U.S. Fish & Wildlife Service

Arcata Fisheries Technical Report TR2008-09

Mercury Contamination in Two Long-lived Filter Feeders in the Trinity River Basin: a Pilot Project

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May 23, 2008

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Key words: Mercury, Trinity River, Lamprey, Ammocoete, Freshwater Mussels, *Lampetra*, *Entosphenus*, *Margaritifera*.

The correct citation for this report is:

Bettaso, J. and D. H. Goodman. 2008. Mercury contamination in two long-lived filter feeders in the Trinity River basin: a pilot project. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR2008-09 Arcata, California.

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Abstract

We investigated mercury levels of lamprey ammocoetes (*Entosphenus spp.*) and western pearlshell mussels (*Margaritifera falcata)* in the Trinity River, California. Lamprey ammocoetes from four sites in the Trinity River and one reference site in the Mad River were analyzed for total mercury and mussels from three of the Trinity River sites were analyzed for total and methyl mercury. Longitudinal gradients were identified in ammocoete total mercury levels and methyl mercury in mussels. A 70 % increase in total mercury in ammocoetes was identified between two of the sample sites, indicating a potential point source of contamination. Ammocoetes contained levels of mercury 12 to 25 times those of mussels from the same site. These data indicates that ammocoetes maybe a superior bioindicator for mercury contamination compared to mussels in the Trinity River.

Introduction

An investigation of mercury contamination on the Trinity River from historical mining practices is currently being conducted by the United States Geological Survey, as elevated levels of mercury contamination have been identified in teleost fishes (May *et al*., 2005). Mercury can pose an ecosystem threat to organisms via lethal and sublethal impacts by immunosuppression, teratogenic effects and endocrine disruption (summary in Wiener and Spry 1996). Bioaccumulation of mercury in aquatic biota can result in biomagnification in higher order predators, and is of particular human health concern for organisms that may be utilized as a food source. Information on mercury contamination collected by the USGS has led the State of California to issue a Health Advisory for consumption of Trinity River fish upstream of Lewiston Dam (Klasing *et al*., 2005).

The ability to focus on taxa within a specific feeding guild provides the opportunity to elucidate the impacts of heavy metal contamination on biota, in relation to the physical chemistry of mercury. Investigating mercury contamination in filter feeders is an approach that has been successfully

implemented in several other drainages (Mallate *et al*., 1986; Malley *et al*., 1996; Renaud *et al*., 1998; Haas and Ichikawa 2004), but has never been applied to studies in the Trinity River. The use of filter feeders in this study has two advantages over previously studied organisms: (1) mussels and ammocoetes (as residents) are relatively long-lived organism, with life spans of ~60-100 years and ~4-6 years respectively, providing a longer period for bioaccumulation (Nedeau *et al*., 2005, Close 2002) , (2) mussel feed primarily from the water column, while ammocoete feeding occurs via burrowing in the soft sediments, providing two different mediums of potential mercury exposure on a site specific basis. Several studies have demonstrated that both taxa uptake mercury in areas of environmental exposure (Mallate et al. 1986; Malley et al. 1996; Haas and Ichikawa 2004).

Two lamprey species of concern are present in the study area; the Pacific lamprey (*Entosphenus tridentatus*), a tribal trust species, and the endemic Klamath River lamprey (*Lampetra similis)*, a state recognized sensitive species. Neither species has been utilized in investigations for mercury contamination in the Trinity River. Lampreys are considered a tribal trust species and thus merit consideration for the potential impacts of mercury contamination in the Trinity River Basin. Contamination of lamprey ammocoetes may also pose a risk for other species through the bioaccumulation pathway, as lamprey ammocoetes are a prey species for both salmonids and birds. Ammocoetes also reside in sediment burrows and may be an indicator of conditions for early life history stages of salmonids when they are buried in sediments. If mercury is found in ammocoetes at levels above background levels found in sediments, it may indicate a greater ecosystem threat.

Objectives:

1. Assess mercury concentrations in western pearlshell mussel (*Margaritifera falcata*) and lamprey ammocoetes (*Entosphenus spp.*) in the Trinity River.

2. Examine the distribution of mercury concentration in western pearlshell mussel (*Margaritifera falcata*) and lamprey ammocoetes (*Entosphenus spp.*) at four sites within the upper Trinity River Basin and one site in the Mad River as a reference site.

Study Area

Collection of organisms occurred at three sites distributed below Lewiston dam, one above the Trinity Reservoir and one reference site on the Mad River (Figure 1; Table 1).

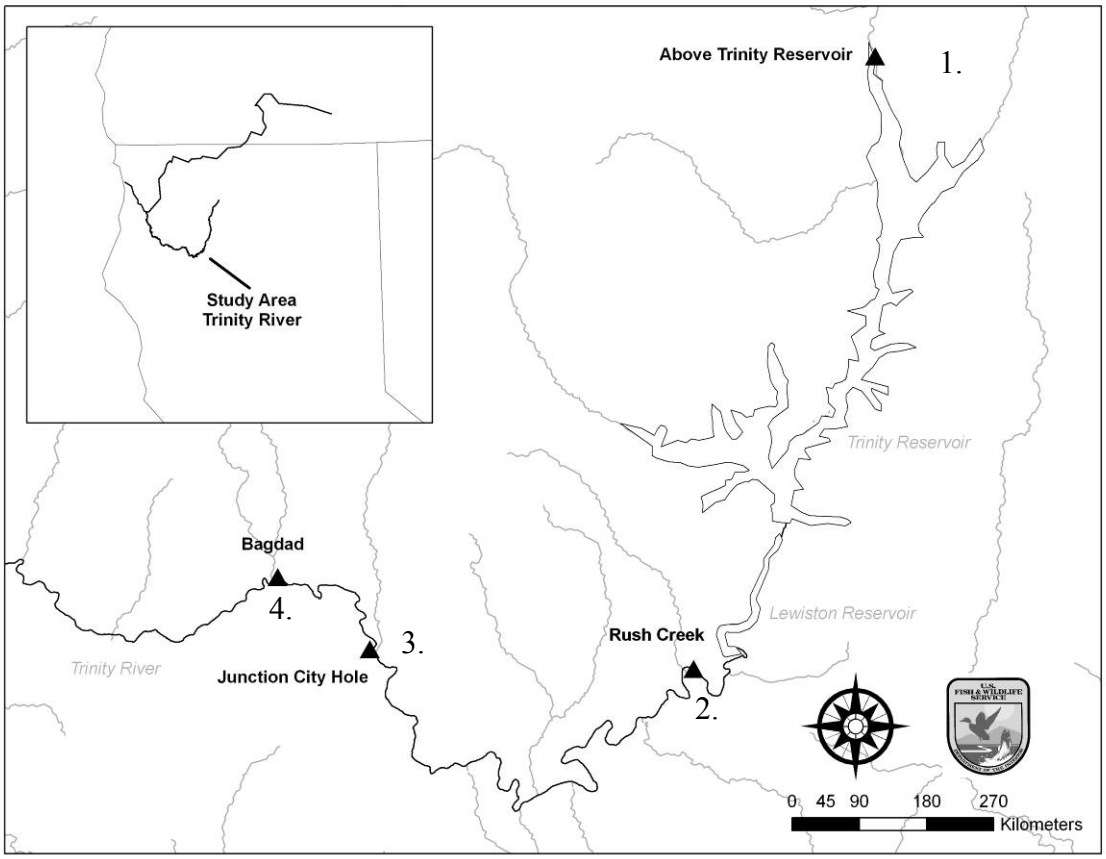

Figure 1. Map of the Trinity River study area with the four collection sites indicated. Mussels were only collected at sites 2 to 4. The Mad River site (Reference; not shown on map) is located in a different drainage approximately 50 miles from Site 4.

Table 1. River, site locations, river mile, date of collection, coordinates and collection species.

River	Site	River Mile	Date	UTM (NAD 83) N	UTM (NAD 83) E	Ammocoete	Mussel
Trinity	1:County Rd 106 Bridge	135	12Mar07	4544870	525432	Y	
	2: Rush Creek Boat Launch	108	13Mar07	4507758	514504	Y	Y
	3: Junction City Hole	79	13Mar07	4508605	494769	Y	Y
	4: Bagdad River Access	72	14Mar07	4513175	489465	Y	Y
Mad	5: Near water treatment facility	NA	19Mar07	4529094	411244	Y	

Methods

Target sample size for the western pearlshell mussel was 50 individuals from each site and at least 5 individuals for lamprey ammocoetes. We collected western pearlshell mussels by snorkeling and lamprey ammocoetes were collected using a Smith-Root backpack electro-shocking unit. Mussel samples

were only collected at the three sites on the Trinity River below Lewiston Dam. All samples were collected in March, 2007.

Samples collected were submitted to Gary Ichikawa, California department of Fish and Game, at the Moss Landing Marine Pollution Studies Laboratory. Ammocoete samples were combined by site and homogenized, acid digested and analyzed for total mercury by cold-vapor atomic absorption spectroscopy. These procedures followed EPA Methods 7473 (EPA 1998) with blanks, duplicates and spikes included for QA/QC standards. At each site, the 50 mussels were combined and analyzed for both total mercury (THg) and methyl mercury (MeHg). Mussel analysis procedures followed EPA Method 7473 for THg and EPA Method 1630 (EPA 2001) for MeHg. Total mercury is expressed as µg Hg/g wet weight (w.w.), whereas methyl mercury is expressed as ng MeHg/g (w.w.).

Results

Concentrations of total mercury in ammocoetes collected from the four sites in the Trinity River ranged from 0.379 (Site 1) to 0.882 THg µg /g (w.w.) (Site 4;
Table 2). All Trinity River ammocoete samples had greater concentrations than the 0.291 THg µg/g (w.w). measured at the reference site on the Mad River. Total mercury concentrations in mussels collected at the three sites on the mainstem Trinty River below Lewiston Dam ranged from 0.030 (Site 3) to 0.036 THg µg/g (Site 2). Methyl mercury levels in mussel samples ranged from 8.0 (Site 2) to 10.0 MeHg ng /g (w.w.) (Site 4).

Total mercury concentrations in ammocoete samples varied longitudinally in the Trinity River (Figure 2). Concentrations increased in all downstream samples particularly between sample sites 3 and 4 where a 70% increase was observed. An increasing downstream trend was also apparent in the MeHg concentrations in mussels (Table 2). This relationship was not mirrored in the THg concentrations in mussel samples which were similar among the three sites.

Table 2. River, river mile, and mercury levels in ammocoetes and mussels collected in 2007.

			Ammocoetes		Mussels			
River	Site	River Mile	N	THg (µg/g)	n	THg (µg/g)	n	MeHg (ng/g)
Trinity	1:County Rd 106 Bridge	135	7	0.379				
	2: Rush Creek Boat Launch	108	9	0.466	50	0.036	50	8.0
	3: Junction City Hole	79	6	0.520	50	0.030	50	9.3
	4: Bagdad River Access	72	5	0.882	50	0.035	50	10.0
Mad	5: Near water treatment facility	NA	7	0.291				

Note: Total Mercury (THg) is reported as microgram per gram (wet weight), and Methyl Mercury (MeHg) is reported as nanogram per gram (wet weight).

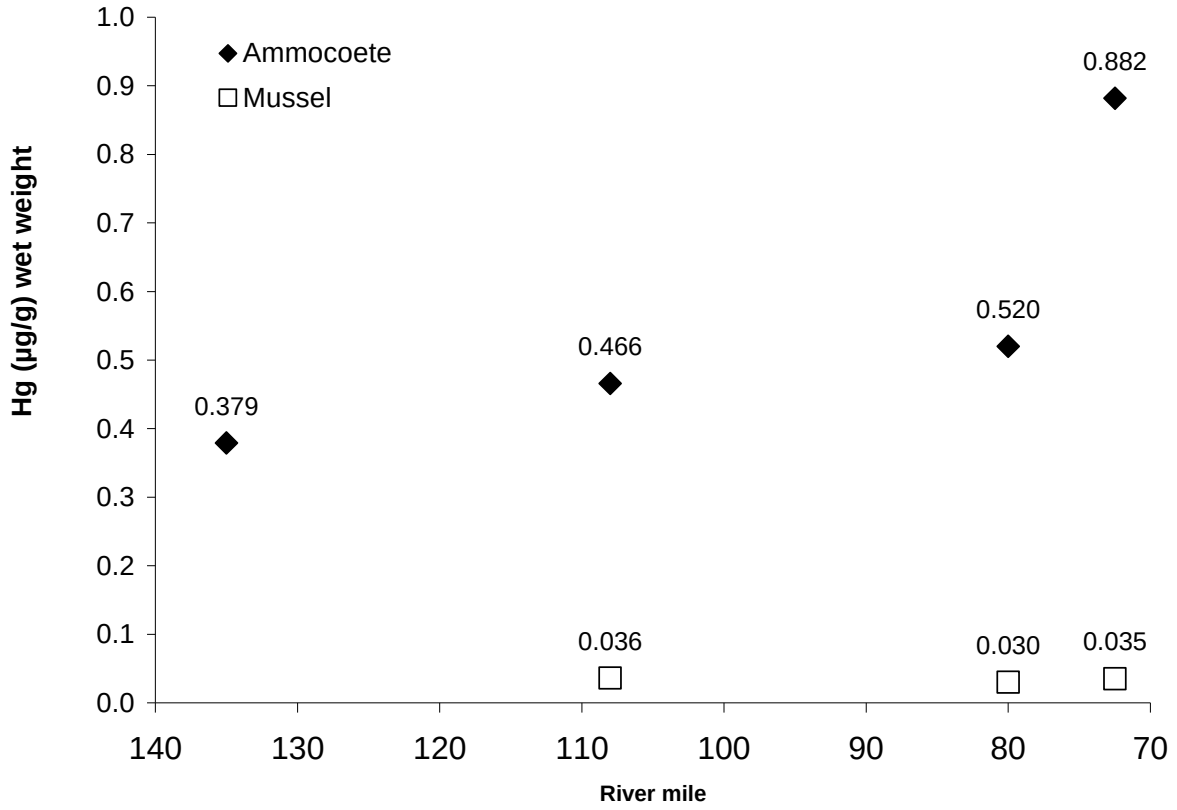

Figure 2. Levels of total mercury (THg µg/g w.w.) found in lamprey ammocoetes and western pearlshell mussels on the Trinity River from March 2007. River mile represents the river distance from the confluence of the Trinity and Klamath Rivers at Weitchpec. Lewiston Dam is located at river mile 110.

Discussion

Overall, THg concentrations were over an order of magnitude higher in ammocoetes than in mussels collected at the three mainstem locations on the Trinity River below Lewiston Dam. Similar differences in Hg accumulation were found between ammocoetes and mussels in the Châteauguay River in Quebec, Canada, where ammocoetes had five times higher concentrations compared to mussels (Renaud *et al*., 1998). Similarly increased Hg concentrations in ammocoetes have been detected in several watersheds in California where ammocoetes exhibited an order of magnitude higher levels of THg at several sites compared to other fish species surveyed (Haas and Ichikawa 2004, Haas and Morrison 2004). Levels of THg in Rainbow trout (*Oncorhynchus mykiss*) were found to average 0.0327 THg µg/g (w.w.) (n=10) for collections at Big Flat on the Trinity River and averaged 0.0499 THg µg/g (w.w.) (n=10) for collections at Hayden Flat on the Trinity River (May *et al*., 2005), therefore our ammocoete samples were an order of magnitude higher than the salmonids in this study. Our results are similar to these studies, though differences in concentration were more extreme in that ammocoetes had 12 to 25 times higher levels of THg compared to mussels from the same collection locality, indicating that mussels may accumulate less aqueous Hg than ammocoetes in the same location.

The difference in THg concentrations between these two taxa may be related to differences in life history strategies as Hg accumulates in sediments as compared to the water column (Boudou and Ribeyre 1997).

Fresh water mussels reside primarily above sediments where they filter feed from the water column, whereas ammocoetes typically reside in subsurface burrows and are sediment filter feeders (Potter 1980). The differences in Hg concentrations observed between the taxa are likely related to these or other differences in life history strategies. Nevertheless, ammocoetes appear to be a better bioindicator of environmental Hg levels as compared to mussels, in the Trinity River watershed.

Increased accumulation of THg levels at successive downriver sites was apparent in ammocoetes; a similar pattern occurred in MeHg levels in the western pearlshell mussels. The ammocoete samples indicated a gradual increase of THg concentrations from above the Lewiston and Trinity dams to the downstream sites sampled, with the furthest downstream sample showing a markedly higher concentration. This trend may be indicative of a chronic mercury contamination in the system. A 70% increase in contamination between the two most downstream sample locations was observed (approximately 7 miles), indicating a possible point source of contamination. Our data cannot resolve the source of this contamination. However, several potential sources exist between the sample sites, including a major tributary (Canyon Creek) with historic mining, historic mining along the Trinity River main channel, and the Hocker Flat Rehabilitation site (constructed in 2005), which includes large dredge pilings (Rytuba et al. 2005). These results indicate that further more-localized sampling is warranted to investigate the source of the contamination, and to document any ecological impacts.

Our data indicate that lamprey ammocoetes are a superior Hg bioindicator to western pearlshell mussels for mercury contamination in the Trinity River. Furthermore, our data indicate that Hg contamination likely occurs as a chronic contaminant throughout the watershed, but with the potential for unidentified point sources resulting in localized contamination. The elevated levels of Hg in ammocoetes pose two potential threats: 1) overall health effects to the individual ammocoetes, and 2) ecosystem effects to ammocoete predators through a bioaccumulation pathway. We recommend further investigation of mercury contamination in the Trinity River system using lamprey ammocoetes. Additional sampling could further elucidate the apparent longitudinal trend, as well as, temporal trends of mercury contamination in the system by repeating the current sample sites, adding additional sites, and sampling seasonally.

Acknowledgements

The underwater cover photo of a western pearlshell mussel bed was taken by Andy S. Quinn. We would like to thank Charles Chamberlain, Jim Haas, Toby McBride and Joe Polos who reviewed the report and provided many useful comments.

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