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## Increase in Abundance of Signal Crayfish May be Due to Decline in Predators

### ABSTRACT

The signal crayfish (*Pacifasticus leniusculus*) was captured coincidental to a burbot (*Lota lota maculosa*) investigation in the Kootenai River, Idaho, USA. Totals of 1,308 signal crayfish and 324 burbot were captured from 1994 through 2006. The signal crayfish was absent in the by-catch from 1994 through 1998, after which its numbers increased consistently to 404 individuals during winter of 2005-2006. During and prior to this time, the burbot population was diminishing from a high catch-per-unit-effort (CPUE) of 0.054 individuals/net-day in 1996 to 0.007 individuals/net-day in 2006. Regression analysis of CPUE of signal crayfish and CPUE of burbot suggested that the increase in signal crayfish abundance may have been influenced by the decline in burbot ( $r^2 = 0.55$ ;  $P = 0.05$ ), a predator.

The signal crayfish (*Pacifasticus leniusculus*), burbot (*Lota lota maculosa*), and white sturgeon (*Acipenser transmontanus*) are native to the Kootenai River in Idaho, USA. Burbot and white sturgeon were once common in the Kootenai River where their numbers have declined to near extirpation (Paragamian et al. 2005, Paragamian et al. 2008) because of habitat alterations (e.g., flow, temperature, nutrients, and sediment transport) related to the construction and operation of Libby Dam in Montana.

The Idaho Department of Fish and Game (IDFG) initiated burbot investigations in the early 1990s, and records of the presence/absence of the signal crayfish in the sampling by-catch were kept since the winter sampling of 1994-1995. Adult burbot were captured using up to 15 baited hoop nets primarily during the winter (November through March), a time selected to coincide with spawning and post-spawning migrations. Nets had a maximum diameter of 0.61 m, with lengths of 2.4 m and bar mesh of 25.4 mm. Nets were deployed in deep areas (usually >8 m or the thalweg) of the Kootenai River between river kilometer (rkm) 123 (British Columbia, Canada) and rkm 245.5 (Ambush Rock, Idaho).

Catch-per-unit-effort (CPUE) of both burbot and signal crayfish was expressed as the number of individuals caught per one 24-h set of each net (one net-day). The CPUEs of burbot and signal crayfish were analyzed by simple linear regression.

Hoop net effort varied annually but generally increased over time, ranging from 496 net-days in winter 1995-1996 to 2,085 in 2001-2002. Total catch of burbot also increased as effort increased until 2001 when the catch declined sharply (Table 1). Burbot CPUE varied from a high of 0.056 individuals/net-day for winter of 1995-1996 to 0.006 burbot/net-day during winter of 2002-2003.

General sampling with baited hoop nets had started in late 1993, but signal crayfish were not caught as by-catch until the winter of 1998-1999 when three individuals were captured (Table 1). Since that winter, crayfish by-catch increased to a high of 0.202 individuals/net-day during the winter of 2005-2006. All total, 1,308 signal crayfish were captured, and these captures occurred only at Ambush Rock. Ambush Rock was also the only river location sampled that had suitable crayfish habitat – large boulders and cobble and depth to 28 m. Ambush Rock was also the most important spawning location for burbot in Idaho, and although they are more common during the spawning season (late January through the first two weeks in February), only a few burbot reside there year-round, according to telemetry studies (Paragamian 2000, Paragamian and Wakkinen 2008). Thus, for comparative purposes in evaluation of data relative to occurrence of crayfish, I used burbot CPUE for the entire study reach as the most representative estimate of burbot population abundance (Paragamian et al. 2008).

Results of regression analysis of CPUEs suggested that the increase in signal

crayfish abundance was influenced by the decline in burbot abundance. The equation was  $CPUE_{\text{Burbot}} = -0.1644 CPUE_{\text{Crayfish}} + 0.0331$  ( $r^2 = 0.55$ ; ANOVA,  $F = 4.8866$ ;  $P = 0.05$ ). The appearance and increasing abundance of the signal crayfish corresponding to the diminishing number of burbot and white sturgeon is yet another indicator of ecosystem disturbance that has disrupted the predator-prey relationships in this river.

Indeed, the construction and operation of Libby Dam, over 100 km upstream, have had dramatic effects on the downstream river. The created reservoir, Lake Koocanusa, acts as a nutrient and sediment trap (Woods 1982) retaining ~63% of the inflowing phosphorus and ~25% of the total nitrogen, which makes these elements largely unavailable to organisms in the river downstream and thus reduces primary production (Snyder and Minshall 1996). An energy budget developed for the Kootenai River by Snyder and Minshall (2005) indicated that autotrophic and detrital energy inputs were inadequate to sustain the estimated fish biomass downstream of Libby Dam. Hauer and Stanford (1997) found changes in the Kootenai River benthic species composition had occurred soon after impoundment of Libby Dam, and Paragamian (2002) found a change in the fish species assemblage of the Kootenai River in Idaho from shortly after impoundment to 20 years later. The assemblage changed from a nearly equal biomass of omnivores and insectivores to a majority of omnivores.

Now, with burbot numbers down and signal crayfish numbers increasing, the predator-prey imbalance may further impact burbot rehabilitation in the form of crayfish predation on burbot eggs, since crayfish are known to prey on fish eggs (Horns and Magnuson 1981). At this point in time however, the crayfish population is also uncertain because the population is now being harvested by local fishers. Also, efforts by fisheries managers are in place to improve fish numbers and biomass (Hardy 2006, USFWS 1994, KVRI 2005).

Table 1. Captures and catch-per-unit-effort (CPUE) of burbot through the Kootenai River study reach and signal crayfish (caught only at Ambush Rock) in hoop nets in the Kootenai River, winters of 1994 -1995 through 2005-2006.

Sampling season	Burbot		Signal crayfish	
	Number of captures	CPUE (no./ net-day)	Number of captures	CPUE (no./net-day)
1994-1995	33	0.048	0	0
1995-1996	28	0.056	0	0
1996-1997	23	0.022	0	0
1997-1998	42	0.034	0	0
1998-1999	44	0.030	3	0.002
1999-2000	36	0.021	9	0.005
2000-2001 <sup>a</sup>	73	0.035	28	0.018
2001-2002	17	0.011	78	0.053
2002-2003	11	0.006	239	0.135
2003-2004	19	0.010	327	0.166
2004-2005	18	0.009	220	0.108
2005-2006	14	0.007	404	0.202

<sup>a</sup> Drought winter; data not used in analysis because individual burbot were caught multiple times.

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