

Northwest Science Notes

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Range Expansion of an Exotic Siberian Prawn to the Lower Snake River

The introduction of non-native plant and animal species in aquatic systems is of increasing concern because of their potentially negative ecological and economic impacts (Sytsma et al. 2004). There are many examples of food web repercussions resulting from non-native invertebrate introductions. For example, in Flathead Lake, Montana, the kokanee salmon (*Oncorhynchus nerka*) population crashed after the introduction of a planktivorous mysid, *Mysis relicta* caused restructuring of the zooplankton community (Spencer et al. 1991) and the introduction of the spiny water flea (*Bythotrephes* spp.) to the Great Lakes also restructured zooplankton communities (Barbiero and Tuchman 2004). The zebra mussel (*Dreissena polymorpha*) has nearly extirpated some native unionid clams through competition for food and shell fouling (Strayer 1999). In San Francisco Bay, California, one of the most highly invaded estuaries in the world (Cohen and Carlton 1998), the benthic fauna has been highly modified by the introduction of hundreds of exotic invertebrates including the Chinese mitten crab (*Eriocheir sinensis*) and the Asian clam, *Potamocorbula amurensis*. Non-native invertebrate species, including the New Zealand

mud snail (*Potamopyrgus antipodarum*) and another Asian clam, *Corbicula fluminea*, have also been introduced to the Columbia River (Sytsma et al. 2004), but the ecological effects to Columbia River species are largely unknown.

The Siberian prawn (*Exopalaemon modestus*), a freshwater crustacean native to the western Pacific Ocean, was recently introduced to the lower Columbia River (Emmett et al. 2002). This species occurs from Siberia south to China, Korea, and Taiwan (Holthuis 1980) where it is associated with a variety of habitats and substrates. Emmett et al. (2002) found the Siberian prawn in sand, silt, and mud substrates ranging in water depth from 0.5 to 26 m in the lower Columbia River and in a shallow, turbid lake adjacent to the mainstem Columbia River. The Siberian prawn, ridgetail prawn (*Exopalaemon carinicauda*), and a smaller prawn, *Palaemon macrodactylus*, have been introduced into various locations along the western coast of North America including San Francisco Bay and the Sacramento and San Joaquin rivers (Wicksten 1997). These latter two Asian species are economically important where they are native (Oh et al. 2002) and may have been introduced into North American waters for food or bait. The Siberian prawn may have been introduced for similar reasons, but Emmett et al. (2002) speculated

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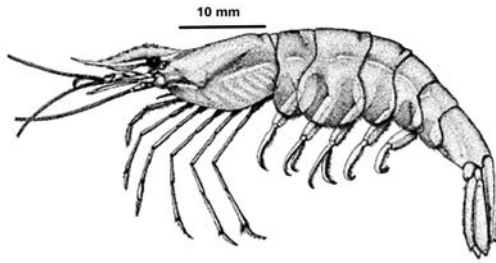


Figure 1. Artist's rendition of the Siberian prawn (*E. modestus*). Reprinted from Emmett et al. (2002) with kind permission of Springer Science and Business Media.

that the Siberian prawn was introduced into the Columbia River through ballast water exchange from oceangoing vessels, a common vector for the spread of invasive species.

There are no freshwater shrimp (Decapoda: Palaemonidae) native to the Columbia River Basin, but native estuarine species inhabit saline waters of the Columbia River Estuary. The Siberian prawn is distinguished from the native estuarine shrimp, *Crangon franciscorum*, by a large toothed rostrum and from the non-native ridgetail prawn by having abdominal segments without carinae (Figure 1). Other "shrimplike" crustaceans found in the Columbia and Snake rivers are much smaller and include the mysid shrimp, *Neomysis mercedis* and the amphipod, *Corophium salmonis*. Although *C. salmonis* and *N. mercedis* are historically estuarine species, they have extended their range upstream from the Columbia River Estuary into Columbia and Snake river reservoirs with significant food web implications. *Corophium* is an important food item for juvenile salmonids (Kirn et al. 1986; Muir and Emmett 1988; Muir and Coley 1996) and *Neomysis* preys on *Daphnia* (Haskell and Stanford 2006), an important food source for subyearling Chinook salmon (*Oncorhynchus tshawytscha*) (Rondorf et al. 1990). The range extension of the Siberian prawn into Snake River reservoirs may result in similar food web interactions. Palaemonid shrimps can play significant roles in food webs by feeding on detritus, algae, aquatic insects, crustaceans, and fish eggs, and can themselves be prey for fishes (Welsh 1975). In San Francisco Bay, the native shrimp *C. franciscorum*, and the oriental shrimp, *P. macrodactylus*, almost exclusively consume the mysid shrimp, *N. mercedis* (Siegfried 1980). Here, we provide the first documentation that the

Siberian prawn is now present in the lower Snake River, Washington, 469 to 575 km upstream from its initial discovery in the Columbia River Estuary in 1995 (Emmett et al. 2002).

We collected 19 Siberian prawns from lower Snake River juvenile salmon bypass facilities (Figure 2), which generally operate from April through October each year (Matthews et al. 1977; Hurson et al. 1999). From late June through October 2005, 10 prawns were collected at Lower Granite Dam (river kilometer 173 as measured from the confluence of the Snake and Columbia), 8 were collected at Little Goose Dam (river kilometer 113), and 1 specimen was collected from Lower Monumental Dam (river kilometer 67) (Table 1). All prawns were preserved in 95% ethanol for subsequent identification and analysis. All prawns were identified as *E. modestus* following Rogers (2005).

Each specimen was measured from the tip of the rostrum to the end of the telson and prawns were dissected to examine gut contents. Specimens ranged in size from 51-80 mm (mean = 62.9 mm). Their maximum size was similar to those in the lower Columbia River (Emmett et al. 2002), but larger than native populations reported by Holthuis (1980). We also counted eggs from female brood pouches as a measure of relative productivity. Of the 19 specimens we collected, 12 were ovigerous females with brood sizes ranging from 37-250 eggs (mean = 148.0), which is slightly less than the brood size range (60-353 eggs) reported by Oh et al. (2002) in Korea where ovigerous females occur from May-September. We collected ovigerous specimens from late August until the end of October, when juvenile salmon bypass facilities were closed for the year. We found no evidence in gut content analysis that Siberian prawns were feeding on other invertebrates. We found that the primary food was macerated detrital fragments, which were unidentifiable.

Prior to our study, there have been anecdotal reports of "large shrimp" at lower Snake River dams. On October 13, 1998, a single specimen approximately 75 mm long was collected at Little Goose Dam (Hurson et al. 1999). It was tentatively, and perhaps incorrectly, identified as a glass shrimp, *Palaemonetes kadiakensis*. Glass or ghost shrimp are names that commonly refer to a number of shrimp, including *P. kadiakensis*, sold through the aquarium trade. *P. kadiakensis* has recently been introduced to central California

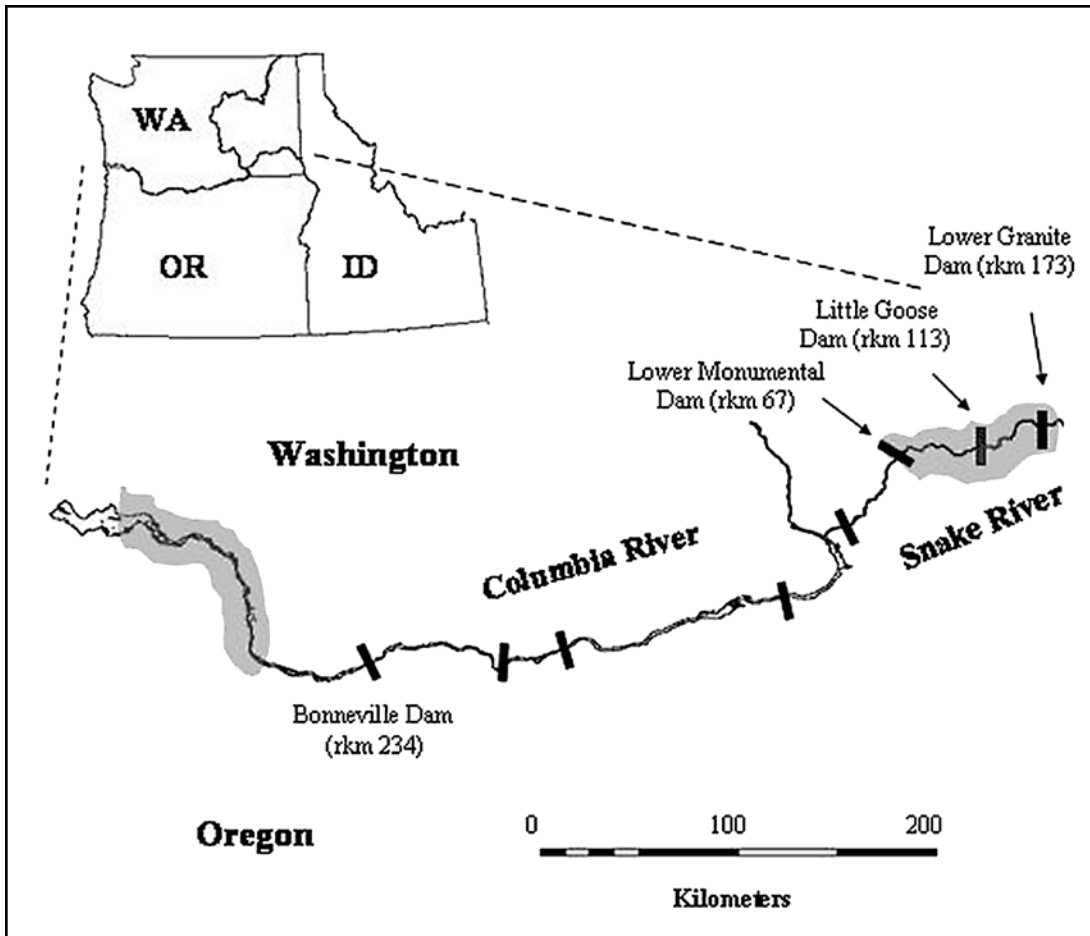


Figure 2. Range of the Siberian prawn (*E. modestus*) in the Columbia and Snake rivers with distribution described by Emmett et al. (2002) (shaded region in the lower Columbia River) and distribution described in this paper (shaded region in the lower Snake River).

(Rogers 2005). Other large shrimp also began appearing in the juvenile salmon bypass facility at Lower Granite Dam in 1998. Since then, reports of shrimp at lower Snake River juvenile salmon bypass facilities indicated only a few specimens were observed annually. However, in 2005 approximately 50 prawns were found at the three dams, 19 of which we collected for further study. Some of these were observed in the juvenile salmon bypass facility at Lower Granite Dam prior to our collection (Fred Mensik, Washington Department of Fish and Wildlife, personal communication). Prawns are diverted, perhaps haphazardly, into juvenile salmon bypass facilities by fish screens in the turbine intakes. Since these screens do not extend to the river bottom, it appears that Siberian

prawns are not strictly benthic but rise in the water column to capture prey. They may also be swept upward by the turbulent flow of water entering the turbine intakes.

In 2006, the number of Siberian prawns observed at Snake River juvenile salmon bypass facilities increased and at least one specimen was seen at the McNary Dam juvenile salmon bypass facility on the Columbia River (river kilometer 470) downstream of the Snake River. From early July through August, 248 prawns were found at Lower Granite Dam and 57 prawns were found at Little Goose Dam. None were observed at Lower Monumental Dam from April through August. On August 5, 2006, a Siberian prawn was collected at the McNary Dam juvenile salmon bypass facility

TABLE 1. Collection date, location, total length (mm), egg number, and water temperature of Siberian prawns collected in the lower Snake River, 2005.

Collection date	Location (hydroelectric dam)	Total length (mm)	Egg number	Water temp. (°C)
27 June 2005	Lower Granite	60	0	19.0
21 August 2005	Little Goose	80	0	19.6
24 August 2005	Lower Granite	75	211	19.9
25 August 2005	Lower Granite	72	37	20.8
26 August 2005	Lower Granite	66	236	21.0
26 August 2005	Lower Granite	57	117	21.0
26 August 2005	Lower Granite	67	244	21.0
28 August 2005	Lower Monumental	72	0	19.7
31 August 2005	Little Goose	51	0	19.3
2 September 2005	Lower Granite	56	154	20.5
2 September 2005	Lower Granite	66	0	20.5
2 September 2005	Lower Granite	54	84	20.5
3 September 2005	Lower Granite	55	119	19.8
7 September 2005	Little Goose	58	84	19.2
15 September 2005	Little Goose	57	187	18.0
23 September 2005	Little Goose	62	0	17.5
17 October 2005	Little Goose	59	53	16.1
18 October 2005	Little Goose	61	0	16.1
31 October 2005	Little Goose	68	250	15.6

and we confirmed its identity. This specimen was the first ever recorded there and subsequently two others have been observed (Brad Eby, U.S. Army Corps of Engineers, personal communication). This information suggests that Siberian prawns introduced into the Snake River have extended their range downstream to McNary Dam. No prawns have yet been reported at Bonneville, The Dalles, or John Day dams on the Columbia River, downstream from McNary Dam.

While information on range expansions of freshwater Carideans, to which *E. modestus* belongs, is lacking, relatively large amounts of information exist regarding upstream range expansion of other Decapods. In particular the signal crayfish (*Pacifastacus leniusculus*), native to the Northwest U.S., has exhibited upstream range expansion at a rate as high as 120 m d⁻¹ in the Truckee River watershed, California (Light 2003). Momot (1997) documented upstream range extension of the exotic crayfish, *Orconectes rusticus*, of 0.5 km yr⁻¹ in tributaries of western Lake Superior. In both situations, physical barriers slowed or prevented further upstream range expansion. However, once upstream of barriers, proximity to these barriers

was associated with higher abundance. Light (2003) showed that signal crayfish abundance was negatively associated with stream gradient, distance from reservoirs, peak discharge, and frequency of bank-full flow events and suggested that artificial barriers and flow manipulation may be an important management tool for preventing upstream dispersal of exotic species. Dams in the Snake and Columbia rivers act as physical barriers for upstream range expansion of Siberian prawns and other exotic species. However, these dams are not insurmountable because vectors could transport them upstream or they could swim upstream via the navigation locks.

River impoundment likely plays a major role in the success of the Siberian prawn in the Columbia and Snake rivers once they have become established upstream of dams. Lacustrine (forebay) reaches exhibit lower water velocities than riverine (tailrace) reaches and may provide refugia for prawns which would otherwise be displaced downstream during periods of high flow. Downstream movement in our study is documented by the collection of prawns in juvenile salmon bypass facilities from upstream reservoirs. However, flows

are clearly not inhibiting population maintenance in the lower Snake River and our data suggest that numbers are increasing. Siberian prawns will likely colonize Bonneville, The Dalles, and John Day reservoirs if they have not already. Regardless of how they became established, the Siberian prawn has apparently naturalized in the Columbia and Snake rivers and will likely become an important food web component.

The ecological role that the Siberian prawn now plays in the Columbia and Snake rivers remains unexplored. However, we speculate that the species will be more important as a prey item for fishes than as a predator of other invertebrates. Welsh (1975) describes a similar shrimp, *Palaemonetes pugio*, as an important food item for killifishes (Fundulidae) in Narragansett Bay, Rhode Island. Siberian prawns could be an important food source for resident fishes, especially in the winter, when abundances of zooplankton and aquatic insects are low. Given their relatively large size, Siberian prawns would provide an energetically profitable food source for juvenile salmonid predators, such as smallmouth bass (*Micropterus dolomieu*), northern pikeminnow (*Ptychocheilus oregonensis*), and walleye (*Sander vitreus*) (Rieman et al. 1991). Petersen et al. (2003) postulated that non-native juvenile American shad (*Alosa sapidissima*) in the Columbia River potentially provide an abundant food source for northern pikeminnow that might contribute to increased growth and survival over the winter. If the Siberian prawn benefits fish populations that also prey on juvenile salmon, it may present an additional threat to endangered

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salmonids. A benefit could also be derived by juvenile salmonids if Siberian prawns are available to them.

Documentation, monitoring, and potential vectors of aquatic nuisance species have been examined in the lower Columbia River (Sytsma et al. 2004) and regulations are now in place which require treatment or exchange of ballast water from ocean-going vessels. With the exception of occasional cruise ships, such vessels do not generally continue upstream past the Willamette River at Portland, Oregon. The Siberian prawn was first documented in the Columbia River Estuary in 1995 (Emmett et al. 2002) and in the lower Snake River in 2005 (possibly as early as 1998). We suspect that its apparently rapid range expansion to southeastern Washington was the result of commercial barge traffic or other human mediated vectors.

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