

Investigating Potential Causes of Episodic Mortality in Culturally and Commercially Important Fish From the Sao Francisco River, Brazil, Using a Surrogate Small Bodied Fish Species



VP Palace^{1,2}, LE Peters², EF Araujo Silva³, MU Teles Gomes⁴, S Kollar¹, A Bartlett¹, M Gray⁵, J Werner², J Emmer⁶ and J Carolsfeld⁶

¹Department of Fisheries and Oceans, Winnipeg, CANADA ²University of Manitoba, Department of Zoology, Winnipeg CANADA ³Universidade Federal de Sao Carlos, Sao Paulo, BRAZIL ⁴Estacio de Piscicultura de Tres Marias (CODEVASF), Tres Marias, BRAZIL ⁵Canadian Rivers Institute, University of New Brunswick, Saint John, CANADA ⁶World Fisheries Trust, Victoria BC, CANADA

Abstract

The Sao Francisco River in Brazil is a culturally and commercially important river. Fishing is estimated to support 1,300 people near the town of Tres Marias, primarily from the harvest of two species: surubim, dourado and dourado. Recent large scale episodic mortalities of these species are estimated to account for losses of more than 100 kg of surubim near the town. Runoff from a zinc refinery, treated sewage and pesticides have all been postulated to contribute to these mortalities. The large bodied, commercially important surubim in which mortalities have occurred are highly migratory, making their exact movements uncertain. A species of ubiquitous small bodied fish, piau, believed to be less mobile, were sampled from several locations to investigate potential causes of mortalities in the larger fish. In addition to overall indicators of fish health and condition (weight, length, condition, gonad size), burdens of metals (Cu, Cd, Ni, As, Se and Hg) in liver and muscle, metallothionein, and metallothionein in liver tissue were measured in piau as specific indicators of exposure. Acetylcholinesterase activity was measured in brain as a measure of exposure to pesticides. Results indicate that while metallothionein exposure is not likely different between sites, Zn exposure is greater at sites closer to the zinc refinery. Additional studies with more species and exposure are required to definitively link these factors to fish mortalities.

In 2004 and 2005, large scale mortalities of several diverse species of fish were documented in the Sao Francisco River, Brazil. Included among the species affected were:



Pacu (*Piaractus mesopotamicus*)
- fruit eating pelagic fish



Pira (*Conorhynchus conirostris*)
- benthic feeder
- detritus, molluscs, invertebrates



Curimba (*Prochilodus lineatus*)
- benthic sediment eater



Mandi (*Pimelodus maculatus*)
- benthic omnivore



Triera (*Hoplias malabaricus*)
- piscivore, prefers calmer waters, lagoons and reservoirs

Of greatest local concern were mortalities of the two culturally and commercially important large bodied fish, dourado and surubim.



Dourado (*Salminus maxillosus*)
- pelagic piscivore
- Highly sought after sport and commercial fish



Surubim (*Pseudoplatysoma corruscans*)

An exclusive piscivore, benthic top level predator, this species contains a very high lipid content and can grow to lengths of up to 3.5m and weigh 80-90kg. It was estimated by local groups from the Tres Marias area that the recent mortalities of surubim account for >40,000 kg of fish.

Episodic mortality was postulated to be related to runoff from a zinc refinery, but treated sewage, pesticide inputs and municipal refuse all have the potential to contribute to the mortalities.

Many of the large bodied fish migrate long distances (>800 km) in the Sao Francisco river, making their use as indicators of point source contaminant input inappropriate.

Materials and Methods

The small bodied fish, piau, believed to be less mobile, were sampled from 6 locations to investigate potential causes of mortalities in the larger fish.



Piau (*Leporinus friderici*)
- omnivore, but primarily vegetation and invert feeder

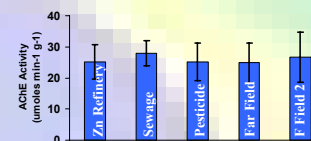


Six Females and 6 Males Collected at 5 Sites
Mean Wt = 42.5 ± 4.8 g Mean Length = 12.6 ± 0.4 cm

Endpoints

General Health Indicators	Specific Contaminant Indicators
Length	Metals in Liver and Muscle
Weight	Metallothionein in Liver
Condition	Vitellogenin in Liver
Liver Size	Acetyl Cholinesterase in Brain
Gonad Size	Pesticides in Muscle

Results and Discussion



Pesticide runoff, primarily from the Abaete River, were one of the potential causes thought to contribute to fish mortalities in the Sao Francisco. Activity of the enzyme acetylcholinesterase was determined in brain tissue (Baird et al. 1990) as a sensitive indicator of exposure to certain classes of pesticides (organophosphates and carbamates). However, AChE activity was similar at all of the sites. It is still possible that other classes of pesticides not impacted on AChE could still have contributed to fish mortality. Analysis of tissues for residues of some of these pesticides is ongoing in our laboratory.

Collection Site	Cd µg/g	Zn µg/g	Cu µg/g	Ni µg/g	Pb µg/g	Fe µg/g
Zn Refinery	0.80 ± 0.28	43.78 ± 3.96	12.76 ± 1.77	0.20 ± 0.09	0.19 ± 0.09	239.95 ± 53.46
Sewage Outfall	0.38 ± 0.07	27.45 ± 2.21	3.69 ± 0.55	0.18 ± 0.03	0.16 ± 0.09	319.38 ± 41.63
Pesticide (Abaete Riv)	0.34 ± 0.08	21.15 ± 1.97	6.80 ± 1.03	0.22 ± 0.08	0.25 ± 0.03	409.70 ± 60.13
Far Field 4	0.28 ± 0.07	24.94 ± 2.14	7.68 ± 1.56	0.39 ± 0.10	0.10 ± 0.01	473.30 ± 63.86
Far Field 5	0.46 ± 0.10	19.34 ± 1.06	4.50 ± 0.40	<0.05	0.07 ± 0.01	245.67 ± 50.89

Concentrations of 6 metals were determined in liver tissue and are presented on a wet weight basis. Cadmium, Zn and Cu concentrations were significantly higher in fish captured near the Zn refinery than in fish captured from the other sites. Iron was higher in tissues of fish captured in, or downstream from, the Abaete River, likely owing to the higher suspended solids in that river (35 NTU) compared to the Sao Francisco main river channel (<1 NTU). Metallothionein, determined by Western blot analysis, was significantly higher in livers of fish from the refinery site relative to the sewage and far field sites. Mt was also elevated in fish from the Abaete River. This may reflect increased oxidative stress from high iron content (Baird et al. 2006), or be a consequence of the higher temperature in the Abaete (28°C) relative to the Sao Francisco (22-23°C) (Van Cleef-Toedt et al. 2001). While Zn concentrations in fish from the refinery site are not in the range expected to be acutely toxic, histopathological analysis of gill tissues are ongoing to assess potential disruption to cellular architecture and function.

Species	n	Hepatic Zn mg/g ww.
Curimba	7	68.84 ± 18.01
Dourado	8	72.94 ± 16.27
Pacu	6	23.87 ± 6.39
Pira	6	28.46 ± 4.95
Surubim	3	91.7 ± 23.89

Conclusion

Collections of large bodied fish are ongoing on the Sao Francisco River. Tissues will be analyzed for their concentrations of metals, with particular emphasis on determining the potential for Cd, Zn and Cu to accumulate in fish captured near the Zn refinery site. However, the highly mobile nature of the large bodied fish could make interpretation of the data problematic. Because the small bodied fish, piau, appears less mobile, and accumulated similar concentrations of Zn in liver as those large bodied fish that we have analyzed thus far, it seems reasonable to utilize the small bodied fish for continued monitoring in the Sao Francisco River.

References

Baird, S. et al. 2006. *Biochem. J.* 394: 275-283.
Fancey et al. 1990. *Can. Tech. Rep. Fish. Aquat. Sci.* 1763
Van Cleef-Toedt et al. 2001. *Cell Stress Chaperones* 6: 351-359.