STATUS AND POPULATION STRUCTURE OF FRESHWATER MUSSELS IN THE ELWHA RIVER 100 YEARS AFTER THE DAMS

David L. Cowles, Layla Cole, Department of Biology, Walla Walla University, College Place, WA 99324;
Patrick Crain, Fisheries Biologist, Olympic National Park, 600 East Park Avenue, Port Angeles, WA 98362-6798;
david.cowles@wallawalla.edu

Figure 3: *Margaritifera falcata* mussels from the Lagoon population.

Figure 9: *Anodonta* cf.. *oregonensis* from Lake Sutherland.

Abstract:

We surveyed the middle and lower reaches of the Elwha River (from Lake Mills to the river mouth) for freshwater mussels in the summer of 2008. The river was surveyed by snorkelers, at least two on each side of the river. Lakes Mills and Aldwell were surveyed by boat and wading, and spot checks were made of Lake Sutherland. No mussels were found in the entire middle reach of the Elwha from Glines Canyon Dam to Lake Aldwell. Several small populations of *Margaritifera falcata*, the western pearlshell mussel, were found in the lower reach of the river below Elwha Dam, in regions still frequented by Chinook salmon. Age estimates based on size and ligament length suggest that some of these mussels may predate the dams. Some younger individuals were present but not abundant in the river populations. Abundant mussels were found in the water system surrounding the Elwha salmon rearing ponds and the associated industrial channel. Approximately 9000 mussels were found in this area. Mussels were abundant both in the stream draining the rearing ponds and in the North Outfall, an overflow from the industrial channel. These populations had many juveniles but few large individuals. This is likely due to robust recruitment combined with mass mortalities as the water levels in the manmade facilities have been manipulated over the years. No mussels were found in Lakes Mills or Aldwell, but *Anodonta* cf. *oregonensis*, the Oregon floater, was found in Lake Sutherland.

Introduction:

Due to the reliance of their glochidia larvae on fish, Pacific Northwest freshwater mussels have a life cycle which is closely tied to that of their salmonid hosts. The previously abundant salmon populations in the Elwha River have declined sharply since the erection of the dams. Migratory salmon have been extirpated from the reaches above the dams although trout still remain. The effects these changes have had on populations of native freshwater mussels in the river are unknown. In this study we examined the river and associated waters to see whether any native freshwater mussels still exist in the river, and examined the population structure of the populations found in order to infer how well the populations being sustained.

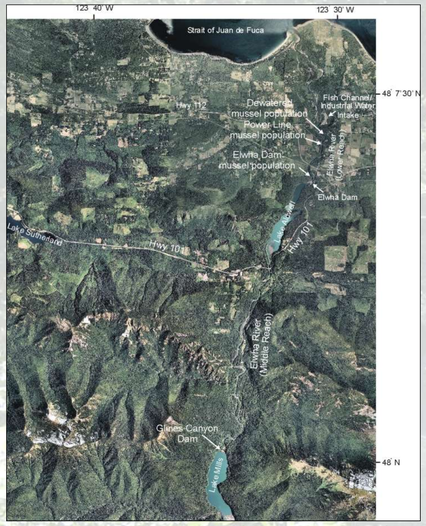

Figure 1: Overview of the middle and lower reaches of the Elwha River, covered in this study. For a closeup of the industrial water intake area see Figure 2.

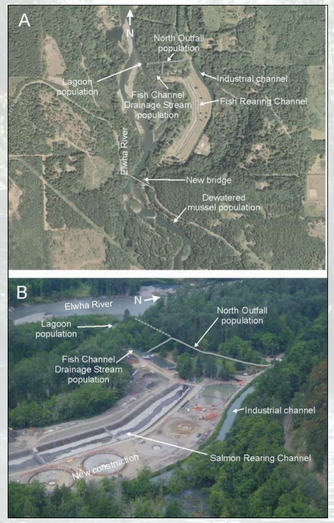

Figure 2: Closeup of the Fish Channel/Industrial Water Intake area (see location in Figure 1). A. View from directly overhead, north to the top. This photo was taken before the construction of the new bridge and changes to the industrial water channel began. B. Oblique view looking from southeast to northwest. The gray lines in A and B mark the North Outfall, which is mostly hidden in the trees. The solid gray line shows current water flow in the channel. The dashed line shows where water previously flowed before being diverted by a temporary dam. A small amount of water still flows through the previous channel but mussel mortality there has been nearly 100%.

Methods:

The Elwha River was surveyed by snorkel from Lake Mills to the river mouth, looking for mussels (Strayer and Smith, 2003; Duncan, 2008) (Figure 1). Rapids, which are not usually frequented by mussels, were avoided for safety. At least two snorkelers surveyed each side of the river. Special attention was focused on quiet-water stretches and side channels where mussels typically live. The recently dewatered portion of the Elwha River near the construction site for the new industrial water intake system was surveyed on foot with special attention to cracks and crevices in the bedrock along the shoreline. In the two reservoirs shorelines were surveyed by boat and viewscope examining the nearshore environment every few hundred yards, while larger shallow areas were surveyed by wading with a viewscope. Only spot checks of the shoreline were made in Lake Sutherland. When mussel populations were located, either every mussel (for small populations) or every fifth mussel (for large populations) were removed from the substrate, shaken dry, weighed to the nearest 0.1 g on a triple-beam balance, and measured to the nearest millimeter for shell length, ligament length, shell width, and shell height using micrometer calipers. For logistic reasons not all these parameters could be measured for some of the populations. Species identification was made using Clarke, 1981, Thorp and Covich, 1991, and Nedeau et al., 2005. Mussels were then returned to the area where they were found and were placed in their normal life position with the anterior end partially buried in the substrate and ventral side facing the current.

Mussel age was estimated based on ligament length and shell length using the relationships found for Pacific Northwest mussels by Stock (1996) and Toy(1998). Regressions based on different populations and measurements from Stock and Toy's data yielded slightly different age estimates, usually varying by up to 10-15%. The median value of each of these sets of estimates was accepted as the most likely age for each mussel in our study. We then used these age estimates with our mussel populations to estimate the most likely age range for each size class in the population (figures 5-7). Since the best-fit curve was calculated separately for each population, the best estimate of age for each size class varied by population.

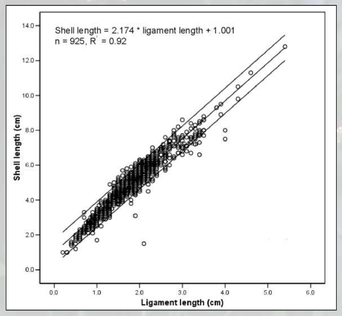

Figure 4: Correlation of ligament length with shell length for Elwha mussels measured (n = 925). Best fit regression: Shell length (cm) = 2.174 x ligament length (cm) + 1.001; $R^2 = 0.92$. 95% confidence interval for individual points is shown.

Results:

No mussels were found in any part of the 9 km middle reach of the river above Elwha Dam, the lowest dam on the river (Figure 1). Several small populations of *Margaritifera falcata* (western pearlshell) mussels were found in the 7.5 km of lower river below Elwha Dam (Figures 1-3). In the lower river, about 80 mussels were found just below Elwha Dam, 34 were found scattered along a stretch about 1 km upstream of the industrial water intake project (the "power line" population), and 133 were found in the dewatered river bed just upstream from the water intake. Much larger numbers were found in the water system associated with the Elwha salmon-rearing channel and the industrial water intake (Figure 2). A group of approximately 1000 mussels were found in quiet "lagoon" waters of the Elwha side stream which receives drainage from the fish facility. About 850 were found in the drainage stream from the fish channel, 6000 in the north outfall which receives overflow from the industrial water channel, and another 3000 in the industrial channel itself.

Mussel size measurements were strongly correlated with each other, suggesting that age estimates based on size measurements are likely to be consistent (Figure 4). Mussel populations in different regions of the river, however, were very different in size distribution and inferred age. Mussels from the main river (Figure 5) had a broad distribution of sizes with relatively few small mussels but a number of very large individuals with estimated ages ranging up to well over 100 years. Mussels from the water system associated with the salmon-rearing channel and industrial water outfall, on the other hand, averaged much smaller in size (Figure 6). Although they also spanned a large range of sizes, the smallest size classes were much more abundant than seen in the river and the large size classes were reduced or missing. In particular, the North Outfall population was strongly skewed toward the smaller size classes and even the rare, largest individuals had an estimated age of only 40 years (Figure 7).

No mussels were found in either Lake Aldwell or Lake Mills. Spot checks of Lake Sutherland, however, revealed the presence of *Anodonta* cf. *oregonensis*, the Oregon floater.

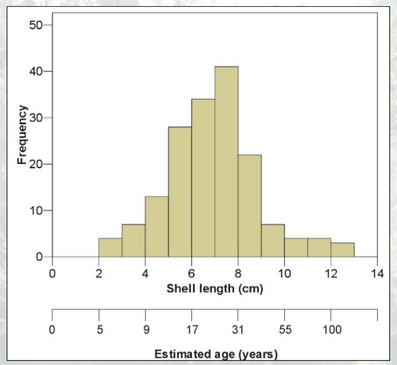

Figure 5: Size-frequency histogram for mussels found in the Elwha River main stream (the power line and dewatered populations, n = 167). A wide range of size/age classes are present. Few of the smallest size classes were found, but the populations include a number of very large individuals which are likely 100 years or more old.

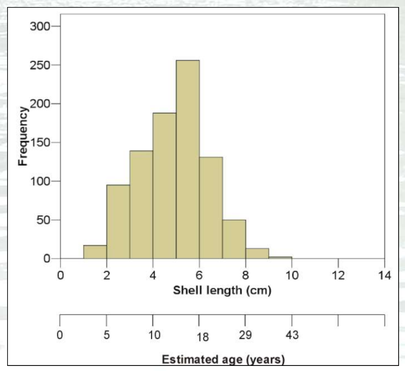

Figure 6: Size-frequency histogram for mussels found in the water system associated with the fish rearing channels and industrial water intake (the lagoon, fish channel drainage stream, and north outfall populations, n = 891). A wide range of size/age classes are present, especially with a large number of juveniles (shell lengths less than 5 cm). However, the largest, older individuals seen in the main river seem to be absent.

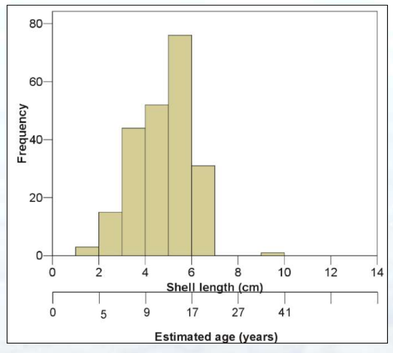

Figure 7: Size-frequency histogram for mussels from the North Outfall (n = 222). The smallest, juvenile age classes are well represented but size classes above about 25 years have only spotty representation and even the oldest individual found was estimated to be only about 40 years old.

Discussion:

The size range of mussels we found in the Elwha and their inferred ages suggests that the original population of native *Margaritifera falcata* have managed to survive the effect of the dams, at least in the lower river. However, their present populations in the main river consist of only a few small groups with a small number of older individuals. The oldest mussels very likely represent relicts of the original population, while some of the younger individuals could be descendants of mussels brought into the river from elsewhere via transplanted fish. The scarcity of the smallest size classes in the main river may represent spotty recruitment, or it could simply be due to the fact that juveniles tend to bury themselves in the sediment and are hard to find. Surveys of natural populations frequently find relatively few juveniles.

The mussel populations clustered around the fish facilities and industrial water intake follow quite a different pattern. The populations are flourishing, which may be related to the presence of Chinook salmon from the rearing channels, which is their preferred larval host. Recruitment here seems to be robust, with an unusual abundance of the smaller size classes. The larger individuals, on the other hand, are spotty or absent from the populations. This likely reflects past dewatering cycles associated with operation of the fish facilities and industrial channels. It is unclear whether the mussels in this area represent descendants of the original river population or are derived from mussels brought in with the fish stocks raised in the channels.

Unlike *M. falcata*, which is strongly associated with Chinook salmon and a few other salmonids, *Anodonta* spp. are thought to have wider preferences, both for substrate and for hosts (Cope, 1959; Martel and Lauzon-Guay, 2005; Moles, 1982, 1983; Roscoe and Redelings, 1964; Nedeau et al., 2005; Lima et al., 2006). Hosts include sockeye salmon, which formerly inhabited Lake Sutherland. It is possible that the *Anodonta* cf. *oregonensis* in Lake Sutherland are continuing to use the kokanee salmon which can still be found there. It is unlikely that any individual *Anodonta* in the lake predated the dams because *Anodonta* tend to be short-lived (Nedeau et al., 2005).

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