to minimize guillemot flushing.
Effects on Birds	Effects of human activity on behavior of breeding American Oystercatchers, Cumberland Island National Seashore, Georgia, USA.	Sabine, J.B., III, J. Meyers, J.M., and C.T. Moore. 2008. Effects of human activity on behavior of breeding American Oystercatchers, Cumberland Island National Seashore, Georgia, USA. Waterbirds 31(1):70-82.	Frequency of occurrence of behaviors relative to different disturbances of American oystercatchers during one year breeding season	pedestrians, vehicles, motorboats	American oystercatchers	no	yes	no	yes	Data indicates that tide, temperature, intraspecific encounters, and human activity influenced oystercatcher behavior, such that reproductive success may have been affected negatively. Ground-nesting birds are more likely to leave their nests when disturbances come from pedestrians rather than vehicles. Managers should minimize pedestrian activity near nests during incubation. During brood rearing, protection from pedestrian activites should be increased, and vehicular activity should be minimized at current levels or less.
Effects on Birds	Effects of recreational activity on wintering bald eagles.	Stalmaster, M.V., and J.L. Kaiser. 1998. Effects of recreational activity on wintering bald eagles. Wildlife Monographs 137(1-46).	Assessment of how recreationists affected eagle numbers, distribution, activity, and feeding on chum salmon	pedestrians, non motorized boats, motorboats	bald eagles	no	yes	yes	no	Based on flushing responses and flushing distances, foot traffic was most disturbing to eagles, fishing boats were intermedite in effect, and eagle-viewing boats were least disturbing. However, boat traffic, especially motorboats, disturbed a greater portion of the eagle population than foot traffic. Recommendations to prohibit recreational activity during the first 5 hours of daylight within 400m of eagles in order to mimimize disturbance of feeding behavior.
Effects on Birds	Responses of bald eagles to human activity during the summer in interior Alaska.	Steidl, R.J., and R.G. Anthony. 1996. Responses of bald eagles to human activity during the summer in interior Alaska. Ecological Applications 6(2):482-491.	Observations of flush response rate and flush distance to recreational boating along narrow river	non motorized boats	bald eagles	no	yes	yes	no	In contrast to flush response, flush distance was strongly associated with age and was greatest for adults, least for juveniles, and intermediate for subadults. Breeding adults were much less likely to flush than nonbreeding adults, and flushed at lesser distances. Author recommends that along narrow wilderness rivers, the impacts of human activity on Bald Eagle populations be regulated with temporal, rather than spatial, restrictions.

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Experimental effects of human activity on breeding Bald Eagles.	Steidl, R.J., and R.G. Anthony. 2000. Experimental effects of human activity on breeding Bald Eagles. Ecological Applications 10(1):258-268.	Observations of breeding eagles in the presence of human campers at a distance of 100 and 500 m	terrestrial anthro-pogenic	bald eagles	no	no	no	no	With humans near nests, adult eagles decreased the time they preened, slept, maintained nests, and fed themselves and their nestlings, and increased the time they brooded nestlings. In contrast nest attendance did not change with humans near nests, however, the time adults were absent from the nest area increased with humans near nests. Throughout the 24 hour treatment, eagle responses to nearby humans diminished, suggesting habituation. Human activity near nests caused clear and consistent changes in behaviors of breeding eagles, suggesting tha frequent human activities near nests could adversely affect reproductive success.
Effects on Birds	National bald eagle management guidelines.	U.S. Fish and Wildlife Service. 2007. National bald eagle management guidelines. FWS. https://www.fws.gov/northeast/pafo/pdf/NationalBaldEagleManagementGuidelines.pdf	Federal recommend-ations for land management practices to benefit bald eagles		bald eagles	yes	yes	yes	yes	Guidelines are intended to: (1) Publicize the provisions of the Eagle Act that continue to protect bald eagles, (2) Advise landowners, land managers, and the general public of the potential for various human activities to disturb bald eagles, and (3) Encourage additional nonbinding land management practices that benefit bald eagles. For PWC: (1) do not operate PWC and (2) avoid concentrations of noisy vessels except where eagles have demonstrated tolerance for such activity. During breeding season, buffer is 330 feet from nest.
Effects on Birds	Disturbance to a foraging seabird by sea-based tourism: Implications for reserve management in marine protected areas.	Velando, A., and I. Munilla. 2011. Disturbance to a foraging seabird by sea-based tourism: Implications for reserve management in marine protected areas. Biological Conservation 144(3):1167-1174.	Evaluation of the best managing options to mitigate the impact of tourism on European shags in MPAs	tourboats	European shag	no	yes	no	yes	Boat disturbance elicited a characteristic avoidance behavior that resulted in a substantial reduction in foraging activity as levels of boat use increased. Management strategies to minimize disturbance to foraging seabirds may depend on the spatial overlap between sea-based recreational activites and foraging seabirds and the spatial variation in marine habitat quality for seabirds.
Effects on Birds	Responses of incubating hooded plovers (Thinornis rubricollis) to disturbance.	Weston, M.A., and M.A. Elgar. 2007. Responses of incubating hooded plovers (Thinornis rubricollis) to disturbance. Journal of Coastal Research 23(3):569-576.	Observations of breeding plovers and disturbances, placing recreational disturbance in context with natural disturbances	terrestrial anthro-pogenic predators, dogs	hooded plovers	no	no	no	yes	Human disturbance is more frequent than natural disturbances, and humans decrease nest attendance substantially and more than any other source of disturbances.

2017 Literature Review of Impacts of Personal Watercraft

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Topic	**Title**	**Full citation**	**Long topic**	**Impact mechanism**	**Species**	**PWC specific**	**General boating**	**Fresh water**	**Salt water**	**Summary statement**
Effects on Birds	Bald eagle response to boating activity in northcentral Florida.	Wood, P.B. 1999. Bald eagle response to boating activity in northcentral Florida. Journal of Raptor Research 33(2):97-101.	Observations of effects of weekend and weekday boating activity on bald eagles on Florida lakes	motorboats	bald eagles	no	yes	yes	no	Boating activity reduced the number of eagles using the shoreline on only one of the three lakes studied, did not influence flush distance, and increased the distance perched from the shoreline by 3 meters. There was no evidence that recreational boating activity negatively affected eagle use of these lakes. The minimal flush distances and the lack of measurable effects on eagle behavior and activity patterns suggested that many of these birds may have become habituated to boating disturbance, although they still show some avoidance behavior.
Eco- logical or Environmental Impacts	Physical impacts of wind and boat traffic on Clear Lake, Iowa, USA.	Anthony, J.L., and J.A. Downing. 2003. Physical impacts of wind and boat traffic on Clear Lake, Iowa, USA. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1):1-14.	Evaluation of potential roles of both wind and recreational boat traffic in the resuspension of sediments in a shallow lake	wind, motorboats	fish, macrophytes	no	yes	yes	no	Intensive monitoring over a wind-event showed that the total phosphorus concentrations can increase by 100% over a daily period and ammonia concentrations increase to levels near to those toxic to fish at the peak of winds. Heavy boat traffic appears to exacerbate wind-induced resuspension and may slow the resettlement of resuspended sediments. Benthic resuspension may contribute to the suppression of fish and macrophyte communites.
Eco- logical or Environmental Impacts	The effects of motorized watercraft on aquatic ecosystems.	Asplund, T.R. 2000. The effects of motorized watercraft on aquatic ecosystems. PUBL-SS-948-00. Wisconsin Dept. of Natural Resources, Madison. PUBL-SS-948-00. PUBL-SS-948-00. http://dnr.wi.gov/topic/ShorelandZoning/documents/201301041052.pdf	All encompassing report covering water clarity, water quality, shoreline erosion, aquatic plants, fish, wildlife, and PWCs	anthro-pogenic	macrophytes, fish, aquatic wildlife	yes	yes	yes	no	Specifically discusses PWC studies on: 1)Noise - PWCs tended to have more variable sound levels at distancs of 300 feet or more, 2)Disturbance to wildlife - The proximity of watercraft and either the fast movement or noise of those operating at high speeds were the most disturbing attributes, and tended to be those associated with PWCs, 3)Emissions - The actual amount of fuel discharged is a function of speed, tuning, size of engine and other other factors, 4)Physical impacts - Some resuspension of fine sediments was documented during tests with frequent stops, starts, and turns in a confined area. Greatest potential for sediment disturbance comes when boats travel at intermediate speeds, between no-wake and planing.
Eco- logical or Environmental Impacts	The ecological impacts and management of recreational boating.	Asplund, T. 2003. The ecological impacts and management of recreational boating. Conference: 21st International Symposium of the North-American-Lake-Management-Society, Madison, Wisconsin, Nov 7-9, 2001. Lake and Reservoir Management 19(1): III-IV.	Perspective of recreational boating from water resource manager	motorboats	terns	yes	yes	yes	yes	Recreational boating impacts the aquatic environment through a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from propulsions systems, waves produced by movement, and noise. Sediment resuspension, water pollution, disturbance of fish and willdlife, destruction of aquatic plants, and shoreline erosion have all been identified and documented as ecological concerns of recreational boating.
Eco- logical or Environmental Impacts	Biological impacts of boating at Kawau Island, north-eastern New Zealand.	ackhurst, M.K., and R.G. Cole. 2000. Biological impacts of boating at Kawau Island, north-eastern New Zealand. Journal of Environmental Management 60(3):239-251.	Sampling of the benthic fauna to detect disturbances from recreational boat anchoring	anchors	bivalve Atrina zelandica	no	yes	no	yes	Experimental anchoring of differing intensities damaged Atrina, which were then attacked by whelks and starfish. Anchoring scars persisted for up to 3 months, but had diminished in area and depth after 1 month. As intense anchoring is localised in a few bays over a short time, and macrobenthos can recover over the remainder of the year, benthic impacts are unlikely to require management at present.

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Eco- logical or Environmental Impacts	The impact of tourism and personal leisure transport on coastal environments: A review.	Davenport, J., and J.L. Davenport. 2006. The impact of tourism and personal leisure transport on coastal environments: A review. Estuarine Coastal and Shelf Science 67 (1-2):280-292.	Effects of various aspects of mass tourism and related transport infrastructure on coastal ecosystem	mass tourism	variety of taxa	yes	yes	no	yes	Comprehensive literature review of recreational transport and tourism on coastal environment, considers PWC particularly worrying with it being highly polluting, very rapid, and extremely noisy. PWCs were never evaluated for environmental impact before widespread promotion in the marketplace, nor have they been subject to the same pollution regulations that control existing technology (e.g. motorcycles and cars).
Eco- logical or Environmental Impacts	Federal lands: agencies need to assess the impact of personal watercraft and snowmobile use.	Estes, B. 2001. Federal lands: agencies need to assess the impact of personal watercraft and snowmobile use. Pages 176-180 in: Harmon, D., ed. Crossing Boundaries in Park Management: Proceedings of the 11th George-Wright-Society Biennial Conference on Research and Resource Management in Parks and on Public Lands, Denver, CO, April 16-20, 2001	Review of PWC and snowmobiles on lands managed by four federal agencies (BLM, USFWS, NPS, and USFS)	PWC	ospreys	yes	no	yes	yes	Highlights differing regulations between management agencies. NPS and USFWS generally disallow recreational use of these vehicles unless it can be demonstrated that no harm would be likely to results to the unit's resources and environment. In contrast, the USFS and BLM generally allow their use unless the unit manager clearly demonstrates potential harm. Extent of use and prohibitions by agency and vehicle type is tabulated. Also noted: researchers at Great White Heron National Wildlife Refuge in the Florida Keys observed that disturbances by PWC contributed to poor reproductive success of nesting ospreys.
Eco- logical or Environmental Impacts	Relationships of human disturbance, bird communities, and plant communities along the land-water interface of a large reservoir.	Francl, K.E. and G.D. Schnell. 2002. Relationships of human disturbance, bird communities, and plant communities along the land-water interface of a large reservoir. Environmental Monitoring and Assessment 73(1):67-93.	Measurements of human activity, plant surveys, and bird surveys were performed at 40 paired transects (one with human disturbance, one without)	pedestrians, land vehicles, watercraft, RVs	91 species of birds, plants	no	yes	yes	no	Study suggests that bird-species composition is regulated more by human activity than by plant-community composition. Also, in studied area, bird communities are a better choice than plant communities to index the effect of human disturbance. To maintain regional diversity of both birds and plants, undisturbed areas should be maintained around reservoirs.
Eco- logical or Environmental Impacts	Human-caused disturbance stimuli as a form of predation risk.	Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1): Article #11.	Further development of risk-disturbance hypothesis, why disturbance stimuli should be analogous to predation risk.	pedestrians, land vehicles, watercraft, bicycles	birds, mammals	no	yes	yes	yes	Prey have evolved antipredator responses to generalized threatening stimuli, such as loud noises and rapidly approaching objects. Literature provides examples of stimuli ranging from the dramatic, low flying helicopter to the quiet wildlife phtographer, and animals responses are likely to follow the same economic principles used by prey encountering predators. Authors also use a predation risk framework to explore four less studied areas: mate acquisition, parental investment, population dynamics, and interactions at the community level.
Eco- logical or Environmental Impacts	Current status of marine leisure activities in Japan.	Gotoh, H., M. Takenwa, and Y. Maeno. 2008. Current status of marine leisure activities in Japan. WIT Transactions on Ecology and the Environment 115:23-33.	Surveys on the utilization of beaches for beach users in Japan			yes	no	no	yes	Recently, various types of marine sports have increased in popularity. It is important to develop a common system of etiquette and safety to facilitate the coexistence of swimmers and marine sports participants. Monitoring of marine sport safety by lifeguards and other rescue personnel is necessary to avoid conflicts with fisherman.

						yes/no				
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Eco- logical or Environmental Impacts	Two strokes and you're out.	Long, R. 1997. Two strokes and you're out. Earth Island Journal 12(2):11	Examination of EPA to regulate emissions from 2-stroke engines	exhaust	fish, marine invertebrates, plankton, algae	yes	no	yes	yes	An overview of Bluewater Networks legal challenge against the EPA in US Court of Appeals. This environmental group believes that EPA has issued faulty regulations, that allow US to become polluted by personal watercraft and motorboats. Bluewater network is embarking on an education program that will encourage boaters to use only four-stroke motors for their outboards and PWCs.
Eco- logical or Environmental Impacts	A review and synthesis of recreation ecology research findings on visitor impacts to wilderness and protected natural areas.	Marion, J.L., Y.F. Leung, H. Eagleston, and K. Burroughs. 2016. A review and synthesis of recreation ecology research findings on visitor impacts to wilderness and protected natural areas. Journal of Forestry 114(3):352-362.	Literature review with a focus on visitor impacts on vegetation, soil, wildlife, and water resources	anthro-pogenic	unspecified	no	yes	yes	yes	This article synthesized recreation ecology research intended for enhancing understanding of recreation impacts while advancing the practice of visitor impact management. The results suggest that advances in recreation ecology have gone further with vegetation and soil, than with water quality. Research on wildlife impacts have gained momentum in recent years.
Eco- logical or Environmental Impacts	Boat wakes as a cause of riverbank erosion: a case study from the Waikato River, New Zealand.	McConchie, J.A., and I.E.J. Toleman. 2003. Boat wakes as a cause of riverbank erosion: a case study from the Waikato River, New Zealand. Journal of Hydrology 42 (2):163-179	Measurements of the wave train and suspended-sediment concentration generated by three different types of power crafts	boat wakes		yes	yes	yes	no	The effectiveness of boat wake as an erosive agent depends on : the resistance of the bed and banks where the waves impact (controlled by sediment, vegetation, water level, and profile), the conditions under which the waves were generated (water depth; channel width; vessel size, displacement, and speed; the distance from vessel to shore; and the frequency of vessel traffic), and the characteristics of the resulting waves (wave energy and freaquency of wave impacts). Vessel-generated waves, because of their greater amplitude, are more erosive than wind-generated waves in riverine environments.
Conflicts	Factors contributing to conflicts and user satisfaction at Lake Gaston: Examining conflict between personal watercraft users and anglers.	Beal, D.M. 2011. Factors contributing to conflicts and user satisfaction at Lake Gaston: Examining conflict between personal watercraft users and anglers. M.S. Thesis, East Carolina University.	Determining with surveys if conflict exists between two user groups	n/a	n/a	yes	no	yes	no	Anglers experienced higher degrees of conflict attributed to PWC users. Anglers assessments of conflict attributed to PWC users were lower for those anglers who had experience in PWC use. Managerial recommendations include developing 'no wake' zones near shore with markers and signage, lake safety education, lake patrols, and penalties.

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Conflicts	Multiuse coastal commons: Personal watercraft, conflicts, and resolutions.	Burger, J. 2001. Multiuse coastal commons: Personal watercraft, conflicts, and resolutions. Pages 195-215 in: Burger, J., E. Ostrom, and R.B. Norgaard, eds. Conference: Symposium on Protecting the Commons - A Framework for Resource Management in the Americas Location: Piscataway, NJ, June 1998.	Delineating common issues in the coastal zone of NJ, describing conflicts of PWCs with other coastal resources, and places PWC use within a commons framework	PWC	migratory birds	yes	no	no	yes	While future equitable use of water surfaces by the various users in Barnegat Bay, NJ is not ensured, this case study clearly indicates that it is possible to achieve action when all relevant parties are included and protections of a particular common-pool resource (migratory birds) is essential. The present study provides an example in which the users are diverse, yet they still arrived at a common solution.
Conflicts	Conflict resolution in coastal waters: the case of personal watercraft.	Burger, J., and L. Leonard. 2000. Conflict resolution in coastal waters: the case of personal watercraft. Marine Policy 24(1):61-67	Using the case study on breeding terns and PWC disturbances, examination of how to resolve conflicts between different user groups	PWC	common terns	yes	no	no	yes	This example illustrates several principles that are relevant to establishing marine policy in other communities: 1) action was promulgated at the local level, 2) discussions included all the relevant users of the water surface, 3) discussions were open to everyone, regardless of their direct interest, 4) discussions were not dominated by either state biologists or state police, 5) no extreme measures were suggested that eliminated PWCs from Barnegat Bay generally, and 6) actions occurred only after everyone was involved in the process. Although the educational and enforcement campaign 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.
Conflicts	Resources and estuarine health: Perceptions of elected officials and recreational fishers.	Burger, J., J. Sanchez, and M. McMahon, M. 1999. Resources and estuarine health: Perceptions of elected officials and recreational fishers. Journal of Toxicology and Environmental Health-Part A 58(4):245-260.	Understanding the perception of multiple user groups in addressing environmental problems in coastal systems	anthro-pogenic	aquatic organisms, birds	yes	yes	yes	yes	For effective management of coastal environments, and the development of wise public policy, it is essential to understand the relationship between the perceptions of the public and those of the officials charged with managing the coasts, as well as those of the managers themselves. Between fisherman and public, there were significant differences in their relative rating of the severity of environmental problems. PWC ranked as the most severe problem for both fisherman and public officials.

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Conflicts	Incorporating recreational users into marine protected area planning: A study of recreational boating in British Columbia, Canada.	Gray, D.L., R.R. Canessa, and R. Rollins. 2010. Incorporating recreational users into marine protected area planning: A study of recreational boating in British Columbia, Canada. Environmental Management 46(2):167-180.	Surveys of recreational boaters in order to achieve social and biological objectives		n/a	yes	yes	no	yes	Results show variability in boater setting preferences. Several marine activites emerged as sources of perceived conflict for boaters, including personal watercraft, commercial whale watching vessels, and shellfish aquaculture. Analysis shows that while some of these issues may be addressed through zoning, others are better addressed through education and communication.
Conflicts	Spatial characterization of marine recreational boating: Exploring the use of an on-the-water questionnaire for a case study in the Pacific Northwest.	Gray, D.L., R.R. Canessa, C. Keller, and C. Peter. 2011. Spatial characterization of marine recreational boating: Exploring the use of an on-the-water questionnaire for a case study in the Pacific Northwest. Marine Policy 35(3):286-298	Study that uses an on-the-water-questionnaire to map recreational boating distribution/density in a complex, multi-use marine setting, applying to ArcGIS	anthro-pogenic	n/a	no	yes	no	yes	Marine spatial planning requires a variety of information on human use of the marine environment. This research has partially addressed a notable information gap gathering an extremely rich baseline dataset for recreational boating and developing a repeatable methodology for future studies. Data can be used by agencies for marine and coastal planning.
Conflicts	Jet Ski riders circle the wagons.	raker, D. 2002. Jet Ski riders circle the wagons. High Country News 34(20):5.	Article documenting National Park Service ban of PWC on Lake Powell	anthro-pogenic	n/a	yes	no	yes	no	National Park Service has issued a moratorium on personal watercraft use at Lake Powell and seven other Western national recreation areas on November 6, 2002. This ban will be until the NPS completes an environmental review of the machines' impacts.
Conflicts	Planning for conflict resolution: Jet-ski use on the Northumberland coast.	oe, M. and J.F. Benson. 2001. Planning for conflict resolution: Jet-ski use on the Northumberland coast. Coastal Management 29(1):19-39.	Study to develop a strategy for water-based recreation, development of management proposals for use of PWC		n/a	yes	no	no	yes	Aim of study was to reconcile the disparate nature of the recreation and conservation interests through production of strategic framework that would act as a mechanism under which conflicts could be identified and resolved. Looking to issue locally relevant proposals to deal with PWC in ecologically sensitive and aesthetically important coastal landscapes.

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Conflicts	Are marine reserves and non-consumptive activities compatible? A global analysis of marine reserve regulations.	Thurstan, R.H., J.P. Hawkins, and L. Neves. 2012. Are marine reserves and non-consumptive activities compatible? A global analysis of marine reserve regulations. Marine Policy 36(5):1096-1104.	Examination of potential impacts of 16 non-consumptive activites and how they might compromise the conservation efforts of marine reserves.	anthro-pogenic	n/a	yes	yes	no	yes	The risk analysis suggests that motor boating and activites which include or require it have a high potential to negatively impact wildlife and habitats if inadequately managed. Some activities traditionall considered benign have the potential to damage marine reserves yet are commonly allowed with little or no regulation. If marine reserves are to provide the strong protection they are inteneded to provide, all activities need careful management considerations.
Conflicts	A comparison of recreation conflict factors for different water-based recreation activities.	Wang, C.P., and C.P. Dawson. 2000. A comparison of recreation conflict factors for different water-based recreation activities. Pages 121-130 in: Northeastern Recreation Research Symposium, Bolton Landing, N.Y., Apr 2-4, 2000. U.S. Forest Service, Northeastern Forest Experimental Station, General Technical Report 276.	Survey taken about recreational conflict problems sampling from landowners and those who registered watercraft in New York State		n/a	yes	yes	yes	no	Results showed that the eight groups are common in structure but not in the value of the conflict factors. Study results also showed a series of asymmetrical conflicts in which landowners were interfered with by both personal watercraft users and motorboaters, motorboaters were affected by personal watercraft users but not landowners, and personal watercraft users were not affected by either one.
Conflicts	Recreation conflict along New York's Great Lakes coast.	Wang, C P., and C.P. Dawson. 2005. Recreation conflict along New York's Great Lakes coast. Coastal Management 33 (3):297-314.	Using goal interference theory to survey and examine recreation conflict among motorboat users, PWC users, and riparian landowners		n/a	yes	yes	yes	no	Goal interference theory can be seen as a general model that contanis four dimensions for explaining recreation conflict, but not every dimension is significant in predicting various conflicts. Not all dimensions (activity style, resource specificity, mode of experience, and lifestyle tolerance) apply in every situation, but they should each be considered as conflict is assessed in coastal recreation planning and management.
Conflicts	Recreation conflict of participants in different mode of water-based activities and their adoption choice.	Wu, C.., C.-P. Wang, and H.-H. Liu. 2009. Recreation conflict of participants in different mode of water-based activities and their adoption choice. Advances in Hospitality and Leisure 5:69-87.	Exploring water-based recreationists' perception on recreation conflict as well as their use of coping mechanisms			yes	yes	no	yes	Among all three groups (motorized, nonmotorized, and dual participants), less conflict was reoprted for nonmotorized participants than motored participants. Moreover, the data also suggest that coping mechanisms are widely employed in outdoor recreation. The level of rereationsts' skill, knowledge, and commitment may slightly influence their willingness to adopt coping mechanisms.

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Conflicts	Kayaking playground or nature preserve? Whitewater boating conflicts in yellowstone national park	Yochim, M.J. 2005. Kayaking playground or nature preserve? Whitewater boating conflicts in Yellowstone National Park. Montana-The magazine of western history 55(1):52-64.	NPS balancing it's duties to conserve the park while determining what forms of recreation are appropriate	kayaks	nesting birds	no	no	no	no	A history of boating in the Yellowstone area, and current decision by the NPS to not allow whitewater kayaking. Discussion of park managers guiding principals of resources, science, values, tradition, human psychology, and society's laws and how that effects decisions on the role recreation plays in natinal parks. These guiding principles imply a vision of nature in which visitors are humbled by nature and its processes through observation and reflection.