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## **Literature Review of Impacts to Personal Watercraft- Summary**

The overarching purpose of this literature review is to determine if sufficient new information exists that would warrant revisiting the regulations (5 AAC 95.310) from 2001 that banned the use of personal water craft (PWC) in the Kachemak Bay and Fox River Flats Critical Habitat Areas.

Much of the information available from the current literature review does not exactly match the conditions of Kachemak Bay or Fox River Flats CHAs in that it is not specific to northern latitude marine waters with a wide range of biological and human uses. Several generalizations can be drawn from the literature as a whole that may help inform the initial direction of ADF&G's decision on how to approach PWC regulation in Kachemak Bay and Fox River Flats CHAs. These generalizations are summarized below.

Technological improvements to PWC engines (4-stroke vs. 2 -stroke) have unequivocally reduced the amount of toxic fuel byproducts introduced to the ecosystem compared to models of PWC that were common 20 years ago. All boat engines release some fuel, fuel additive, or exhaust into the water column and atmosphere. Research indicates that dispersed boating in large waterbodies does not have acute toxic effects since lethal concentration thresholds are not exceeded in the water column. Acute toxicity events tend to occur with fuel spills, intense traffic in closed systems, or where sensitive lifestages are present. Updated research has also better characterized the long term, cumulative fate of fuel, combustion byproducts, and fuel additives to aquatic ecosystems, regardless of the source (boat, PWC, spills, etc.) These characterizations highlight the increased vulnerability of nearshore and shallow water areas. Long term concentrations of large polycyclic aromatic hydrocarbons (PAHs) (non-volatile) tend to occur when these hydrophobic molecules bind to sediment or particulates or form a surface layer on the water. The surface layer concentration is particularly concerning in shallow tidal areas, where tidal changes coat the intertidal area and organisms with the surface contaminants as the water level changes. The surface microlayer is also highly biologically productive area for low trophic levels (plankton, algae, bacteria). Sediment accumulations of PAHs are also of concern in shallow areas where prop, jet, and wake energy can re-suspend the contaminants into the water column. Additionally, PAHs have increased toxicity to fish and zooplankton in the presence of UV light, which would be more prevalent in nearshore, shallow water areas. Updated technology has resulted in modern PWCs that are less polluting than earlier models; updated research also indicates that impacts from fuel byproduct pollution are likely exasperated in shallow water areas.

While improvements in technology provide cleaner burning engines and variable reductions in decibel levels of engines, they have also provided larger engines with increased horse power. The use of PWC is more widespread than in 2000. . PWC tend to have longer stopping distances than comparable power boats, due to relatively low displacement. Collision avoidance on PWC can also be complicated by the loss of steering ability with the loss of throttle. Various manufacturers have implemented different technological approaches to improve safety due to high accident rates for PWCs in the early 2000s. "Braking" and off throttle steering is now feasible, but depends on the individual craft and operator

experience. As indicated by newer research, what remains immutable in the face of technology is that PWC are intended for a type of use associated with certain behavior and movement patterns that are distinct from traditional boat use. Rapid changes in speed, erratic turns, traveling in groups, travel in shallow draft areas near shore, and recreational riding in wave features are activities that differ from traditional boat traffic. Although a PWC can be operated like a boat (e.g. direct transit limited to deeper water areas) it is not reasonable to assume that other types of use will not occur. The perceived and actual potential impacts are compounded by PWCs' capability to operate in shallow nearshore environments that are more biologically sensitive, and in some cases, readily visible to user groups on shore.

There have been considerable studies completed on the topic of disturbance by boats and PWC since 2000. Wildlife disturbance responses to boat, PWC, and other anthropogenic traffic are incredibly variable based on species, life stage, angle and speed of approach, availability of escape terrain, value of occupied habitat, degree of habituation, etc. and are hard to quantify as population level effects. Behavioral reactions are easily recognizable, but may not reflect true survival costs as documenting reduced reproductive success due to stress, or abandonment of a particular area is hard to directly observe. There are plausible and documented mechanisms (nearshore approaches, high speeds) for PWC to be more disruptive than other boat traffic to marine mammals and seabirds, but it cannot be said that all PWC are more disruptive than all other boats. Buffer zones and speed limits have been implemented in some areas to mitigate disturbance to birds and wildlife from vehicles, air and water craft. . However, even with the assumption of user compliance, any one mitigation technique such as speed limits or buffer distances would not be consistently effective for a majority of species or locations.

The signature of PWC noise is more disruptive to both humans and wildlife than simple measures of the decibels produced by a small engine might indicate. Frequent and irregular changes in intensity, pitch, and direction can result from rapid maneuvering. With a shallow draft jet pump the changes in volume and pitch as the jet leaves and enters the water, create a distinctive, irregular noise. Studies indicate that, in general, sporadic, non-predictable stimuli are more likely to produce startle or alarm responses. PWCs are quieter underwater than boats, indicating the disturbance responses are more of a concern for wildlife than fish. Avoidance behavior and stress responses have been recorded for both hauled out (sea lions) and submerged (dolphins) marine mammals.

From a legal and regulatory standpoint, it is defensible for the state or the federal government to prohibit a certain type of craft based on its potential impacts to public resources. Several studies document lower levels of compliance by PWC operators than other boat operators with posted regulations or highlight additional effort needed to engage and create voluntary buy-in with PWC user groups.