A Case Study of the Aquatic Invasive Species:

Yellow Perch (*Perca flavescens*)

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Taxonomy

Order: Perciformes

Family: Percidae

Genus: Perca

Species: *P. flavescens*

Common names: Yellow Perch, Perch, American Perch, Rock Perch

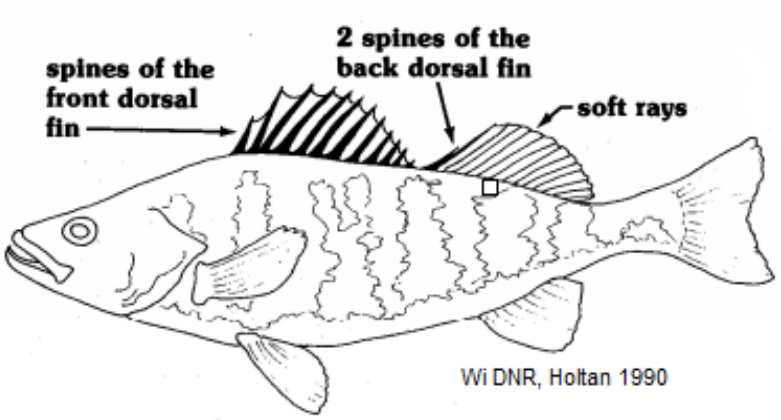


Figure 1. The two dorsal fins of the yellow perch have sharp spines.

Species Identification Key

Family: Percidae- Spines in anal fin 1 or 2; spinous and soft dorsal fins separate. (Simpson & Wallace *Fishes of Idaho*)

1a. Canine teeth present; some mottling but no distinct vertical dark bars absent from the side of a cylindrical body; anal fin with 2 spines and 12 to 13 soft rays

- Walleye, Stizostedion vitreum vitreum

1b. Canine teeth absent; prominent vertical dark bars on the sides of a compressed body (may be faint in young); anal fin with 2 spines and 6 to 8 soft rays (9-10 in fish from Lake Roosevelt)

- Yellow Perch, *Perca flavescens*

Other non-native Percidae fishes are not currently known to inhabit freshwater systems in Washington State. No native Percidae are present in Washington.

Life History

P. flavescens are short-lived fish which typically do not live longer than 7 years, (Wydoski & Whitney, *Inland Fishes of Washington*). Newly hatched fry migrate to the limnetic zone for a period of over one month, until they have grown to over 40 mm, (Whiteside, 1985). After achieving 40 mm, yellow perch fry migrate into the littoral zone, where feeding opportunities are better. Some studies suggest that egg to early fry life stages are the limiting factor in adult recruitment, (Isermann & Willis, 2008), though the risks in this stage for *P. flavescens* are unstudied. They usually mature between 1 and 3 years of age, (Holtan, 1990), with males typically maturing earlier than females at ages 1 to 2, and females maturing at ages 2 to 3, (Wydoski & Whitney). However, size, and age of maturity both have some degree of plasticity depending on environmental factors, (Purchase et. al, 2005; Jansen, 1996). Initial growth is high, but tapers

	Age									
Location	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10
Washington Average	2.4	4.7	6.0	7.6	8.4	8.7	9.2	10.5	9.6	10.1
Lake Erie (males)	3.6	6.6	8.4	9.4	10.1					
Red Lakes, MN (males)	2.9	5.2	6.8	7.9	8.7	9.2	9.5	9.6		

Wydoski & Whitney, 2003 Average Total Lengths (inches) of Yellow Perch at the End of Each Year of Life

off as fish mature, and in many cases, adult fish are stunted due to lack of available resources and high density. As relatively small fish, *P. flavescens* are prey for larger fishes, including walleye, which are used as a population controlling predator in many systems, (Holtan, 1990). Yellow perch tend to form loose schools that stay near the bottom, (Wydoski & Whitney). These schools tend to shift on a seasonal basis, with fish coming nearer to shore in the Spring to spawn, remaining slightly deeper in the summer to feed on invertebrates, and moving to the depths of the lake in the winter, (Holtan, 1990). In the summer months, yellow perch tend to school between 15-25 feet, (Wydoski & Whitney). Yellow perch appear to drop in and out of schools on a regular basis, (Helfman 2006), suggesting that while beneficial, schooling is not necessary. *P. flavescens* tend to school with individuals of a similar age and size, (Simpson & Wallace, *Fishes of Idaho*). Generally yellow perch tend to form spindle-like schools, with the majority of individuals in the center, (Holtan, 1990). Yellow perch are highly fecund, with females producing between 10,000 and 50,000 eggs, (Simpson & Wallace, *Fishes of Idaho*). Some fish in Lake Washington have been found with over 130,000 eggs, (Wydoski & Whitney). In Washington, spawning typically occurs in April or May, but is dependent on water temperature, thus it may occur at later times in higher altitudes, (ibid). Yellow perch usually spawn in water temperatures between 48 and 52 degrees Fahrenheit. Males tend to arrive in the spawning grounds before females. *P. flavescens* prefer to spawn in submerged brush or structure, but will also spawn in the open if preferred

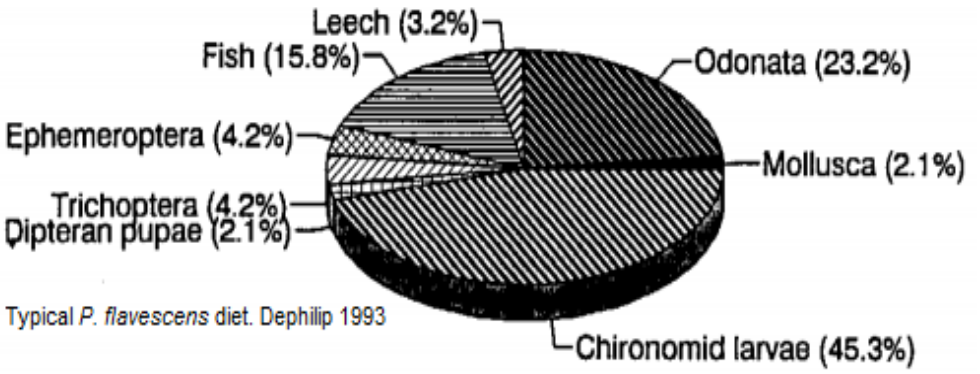
Figure 4. Spindle-shaped school of yellow perch.

habitat is unavailable, (Holtan, 1990). Groups of males closely follow females, sometimes in large aggregations, and release milt directly after she releases her eggs.

Violent competition for females is somewhat limited, as many males will pursue and mate with a single female, yet sperm competition is high. With large aggregations of males, sperm have to compete with that of many other males. Yellow perch do not provide any parental care, and immediately abandon the eggs, which generally will float for a time before sinking to the bottom or becoming submerged in debris, (ibid). Sinking helps prevent predation from fish and birds. Eggs hatch 10-20 days after fertilization depending on population and environmental factors, (Whiteside et al., 1985). Initial fry are larval and feed on unabsorbed yolk. These short incubation times might help buffer *P. flavescens* populations, which as discussed above, may be limited in early life stages.

Diet

Yellow perch are visual predators that are known to selectively consume large prey, (Michaletz et al., 1987). In their native range, age-0 *P. flavescens* consumed mostly *gammerus spp.* and isopods. In Lake Michigan, these organisms comprised 97% of the diet of sampled fish, (Pothoven et. al., 2000). The following year, the age 1 fish now consumed largely mysis shrimps. In Long Lake, Nebraska, very near their native range, Yellow perch eat a similar diet consisting largely of macroinvertebrates including chironomids and amphipods, (Wilkens et al., 2002). While clearly selective for certain prey items, adult yellow perch are generalists, and will consume a variety of organisms depending on their prey availability. In Lake Washington, yellow perch have been documented consuming sculpins (*cottidae spp*), mysis shrimp, and chironomids. These prey species are generally associated with the benthic community, with the exception of mysids, which move freely but can also be found near the bottom, (Costa, 1979). These species are also extremely abundant in Lake Washington, making them a readily available food source. This diet would be appropriate for *P. flavenscens* as they are poor swimmers compared to many other fishes, (Brown, 2009). Predation in Lake Washington perch was highest in the hours directly before dark, which supports the theory that yellow perch are visual hunters.



Typical *P. flavescens* diet. Dephilip 1993

In their native and non-native range, yellow perch have a similar diet that is highly variable but consists largely of chironomids, (Lott et al. 1995), until at least age 3, when *P. flavescens* begins to consume fishes as well, (Dephilip & Berg, 1993).

Environmental Tolerances

P. flavescenes is an environmentally plastic fish. Currently ranging from Nova Scotia to Florida, yellow perch experience a wide range of temperature and water chemistry. *P. flavescenes* has been found in lakes with pH as low as 4.6, (Rahel, 1983). Another study demonstrates that yellow perch will tolerate water as acidic as pH 4.1 before exhibiting avoidance behaviors, (Peterson et. al, 1989). Most fishes exhibit avoidance behaviors at higher pH's than *P. flavescens*, making it one of the more acid-tolerant freshwater predatory fishes. In the Eastern United States, which experience chronic acid rain deposition, yellow perch tolerate waters acidic enough to damage or alter the behavior of other fishes.

Yellow perch are also highly tolerant of low oxygen conditions and can survive winterkill, (Holtan, 1990). This allows yellow perch access to otherwise largely inhospitable lakes, and can be a great benefit for their population, as winterkill may reduce predators without large winterkills of yellow perch. Juvenile yellow perch can tolerate salinity up to 13.0 ppt., however, egg survival decreases in salinity above 2.0 ppt. Perch can tolerate waters up to 30 C (Piavis), with 32.3 C the non-lethal limit (Ferguson, 1985). Having a high tolerance of warm water, combined with the ability to survive winter kill, allows *P. flavescens* to inhabit a broad geographic range.

Yellow perch eggs, like other fish eggs, are susceptible to UV damage, (Williamson et al., 1997), which may limit the regional distribution of *P. flavescens* to deeper, more turbid, or high DOC lakes. Like many other fishes, yellow perch are susceptible to sub-lethal doses of heavy metal contaminants. Heavy metals have been found to delay reproduction, yet conversely cause premature development of immature gonads, (Levesque et al., 2003). While UV and heavy metals can impair or kill yellow perch, these effects also tend to kill eggs from other fish. Yellow perch are a hardy, tolerant species of freshwater fish.

Lifestage	Temperature C	Salinity ppt	pH
Egg	7 20	0-2	6-8.5
Larvae	10 30	0-2	6-8.5
Juvenile	10 30	0-5	6-8.5
Adult	6 30	0-13	6-8.5

Dissolved O2 mgL-1	Suspended solids mgL-1
NA	<1000
NA	<500
>5.0	NA
>5.0	NA

Associated Biota

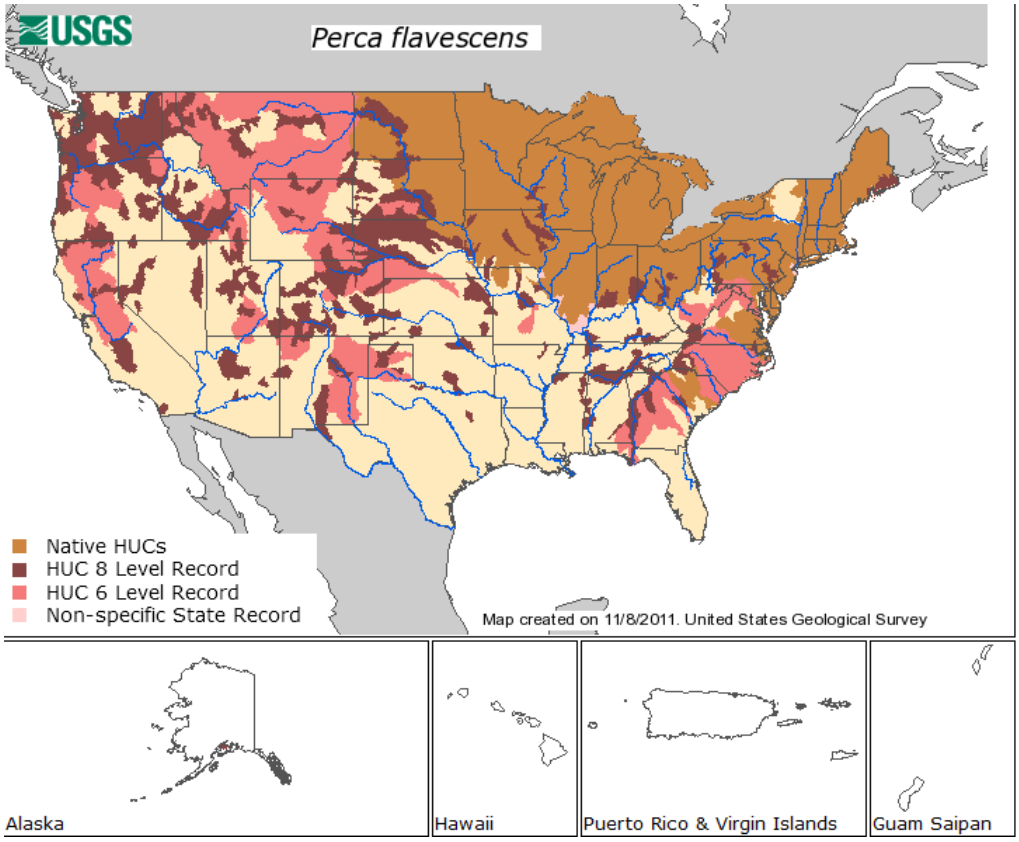
P. flavescens is a host for numerous parasites, none of which are known to be harmful to humans if the fish is properly prepared. Some of these parasites, however, can damage yellow perch. Some protozoans (*Trichodina spp., Chilodonella*, and *Epistylus spp)* and parasitic copepods are known to cause skin lesions, (Hart et al., 2006). Black spots on the outside of the body can be a sign of trematodes, which use perch as an intermediate host, (Ibid). Other trematodes can cause cataracts, and may cause yellow perch to lose their eye lens. In addition to these parasites, there are other parasites which do little to harm yellow perch, but make them unappealing to eat. *Heterosporous spp* causes opaque blotches on the fillets of yellow perch, while nematodes can survive in cysts in the meat of the fish, (ibid).

Recently, another disease, viral hemorrhagic septicemia, (VHS), has been associated with die-offs of yellow perch in the Eastern United States, although it has not been found in yellow perch in Washington. VHS is not harmful to humans, but can kill fish. Yellow perch juveniles may be particularly susceptible to the disease, (Eggold et al., 2008). Heavily infected fish display numerous hemorrhages all over the body, and often begin to swim in circles, or act lethargic, (MN DN, *VHS*). Yellow perch are not known to have commensal or mutual relations with other organisms, though due to its wide geographic location, such relationships are possible, and may continue to go undocumented.

DNR, MN VHS infected fish

Range

Yellow perch are found in their native range from as far north as Nova Scotia to South Carolina, and throughout much of the Eastern United States. They are not native to the Appalachian Mountains. They have a natural northwestern Canadian range as well, but are absent from the native biota of the Pacific Northwest, and Washington state. They have been introduced throughout the rest of the United States, and likely occur in all of the lower 48 states (Holtan, 1990). Due to different reporting standards, the exact range of yellow perch is unclear, though widely distributed.



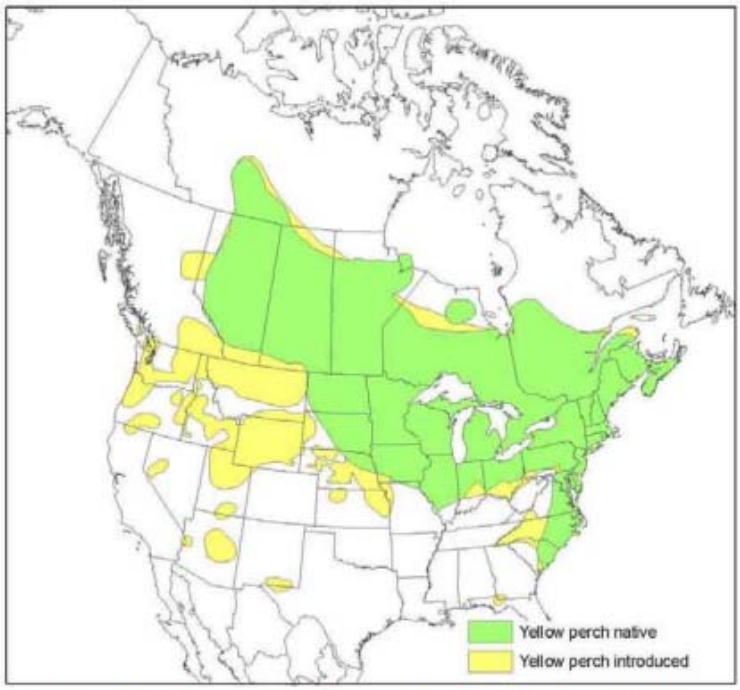


Figure 2. Native and introduced range of yellow perch in North America from Bradford et al. (2008).

History of Invasiveness

Yellow perch have established populations well outside their native range, but remain confined to the North American continent. Its two closest relatives, the European perch (*P. fluviatilis*) and the Balkhash perch, (*P. shrenkii*) occupy Europe and Asia; limiting the need to introduce yellow perch to these waters. Along with many other freshwater fishes, yellow perch were intentionally stocked west of their native range in a national effort to create angling opportunities for sport fish. Yellow perch continue to spread, with recent introductions occurring in British Columbia (Brown et al., 2009). Recently, yellow perch were discovered in Alaska, which had previously been *P. flavescens*-free, and generally has a low occurrence of invasive species, (Fay, 2002). This population has been eradicated; however, this example illustrates that even distant locations with few humans, such as Alaska, are susceptible to invasion by yellow perch.

Invasion Process

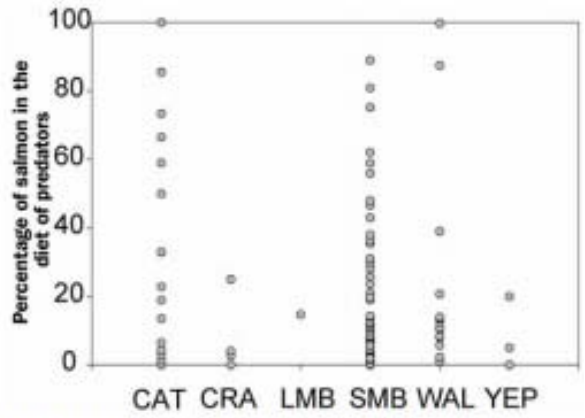
Yellow perch were purposefully introduced into eastern Washington in the 1800's for fishing, (Brown et al., 2009). The first recorded introduction events occurred across the state in places such as Tacoma, the South Palouse River, and Silver Lake, Cowlitz County in 1890-92, (Wydoski & Whitney, *Inland Fishes of* Washington). Yellow perch were also probably first introduced into the Columbia River in the late 1800's in a shipment of mixed fishes. Other introductions have cited fishing opportunities and providing forage fish for other sport fish such as walleye. "Bucket biologists" can also be a problem, as they may intentionally stock yellow perch as forage fish for smallmouth bass, walleye, or other piscivorous fishes, (Brown et al., 2009). Yellow perch may also have been released as live bait, as they are a common bait fish in some areas of Canada and the United States.

Since their introductions, yellow perch have become established in Washington State. In some lakes, such as Lake Washington, *P. flavescens* are one of the most dominant fishes, (Costa, 1979). Yellow perch can be found in every reservoir in the mid and lower Columbia River, as well as the lower Snake River. *P. flavescens* is also capable of colonizing available habitat in the same watershed, as found in the Klamath River system.

Yellow perch possess many biological traits that make them particularly adept at invading new watersheds. As discussed previously, *P. flavescens* is highly tolerant of a variety of factors including temperature, pH, and water chemistry. These traits not only allow for a large possible range, but may also allow yellow perch to colonize recently disturbed habitats that are largely unsuitable or undesirable for native fishes. Changes in pH from acid rain or industrial activities are less harmful to yellow perch than many other freshwater fishes. Tolerance to moderate levels of salinity (13.0

ppt) allows for invasion of saltier lakes or coastal freshwater bodies, such as the lower reaches of river systems. Tolerance to temperature allows yellow perch to do well in warm summers that may stress local fishes, and to survive extra cold winters that will eliminate most fish from a lake. Yellow perch are highly fecund fish that mature early and achieve rapid growth within their first few years. Additionally, they are abundant and widely distributed, allowing for much genetic diversity within their populations. Yellow perch are also associated with human activities, mostly fishing, and thus are more likely to be introduced. Yellow perch fit most major characteristics that are commonly associated with invasiveness, (Olden, 2009)

Yellow perch in most systems consume largely common unexploited, non-limiting resources, and may not be of concern to humans. Most fish consumed by perch tend to be small, economically invaluable fishes such as minnows. In some instances, however, *P. flavescens* may have major ecological effects. In small lakes with less diverse communities, yellow perch often come to dominate the fish community to such an extreme that they often become stunted due to population density and lack of abundant prey resources, (Wydoski & Whitney). By reducing other fish populations, yellow perch may reduce fishing opportunities. Worse, if yellow perch dominate and growth becomes stunted, yellow perch themselves provide poor angling opportunities. In some cases, yellow perch interact with endangered



Sanderson, 2009. Yellow perch (YEP) consume varying numers of salmon in the Columbia River

aquatic organisms, such as populations of Washington Pacific salmon. Yellow perch diets have been shown to vary, but can contain large proportions of young salmon, (Sanderson et al. 2009). While some other non-native fishes may consume higher proportions of salmon, yellow perch are worrying because of the high number of individual fishes possible in many systems. In addition to their environmental impact on salmon, perch are also having an economic impact by possibly reducing total catch of adult salmon in the future. Yellow perch, while harvested commercially, and raised in aquaculture in the Eastern United States, are economically unimportant in the Western United States except for recreational fishing opportunities.

Management and Control

There are few methods to control the spread of yellow perch, and prevention, as in

most situations, is a much more effective option. Education is one component of prevention that is often overlooked in management strategies and could be beneficial for prevention of yellow perch. “Bucket biologists” are a known issue for many sport fish, and education may help prevent some instances. Tougher regulations may also work. Making it illegal to use live yellow perch as bait would ensure that they were not introduced accidently or offhandedly from bait buckets. Once in a lake, yellow perch are nearly impossible to get rid of. Their quick generation time and high fecundity almost ensures that by the time they are noticed they will be present in high numbers. Rotenone, a piscicide, has been used, especially in small lakes, but is not a species-specific poison, and will eliminate nearly all fishes, (Boersma et al., *Invasive Species in the Pacific Northwest*).

Stocking highly piscivorous predators is another strategy that has some success, although complete elimination is unlikely, and yellow perch often become spinier and stockier in the presence of large numbers of predators, (ibid) thus making them less desirable for angling. Perch makes up a large portion of the diet of predators such as walleye, which can also provide fishing opportunities, (Wydoski & Whitney). Eradication of yellow perch is nearly impossible, making control a better option. However, as in most cases, prevention is a better option than either control or eradication. With a high environmental tolerance, yellow perch have the ability to invade most of North America, thus appropriate management strategies should be considered in watersheds where *P. flavescens* is not currently found.

Current Management Efforts

In Washington State, yellow perch are relatively unmanaged. Some assessments are performed by the Washington Department of Fish and Wildlife to look at basic information including growth rate and abundance. In some systems, such as Lake Washington, yellow perch are believed to be one of the most abundant species, yet little is known about their influence on the ecosystem. The most common management practice has been to stock piscivorous fish to reduce the impact of yellow perch, (Holtan, 1990). Stocking predacious fish reduces, but does not eliminate yellow perch, (Boersman et al.). In most locations in Washington yellow perch are largely unmanaged. In Lake Washington, for example, there is no angling daily limit on yellow perch, yet there are limits for native fish such as salmonids, (WDFW, *Fishing in Washingon*). By having no size limit, or numerical limit, the state is encouraging the catch of yellow perch and other non-native fishes over that of native fish which have more stringent management.

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Expert Contact Information

Fisheries scientists who focus on yellow perch tend to work in the Eastern United States on recovery plans and aquaculture. However, some work is done in the Pacific Northwest with invasive yellow perch. Cited below is contact information for local scientists who work with invasive species and have published some research relating to yellow perch.

Sergeant Eric Anderson. Washington Department of Fish and Wildlife.

Work address: 1111 Washington St. SE, Olympia WA, 98501

Dr. Robert Piorkowski, Scientific Program Manager.

Work address: ADF&G-CF Headquarters, Box 25526, Juneau Alaska, 99802

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Dr. Beth L. Sanderson, Research Fish Biologist. Northwest Fisheries Science Center, FE Division..

Work Address: 2725 Montlake Blvd. E. Seattle, WA, 98115

Email: Beth.Sanderson@noaa.gov

Continuing Research

The Alaskan Department of Fish and Game continues to do risk assessments for potential invasive species (Fay, 2002). British Columbia, too, does risk assessments on yellow perch, and continues to study their interactions in already invaded areas. In Washington and the rest of the Pacific Northwest, however, studies are limited. Little work is being done directly on yellow perch, likely because they have not been identified as a major ecological or economic nuisance. With few or no native game species in many of the small invaded watersheds, yellow perch have been beneficial for anglers. Some predation does appear to occur on salmonids, however, and this is of concern. The National Marine Fisheries Service and other organizations continue to work on predation of salmon by non-native fishes, with some notable examples, (Sanderson et al., 2009).