Mercury Bioaccumulation in Pacific Lamprey Ammocoetes: the Role of Life History

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Introduction

Objectives were to evaluate distribution of mercury from historic mining operations and correlations of Hg concentrations in sediments and biota with indicators of biological health at different levels of biological organization. Ammocoete densities (lampreys/100m2) were evaluated in relation to Hg concentrations and other habitat parameters.

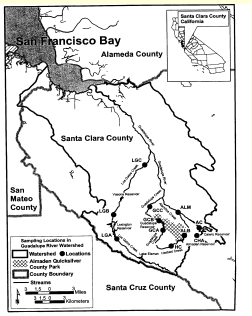
Methods

1. Sites above and below historic mining areas in the Guadalupe River drainage (Fig. 1) were sampled for total mercury in sediments, benthic macro-invertebrates (BMI), and fish using a Perkin-Elmer FIMS-100.

2. Fish were captured and densities estimated by quantitative electrofishing (Armour *et al.* 1983) in 100 m stream segments.

3. Habitat evaluations were performed to separate potentially confounding effects of habitat quality from Hg effects on BMI and fish health indicators (Armour *et al*. 1983; Welsh and Lind 1996).

Fig. 1. Site Map



Results/Discussion

1. Sediment T-Hg concentrations showed a negative exponential relationship with distance from historic mining areas (Fig.2).

2. Lamprey ammocoetes were found at 3 of 11 locations, characterized by low elevation, greater numbers of pools, lower water velocity, and higher water temperatures (Table 1).

Abstract

Stream sediments in several subwatersheds of the Guadalupe River drainage are contaminated with mercury (Hg) at concentrations exceeding hazardous waste criteria due to historic mining operations. From 1995-1998 we collected sediment, benthic macroinvertebrates, crayfish, and fish samples at sites with different mining histories and analyzed them for total mercury (T-Hg) and/or methylmercury (M-Hg). Fish and invertebrate Hg concentrations at each site were correlated with sediment T-Hg and to T-Hg in other species. We found Pacific lamprey (*Lampetra tridentata*) ammocoetes at the lowest elevation sites in three of the subwatersheds. Mercury concentrations in ammocoete tissues were positively correlated with sediment M-Hg concentrations. At each location, mean ammocoete tissue Hg concentrations were 2-19X higher than those in other fish species. Ammocoete densities were inversely correlated with tissue Hg concentrations. Other habitat correlates with ammocoete density included water temperature and depth and number of pools; however, the small number of sites at which we found lampreys precluded multi-variate analyses. Trophic level is considered an important indicator of Hg bioaccumulation potential in fish, but other life history parameters seem to be more important in the lower trophic level lamprey ammocoetes. These include longevity, close contact with the substrate, and diet.

Table 1. Selected habitat parameters of sites occupied by Pacific lamprey ammocoetes in Guadalupe River tributaries.

Site	Lamprey/ 100m^2	Sediment T-Hg (ug/g dw)	Elevation (m)	Water Velocity (m/s)	Slope (m/km)	Number of Pools (mean)	% Algal Mat Cover	Water Temp. (Deg. C)	pH	DO (mg/l)
Guadalupe Creek (M)	0.4	87.2	70	0.51	8	3.2	0.0	14.4	8.1	8.6
Alamitos Creek (M)	0.7	62.9	69	0.24	5	8.0	0.0	15.9	7.7	8.5
Los Gatos Creek (Ref)	4.4	0.07	54	0.08	5	49.6	19.6	17.9	7.8	8.4

M=Mining impacted

Ref=Unmined reference creek

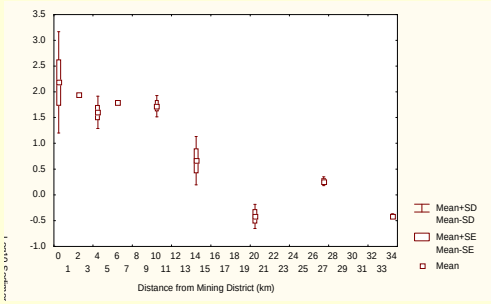


Fig. 2. Sediment log10 (Hg+1) (ug/g dw) in relation to distance from mines.

3. T-Hg concentrations in lamprey whole bodies were correlated with sediment T-Hg (Fig 3)

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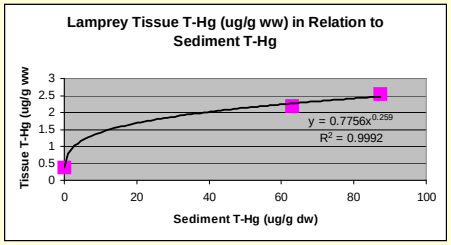


Fig. 3 Log-log correlation of ammocoete T-Hg to sediment T-Hg

4. T-Hg concentrations in lamprey ammocoetes exceeded concentrations in co-located species at each location (Fig. 4).

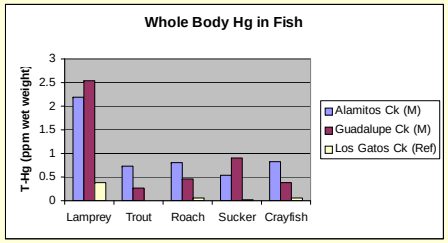
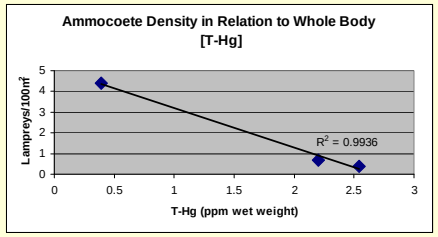


Fig. 4. Site-specific differences in fish whole body T-Hg concentrations.

Fig.5. Ammocoete density correlated negatively with tissue T-Hg.



5. Ammocoete densities correlated negatively with whole body T-Hg concentrations (Fig. 5). Other factors such as elevation, number of pools, water temperature, could be significant with a larger data set.

Conclusions

1. The pattern of T-Hg concentrations in sediment and biota established the predominant role of the historic mines as a source of Hg loading to the Guadalupe River.

2. Trophic level is generally considered the predominant factor affecting Hg bioaccumulation in fish, but other life history parameters seem to be more important in lamprey ammocoetes. These include longevity, close contact with the substrate, and feeding behavior (Table 2).

3. Further work is needed to determine which factors limit ammocoete density.

Table 2. Selected life history traits of native fish species analyzed for Hg bioaccumulation (Moyle 2002

	Species			
	Pacific Lamprey	Sacramento Sucker	California Roach	Rainbow Trout
Life Stage Analyzed	Ammocoete	Juvenile/Adult	Adult	Juvenile
Diet	Algae, phytoplankton	Omnivorous	Algae	Aquatic and terrestrial insects
Breeding Strategy	Semelparous; non-guarding brood hiders - benthic	Iteroparous; non-guarding benthic spawners - course bottoms	Iteroparous; non-guarding benthic spawners - course bottoms	Iteroparous; non-guarding brood hiders - benthic
Micro-habitat Use	In fine-grained substrate	On course substrate	Water column	Water column
Heat and Hypoxia Tolerance	High	Moderate	High	Low
Life Span	5-6 years	0-4/10+ years	4-5 years	0-1 year

Acknowledgements. Funding was provided by the Department of the Interior NRDAR Fund, the California Department of Fish and Game Pollution Abatement Fund, and the U.C. Toxic Substances Research and Teaching Program.