Invasive Species of the Pacific Northwest:

Northern Pikeminnow, *Ptychocheilus oregonensis*, Northern Squawfish

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Figure 1: Adult *P. oregonensis* (above) and juvenile (below). Images are not to scale. Photos from http://www.pikeminnow.org/wp-content/uploads/2014/02/Pikeminnow-2.png and http://www.fpc.org/bon_jda/Pictures/northern%20pikeminnow.jpg.

Classification

Order: Cypriniformes

Family: Cyprinidae

Genus: *Ptychocheilus*

Species: *oregonensis* (Richardson)

Identification Key

Formerly known as the Northern Squawfish, the *P. oregonensis* received its new name after an international committee held in 1998 agreed to the complaint from various Native American tribes, which claimed the term 'squawfish' was highly offensive to women (Spokesman's Review, 1998). The *P. oregonensis* belongs to the minnow family, Cyprinidae, a family of fishes with long, slender bodies. Pikeminnow from the Columbia River system are generally a bright silvery color, while those from tributaries will usually be darker and more colored. Juveniles have a prominent dark spot at the base of the caudal (tail) fin (Figure1). *P. oregonensis* have no teeth and have a deeply forked tail (Figure 1).

According to Scott et al, pikeminnow prefer lakes or slow moving runs of rivers just like the large pools formed just above hydroelectric dams. Juvenile pikeminnows prefer shallow waters during the summer, moving to deeper waters in the fall, while larger individuals remain deeper (Page and Burr, 1991).

The *P. oregonensis* has an elongated body that averages a length of 200 to 350mm (8 to 12 inches) in length, but may reach up to 600mm (24 inches). Their head makes up about 25% of the length (Montana Field Guide, 2014). Average weight of the fish can be about a pound. Catches of 7 pounds have been reported in Montana and up to 30 pounds in British Columbia (Montana Field Guide, 2014). Although they lack teeth, their predator voracity makes them an undesirable fish.

Their close resemblance to the peamouth chub could be a problem when attempting to control *P. oregonensis*. The peamouth, unlike the *P. oregonensis*, have small mouths and their jaw bend stops way before the eye (Figures 3 & 4). The *P. oregonensis* has a fairly large mouth, where up two three fingers fit inside and the jaw bend goes beyond the eye (Figure 2). Pikeminnows tend to have a flat head (Figure2), whereas peamouth chubs have a round head (Figure 4). The hints of bright orange on the peamouth's mouth, gill plate and fins are another great indication it is not a pikeminnow. The distinction between a pikeminnow and a chub are important when harvesting to kill, in order to protect chubs, a fish harmless to the salmonids of the Pacific Northwest.

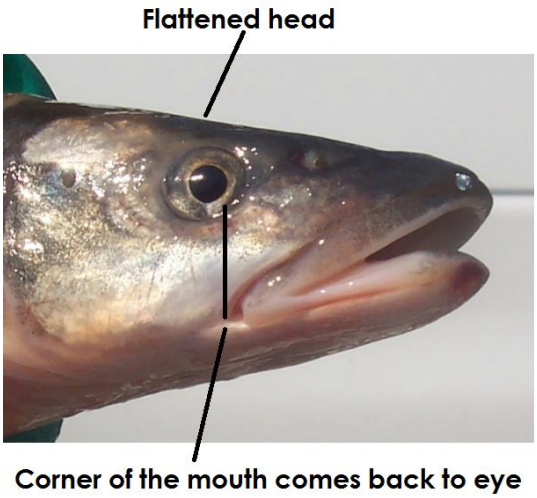

Figure 2. Facial characteristics of the *P. oregonensis* used to compare to Peamouth chub. http://www.pikeminnow.org/how-to/how-to-tell-a-northern-pikeminnow-from-a-peamouth.

Figure 3. Peamouth chub adult. Notice the hints of orange on the fins and mouth. http://www.pikeminnow.org/how-to/how-to-tell-a-northern-pikeminnow-from-a-peamouth.

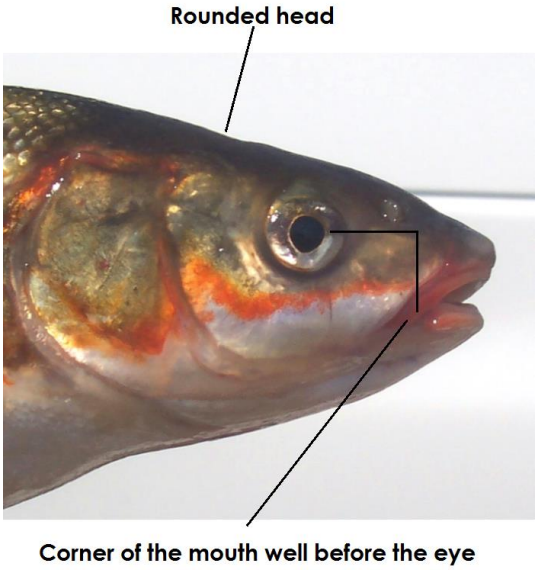

Figure 4. Facial characteristics of the peamouth chub which allow easier distinction from the pikeminnow. http://www.pikeminnow.org/how-to/how-to-tell-a-northern-pikeminnow-from-a-peamouth.

Life History and Basic Ecology

Life Cycle and Reproduction

When the water temperature begins to warm up in the spring into early summer, the pikeminnows are ready to spawn. *P. oregonensis* reach sexual maturity in about 3 to 8 years (Scott et al, 1973). When they are ready to spawn, fish migrate upriver into calmer water. The fish may swim into small tributaries or backwater pockets where they seek where the current will not drift their eggs away. Lake tributaries and reservoirs are also used to spawn where more gravel and soft sand bottom are found (Gadomski et al. 2001).

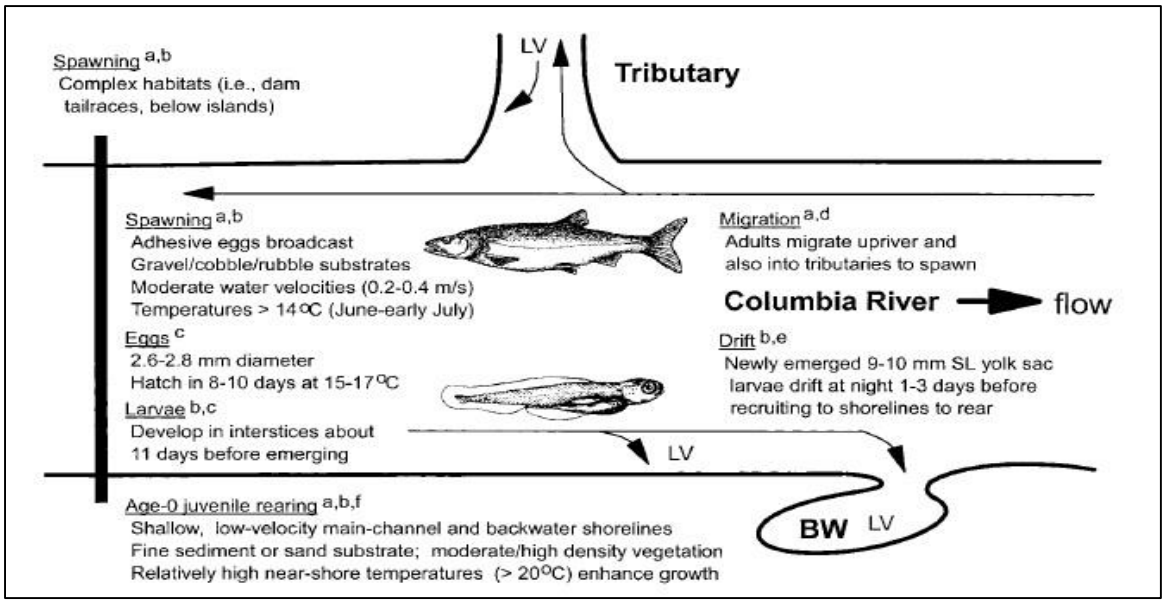

Figure 5. Northern pikeminnow life cycle from (Gadomski et al. 2001)

The ideal temperature for pikeminnow spawning is approximately 65 degrees Fahrenheit (Gadomski et al. 2001). Once the upstream migration occurs, fish try to find a mate. Once the spawning groups are formed, Page and Burr (1991) found that a female is surrounded by males close to the bottom, where eggs and sperm are released at the same time and eggs settle in the gravel. Female pikeminnow will typically have a fecundity of about 25,000 eggs a year (Parker et al. 1995). Unlike salmonid eggs, pikeminnow eggs are much smaller and have a sticky texture to them. *P. oregonensis* eggs average from 2.6 to 2.8 millimeters in diameter and will hatch in about 8 to 10 days, depending on the temperature of the water they were laid in (Figure 5). After the eggs are laid, the pikeminnows do not attend the fry, so after about 11 days, the larvae emerge and drift slowly downstream at night for 1 to 3 days (Gadomski et al. 2001).

The warm temperatures in a river are found in more shallow, slower water, which is found in the tributaries and backwaters away from the main current. The vegetation found in the littoral areas of the rivers provides cover from predators to juvenile fish. After successful survivorship, a juvenile *P. oregonensis* will mature into an adult after reaching a length of between 200 - 350 mm (Beamesderfer, 1992). Depending on genetic and positive environmental factors, juveniles may mature in 3 years. At this point, the fish are now 8 to 12 inches. Considering *P. oregonensis* lives 15 to 20 years (Scott, 1973), a single fish may spawn 12 to 17 of the remaining years in their lifetime.

Such was the case study of Beamesderfer et al (1996) where *P. oregonensis* rearing in littoral habitats of the upper John Day Reservoir thrived in stillwater factors such as high vegetation growth and high near-shore water temperatures. Phenotype differences in the sexes are not noticeable, but Parker et al (1995) found that females mature slower than males and males develop a yellow tint to their fins when spawning. Patten et al (1979) found that females

are easy to recognize during the prespawn, when they have enlarged abdomens from the eggs developing inside. Extraordinary congregations of fish occur during spawning season, which occur every year. Erratic movements of fish end up with reproduction acts that may result up to 6 males chasing a female (Patten et al, 1979).

Feeding Habits

The voracious predatory instinct of *P. oregonensis* is what gives them the reputation of a trash fish, but most importantly, makes them a species of ecological concern. The largest problem associated with *P. oregonensis* in all time has been the predation of salmonids. When juvenile salmon are preparing to migrate out of backwaters into the main river systems such as the Columbia River to journey back to the ocean, *P. oregonensis* are preparing to spawn. Just as pikeminnows migrate upstream to in the spring into backwaters or to the pools created by dams, schools of salmon may be intercepted by the pikeminnows at these points at eaten. As mentioned before, the erratic commotion created during the spawning may increase the interactions and predation on salmonids.

In the John Day reservoir of the lower Columbia River, Poe et al (1991) recorded an average trophic level of 4.3 of the pikeminnows after consuming an average of 83 percent of fish in their diet, about 66 percent consisting of salmonids. At warmer temperatures, fish were found to digest salmonids quickly (up to 50% per hour) and continue to eat. (Brown et al. 1981). Not all pikeminnows are considered a threat to out-migrating salmonids, though. *P. oregonensis* 11 inches and larger were found to be the most vulnerable to feed on out-migrating salmonids (Petersen, 2001). Juvenile *P. oregonensis* feed on plankton, aquatic and terrestrial insects and other small invertebrates in the littoral zone as any other fish in its habitat.

Figure 6. Pikeminnow eat a substantial amount of juvenile salmonids to the point of satiation.

In the Columbia River, invertebrates dominate the diets of *P. oregonensis* that are smaller than 11.8 in (300 mm), with fishes and crayfish increasing in importance as fish size increases (Poe et al. 1991). Being high on the trophic level means *P. oregonensis* eventually turn their diet to juvenile fish of any species they share habitat with, such as bass and other panfish as well as small baitfish like sculpins abundant in the Columbia River, for example. Unfortunately for salmonids, the larger the pikeminnows get, the more they will be able to consume at a time. This means that sometimes pikeminnows will even consume out-migrating salmonids at rates greater than what they can hold as seen in Figure 6 (Thompson et al, 1959).

Many fish increase their prey size as they grow to a size capable of eating larger prey. At various surveyed areas along the Columbia

River, *P. oregonensis* were found to have a diet of fish and crawfish, with fish prey size increasing as length of pikeminnow increased (Zimmerman et al, 1999). Perhaps the most surprising prey of the *P. oregonensis* is the cannibalistic predation of the eggs of other pikeminnows, almost exclusively from males, as observed by Scott et al (1973) in surveys during the spawning season.

Environmental Conditions

P. oregonensis generally prefer slower, less turbid water where they could seek cover in their juvenile stages. As the fish develop, the vegetation that is found in littoral zones may provide protection to the juveniles from other predators such as walleye and bass also found in their range. The juvenile pikeminnows may greatly benefit from a wide array of aquatic insects that depend on aquatic vegetation for their life cycle.

Many fish require an ideal water conditions that can remain steady in order to assure maximum possible survivorship of their eggs and hatchlings. A study in Southwest Washington found the average water temperature during pikeminnow spawning in Merwin Reservoir was 62.5°F (17°C) (Patten et al. 1969). In a river system, the warmer temperatures will be found in the shallow banks that tend to also have calmer current flows preferred by the fish in the same study (Patten et al. 1969). Like many warmwater fish such as bass, ideal spawning conditions are in the spring, where the water reaches about 65 degrees. Not surprisingly, *P. oregonensis* eggs in a laboratory study were incubated successfully under water temperatures of 59°F–62.6°F (15°C to 17°C) (Gadomski et al. 2001). The same study revealed ideal hatching conditions which resulted in eggs hatching in 8 to 10 days under these ideal temperatures (Gadomski et al. 2001). Building of dams on the Snake and Columbia rivers has been controversial in respect to ecological impacts on salmon. An indirect effect would be the creation of more ideal water conditions for *P. oregonensis* to thrive. Impoundments slow down oxygenated water and raise water temperature, which create conditions favorable for a pikeminnow, but not for salmonids (Brown et al. 1981). Increased turbidity is also unfavorable for the *P. oregonensis*. Increased water turbidity decreased visual predation on juvenile white sturgeon in controlled predation studies (Gadomski et al. 2000, 2001, 2002). As with other Pacific Northwest warmwater fish, the ideal temperatures to feed and spawn are similar for the *P. oregonensis*, increasing up to about 75 degrees Fahrenheit, where then will seek cooler water. Large *P. oregonensis* have been observed in benthic areas (bottom dwellers) that may reach up to 15 feet, which is highly possible in the large river systems it inhabits.

In 1999, ideal temperatures for living and growing of *P. oregonensis* were observed for the Idaho Division of Environmental Quality.

According to the observation, there was three major pieces of data recorded: Final Temperature Preferendum (FTP), Upper Lethal Temperature (ULT) and Optimum Temperature Range (OTR). Final Temperature Preferendum (FTP) was defined as the temperature for maximum growth. Upper Lethal Temperature (ULT) was defined as the temperature at which survival is 50% in a 10-minute exposure. Optimum Temperature Range (OTR) is a range of temperatures that provide for feeding activity, normal physiological response, and normal behavior. In the observations, Hillman, T. W, et al (1999) found a FTP of 16.1°-22.8°C (about 60 to 70 degrees Fahrenheit), an OTR of 16.1°-24.4°C (about 60 to 75 degrees Fahrenheit) and an ULT of 29.4°-32.0°C (about 84 to 89 degrees Fahrenheit).

Predators of P. oregonensis

Environmental factors indirectly affect *P. oregonensis* as well. A good recruitment of pest species to *P. oregonensis* may be bad news. Three main predators throughout the life cycle of the *P. oregonensis* are walleyes (*Sander vitreus*), prickly sculpin (*Cottus asper*) and smallmouth bass (*Micropterus salmoides*) (Zimmerman, 1999). Beamesderfer et al. (1996) suggested that the non-native species, walleye, might reduce *P. oregonensis* numbers through predation. Smallmouths live in similar habitat as the pikeminnow, so their aggressiveness would explain the predation on juvenile pikeminnow. Prickly sculpins live in benthic habitat, so during the spawn, the small predator may feed on pikeminnow eggs, emerging larvae and juveniles present.

Biotic Associations

P. oregonensis is no exception to parasites or diseases. Four main parasite groups are *Acanthocephala* (spiny-headed worms), *Cestoda* (cestodes or flatworms), *Nematoda* (round worms) and *Trematoda* (flukes or flatworms) (Hoffman, 1967). These parasitic groups go well together since they form in the stomachs of the fish after accidental ingestion of infected prey (Hoffman, 1967). These various groups of worms do not always kill the fish, as compared with tape worms in a dog.

Parasites are not always microscopic or in the interior of a host. Another class of parasite for *P. oregonensis* is leeches and lampreys which attach their mouths to the body of a fish and feed off their blood supply (Hoffman, 1967). A member of the mollusk family, *Glochidia,* is a parasite that uses *P. oregonensis* by transporting larva mussels to other areas using the gills of the fish (Hoffman, 1967). The last main group of parasites are the microscopic crustaceans such as *Lernaea cyprinacea* and *Ergasilus caeruleus* (Hoffman, 1976), more commonly known as gill lice. These parasites attach to fleshy gills of the fish where they can live off the fish's juices.

Geographic Distribution

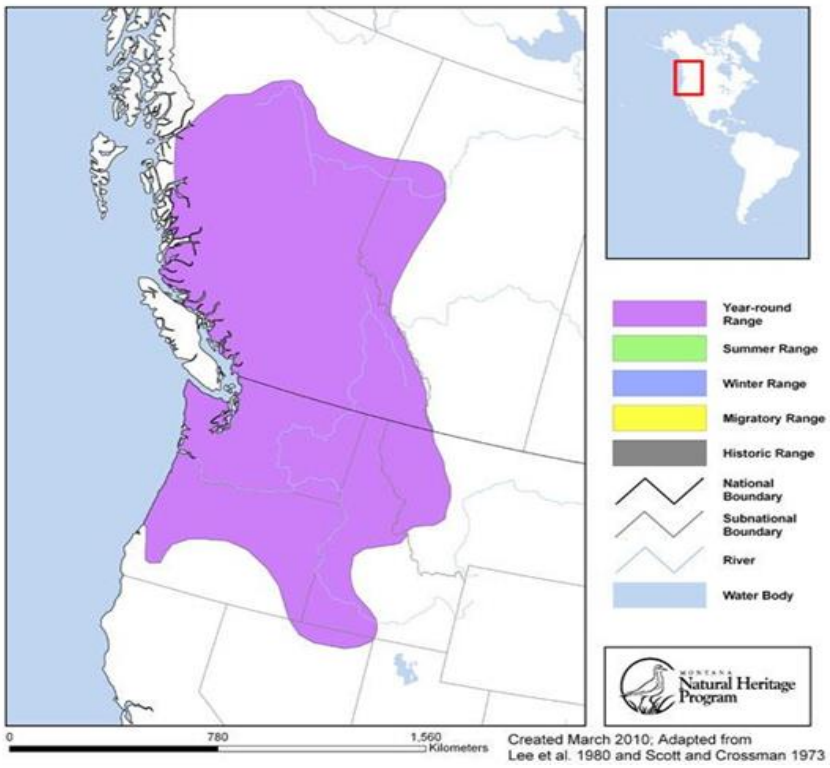

Figure 7. Distribution of *P. oregonensis* in its year-round range according to Lee et al, (1980) and Scott and Crossman, (1973).

P. oregonensis is a native fish to the Pacific Northwest. Major distributions are found all along the Columbia River and most of its tributaries and drainages that cause distribution as far east as Montana and North into British Columbia's Nass River (Figure 7). The Snake River's Shoshone Falls is a natural barrier that prevents distribution further southeast (Figure 7). The area covered in Figure 7 is on a latitude range of 55°N - 39°N as the stated distribution by Page, L. M., et al (1991). The successful establishment of the species in these rivers may be in part from the damming of the river systems (Brown et al, 1981). The *P. oregonensis* occurs in Pacific drainages in British Columbia south to the Columbia and Snake River basins in Washington, Oregon, Idaho, Wyoming, and Nevada.

History of Invasiveness

P. oregonensis is not an invasive species since it is a native fish to the region. The predation on juvenile fish gives it the reputation of a "trash" fish, more appropriately, a nuisance to sport fishermen. *P. oregonensis* may spread throughout watersheds if waterways that are uninhabited are connected to pikeminnow-free waters; they would simply swim across. In a more complex situation, global warming may increase water temperatures that allow spread of the species northward into regions previously

not warm enough. The impoundments as stated by Brown et al (1981) built on the river systems such as the Columbia River have altered the natural flow of the river, allowing slower current and warming up the water for a more ideal habitat.

Environmental/ Economic Concerns

P. oregonensis has been a concern for many decades ecologically and economically. *P. oregonensis* eat millions of juvenile salmonids a year in the Columbia and Snake River systems, approximately 16.4 million juvenile salmonids annually in Columbia River Basin, alone (Beamesderfer et al. 1996) . Large quantities of money may be placed into these salmon smolt through hatchery funds throughout the state, costing the state thousands, if not millions of dollars annually in lost fish (Washington Department Fish Wildlife, 2014.)

Management Efforts/ Control Methods

Before current day efforts were put to test, more unorthodox methods of removal or eradication were set into play. Some early efforts to control pikeminnow populations included chemicals, dynamite, lowering of lake levels and traps (Nevada Department fish and game). Since *P. oregonensis* are voracious predators upon juvenile salmonids, various organizations have put forth the effort for the past 24 years to help reduce numbers of adult pikeminnow. The effort to remove adults is due to the fact salmonid prey is generally more important to the older, larger specimens (Vigg et al. 1991). A large-scale predator removal program has been operating since 1990 with The Bonneville Power Administration at the head of funding the project (Beamesderfer et al. 1996)

Current Management Efforts

Of all the management efforts to reduce the amount of large adult pikeminnows, the current effort of a Sport Reward Fishery brings the most attention to the public, which takes place downstream of the Snake River's Lower Granite Dam all the way to the mouth of the Columbia River on the Washington/ Oregon border (Figure 8). Public attention is caught by setting out 4 to 8 dollar rewards per fish, depending on the amount that is caught in a season, some rewards reaching 500 dollars from tagged fish (Pikeminnow Sport Reward Program). The season runs from May to September and in some cases of die-hard anglers, have brought up to 70,000 dollars in rewards (Pikeminnow Sport Reward Program). Since 1991 through 2011, over 3.9 million *P. oregonensis* have been removed by the Sport

Figure 8. Stations along the Snake and Columbia river to report catches towards the Pikeminnow Reward Program.

Reward Fishery activities in the program area (PSRP).

Other research includes whether or not these angling efforts are working in reducing salmonid predation. The PSR program has resulted in the removal of nearly 3.5 million pikeminnow from the Columbia and Snake Rivers, reducing predation on young salmon by an estimated 40 percent (Pikeminnow Sport Reward Program). This is 4 to 6 million juvenile salmon annually that otherwise would have been eaten by this predator, saving the hatchery funders a lot of money from higher fish recruitment.

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