

From National Marine Fisheries Service regarding Dock Impacts

Predator species such as northern pikeminnow (*Ptychocheilus oregonensis*), and introduced predators such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*) white crappie (*P. annularis*) and, potentially, walleye (*Stizostedion vitreum*) (Ward *et al.* 1994, Poe *et al.* 1991, Beamesderfer and Rieman 1991, Rieman and Beamesderfer 1991, Pflug and Pauley 1984, and Collis *et al.* 1995) may use habitat created by over-water structures (Ward and Nigro 1992, Pflug and Pauley 1984) such as piers, float houses, floats and docks (Phillips 1990). Carrasquero (2001), in reviewing the literature regarding impacts of over-water structures, reports that smallmouth and largemouth bass have a strong affinity to structures; forage and spawn in the vicinity of docks, piers and pilings; and, largemouth and smallmouth bass are common predators of juvenile salmonids.

Major habitat types used by largemouth bass include vegetated areas, open water and areas with cover such as docks and submerged trees (Mesing and Wicker 1986). During the summer, bass prefer pilings, rock formations, areas beneath moored boats, and alongside docks. Colle *et al.* (1989) found that, in lakes lacking vegetation, largemouth bass distinctly preferred habitat associated with piers, a situation analogous to slack water areas of the Columbia River. Marinas also provide wintering habitat for largemouth bass out of mainstem current velocities (Raibley *et al.* 1997). Wanjala *et al.* (1986) found that adult largemouth bass in a lake were generally found near submerged structures suitable for ambush feeding. Bevelhimer (1996), in studies on smallmouth bass, indicates that ambush cover and low light intensities create a predation advantage for predators and can also increase foraging efficiency.

Pribyl *et al.* (2005), in studies on piscivorous fish in the Lower Willamette River found that smallmouth bass were the most prevalent species captured. They found that smallmouth bass were found near beaches and rock outcrops more frequently in the winter and spring, and highly associated with pilings regardless of the season. For largemouth bass, they found that they were found near pilings and beach sites in summer and autumn and near pilings, rock and beach areas during winter and spring. They also indicated that large sized predators were present at very low densities, but juveniles were fairly abundant. Smallmouth densities were highest in riprap, mixed riprap/beach and rock outcrop areas. Largemouth bass densities were low throughout the year, with riprap sites and alcoves being the highest density areas.

Black crappie and white crappie are known to prey on juvenile salmonids (Ward *et al.* 1991). Ward *et al.* (1991), in their studies of crappies within the Willamette River, found that the highest density of crappies at their sampling sites occurred at a wharf supported by closely spaced pilings. They further indicated that suitable habitat for crappies includes pilings and riprap areas. Walters *et al.* (1991) also found that crappie were attracted to in-water structures.

Ward (1992) found that stomachs of northern pikeminnow in developed areas of Portland Harbor contained 30% more salmonids than those in undeveloped areas, although undeveloped areas contained more northern pikeminnow. Pribyl *et al.* (2005) found no fish in the stomachs of pikeminnow, but did find fish remains in the stomachs of smallmouth bass.

There are four major predatory strategies used by piscivorous fish: They run down prey; ambush prey; habituate prey to a non-aggressive illusion; or stalk prey (Hobson 1979).

Ambush predation is probably the most common strategy; predators lie-in-wait, then dart out at the prey in an explosive rush (Gerking 1994). Predators may use sheltered areas that provide slack water to ambush prey fish in faster currents (Bell 1991).

Light plays an important role in defense from predation. Prey species are better able to see predators under high light intensity, thus providing the prey species with an advantage (Hobson 1979, Helfman 1981). Petersen and Gadomski (1994) found that predator success was higher at lower light intensities. Prey fish lose their ability to school at low light intensities, making them vulnerable to predation (Petersen and Gadomski 1994). Howick and O'Brien (1983) found that in high light intensities prey species (bluegill) can locate largemouth bass before they are seen by the bass. However, in low light intensities, the bass can locate the prey before they are seen. Walters *et al.* (1991) indicate that high light intensities may result in increased use of shade-producing structures. Helfman (1981) found that shade, in conjunction with water clarity, sunlight and vision, is a factor in attraction of temperate lake fishes to overhead structure.

Other direct physical and chemical effects are unique to over-water structures. These are disruption of nearshore habitat, shading and ambient light changes, water flow pattern, and energy disruption (Carrasquero 2001). Over-water structures can alter predator prey relationships by improving predator success (Hobson 1979, Bell 1991, Metcalfe *et al.* 1997), although the environmental conditions created by over-water structures that can increase predation on salmon can be avoided or minimized using project design criteria that reduce shaded area and avoid placement in shallow water and other low velocity locations (Carrasquero 2001).

The obvious indirect effects of recreational boating facilities are those associated with boating activities. Boating can result in discharges of many pollutants from boats and related facilities, and physical disruption to wetland, riparian and benthic communities and ecosystems through the actions of a boat hull, propeller, anchor, or wakes (USEPA 1993, Carrasquero 2001, Kahler *et al.* 2000, Mosisch and Arthington 1998). Boats may interact with the aquatic environment by a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from the propulsion system, waves produced by movement, noise, and movement itself (Asplund 2000). Sediment resuspension, water pollution, disturbance of fish and wildlife, destruction of aquatic plants, and shoreline erosion are the major areas of concern (Asplund 2000).

Wakes derived from boat traffic may also increase turbidity in shallow waters, uproot aquatic macrophytes in shallow waters, or cause pollution through exhaust, fuel spills, or release of petroleum lubricants (Warrington 1999b, McConchie and Tolman 2003). Hilton and Phillips (1982) in their studies on boat traffic and increased turbidity in the River Ant determined that boat traffic definitely had a large effect on turbidity levels in the river. Nordstrom (1989) says that boat wakes may also play a significant role in creating erosion in narrow creeks entering an estuary (areas extensively used by rearing juvenile salmonids). Kahler *et al.* (2000) indicates that wake erosion results in continuous low level sediment input with episodic large inputs from bank failure.

Dorava (1999) indicates that boat wake erosion was the cause of substantial bank erosion on the Kenai River, Alaska (whose primary traffic is 10- to 26-foot-long recreational boats) and the reason for substantial bank stabilization measures to arrest that erosion. The result of the erosion in important salmon areas is a reduction in numbers of salmon

(Dorava 1999). Dorava (1999) further indicates that juvenile Chinook salmon rearing habitat features are easily altered by boat wake induced streambank erosion and streamside development.

McConchie and Toleman (2003) in their studies on the Waikato River found that effects from boat wakes are site specific and dependent on bank vegetation, bed and bank material, availability of sediment, channel profile, water depth and vessel speed. They further found that boat generated wakes have a greater potential effect where the river channel is narrow and where boat use is regular, concentrated and close to shore, and also in systems where systems are regulated and not subject to high erosive flows.

Klein (1997) citing several EPA studies indicates that boat traffic in waters less than 8.2 feet in depth result in substantial impacts to submerged vegetation and benthic communities. Klein (1997) also indicates that sediment resuspension is substantial if a boat operates in less than 7.2 feet of water and that a slight increase in depth would prevent the resuspension. Asplund (2000) evaluating the literature on boating effects to the aquatic environment found that impacts were few in waters greater than 10 feet. Limiting the placement of structures to areas where any moored boats are in waters deeper than 10 feet (as measured at OLW) would minimize any resuspension and submerged vegetation impacts.

Bauer *et al.* (2002) developed algorithms to predict erosion rates from boat traffic. They verified their models by using data measured during a field experiment in which a 7.5 m (24.6 feet) boat was driven past the site over a range of speeds to generate waves of varying size in a levee bank in the Sacramento–San Joaquin River Delta. Based on their test findings, erosion rates averaged about 0.01–0.03 mm/boat passage. The models predicted erosion estimates from their two models were similar, and ranged from less than 0.01 mm/boat passage for the weakest boat-wake event to 0.22 mm for the most energetic boat-wake event. They judged that the uppermost values overestimate the true erosion rate associated with single boat passages. However, two multiple boat-passage experiments yielded erosion rates of roughly 0.01–0.03 mm/boat passage, which agree with the lower estimates from the analytical methods.

Stuber *et al.* (1982) in their development of a habitat suitability index model for largemouth bass found that adults are most abundant in areas of low current velocity and velocities greater than 20cm/sec (0.7 fps) were unsuitable. Placement of in-water structures in areas with velocities greater than 0.7 fps will minimize the susceptibility of juvenile salmonids to piscivorous predation resulting from these types of projects. Juvenile salmonid species such as spring Chinook, sockeye, and coho salmon, and up-river steelhead usually move downriver relatively quickly and in the main channel. This would aid in predator avoidance (Gray and Rondorf 1986). Fall and summer Chinook salmon are found in nearshore, littoral habitats and are particularly vulnerable to predation (Gray and Rondorf 1986). In addition, the presence of predators may force smaller prey fish species into less desirable habitats, disrupting foraging behavior, resulting in less growth (Dunsmoor *et al.* 1991).

Placement of dock structures in shallow water may also disrupt migration of smaller juvenile salmonids that use nearshore areas. Boat activity and the physical presence of the structures may result in juvenile salmonid delaying passage or forcing them into deeper water areas in an attempt to go around the structures. Juvenile Chinook and coho salmon use backwater areas during their outmigration (Parente and Smith 1981). Littoral areas

are important for juvenile salmonid migration (Ward *et al.* 1994). McCabe *et al.* (1986) using a 50m (164 feet) beach seine found extensive usage of nearshore areas in the Columbia River estuary by subyearling Chinook salmon. Ledgerwood *et al.* (1990) using a 95m (312 feet) beach seine fishing in depths to 6m (20 feet) found extensive use of nearshore habitat in the Lower Columbia River by subyearling Chinook salmon. Dawley *et al.* (1986) using a 95m beach seine fishing in depths to 3m (10 feet) found extensive use of nearshore habitat in the Lower Columbia River by subyearling Chinook salmon. Sampling by them in 1968 found nearshore usage by subyearling Chinook salmon to be 15 times greater than in the adjacent channel area and that yearling Chinook salmon, coho salmon and steelhead were more often caught in deeper waters (Dawley *et al.* 1986).

Ward *et al.* (1994) reported mean distance offshore for juvenile salmonids caught while vertical gill netting in the Willamette River to range from 39 to 93 feet with most fish caught in waters 18 feet or less in depth. This indicates that the nearshore area in the Lower Willamette River is heavily used by smaller salmonids.

Placement of docks close to the shore impacts the ability of juvenile salmonids to safely migrate past.

Shading from docks, piers, boat houses, moored boats, and marinas may also reduce juvenile salmonid prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler *et al.* 2000).

Boating activities may adversely affect listed salmonids and aquatic habitats directly through engine noise or prop movement, and the physical presence of a boat hull may disrupt or displace nearby fishes (Mueller 1980, Warrington 1999a). Mueller (1980) in studying boating effects on long-eared sunfish found that boating affected fish behavior.

Depending upon speed and proximity to the nests, boats caused spawners to abandon their nests for varying periods in order to find protective shelter. Type of craft (johnboat or canoe) had no noticeable difference in effect, but speed and distance were important. Slow-moving craft (paddled or motored at 1 m (3 feet)/second) passing near a spawner chased it from its nest more often than craft moving at faster speeds. In most predation cases, speed and distance of passing craft made a large difference. Slow-moving craft, whether paddled or motored near nests chased spawners away more frequently than faster-moving craft. Graham and Cooke (2008) studied the effects of three boat noise disturbances (canoe paddling, trolling motor, and combustion engine (9.9 hp)) on the cardiac physiology of largemouth bass (*Micropterus salmoides*). They found that exposure to each of the treatments resulted in an increase in cardiac output in all fish, associated with a dramatic increase in heart rate and a slight decrease in stroke volume, with the most extreme response being to that of the combustion engine treatment.

Recovery times were the least with canoe paddling (15 minutes) and the longest with the power engine (40 minutes). They postulate that this demonstrates that fish experienced sublethal physiological disturbances in response to the noise propagated from recreational boating activities.

These boating impacts indirectly affect listed fish in many ways. Turbidity may injure or stress affected fishes (see above). The loss of aquatic macrophytes may expose salmonids to predation, decrease littoral productivity, or alter local species assemblages and trophic interactions. The continual loss of bankline results in requests for bank stabilization measures that further disrupt natural stream processes. Despite a general lack of data

specifically for salmonids, pollution from boats may cause short-term injury, physiological stress, decreased reproductive success, cancer, or death for fishes. Further, pollution may also affect fishes by affecting likely prey species or aquatic vegetation.