Toxaphene bioaccumulation in Bow Lake

An aquatic food web reveals its secrets

Linda Campbell

INTRODUCTION

In 1991 and 1992, Donald *et al.* (1993), surveyed 14 lakes in the Canadian Rocky Mountains for organochlorine contamination by pesticides such as DDT, insecticides like toxaphene and industrial PCB compounds. Bow Lake in Banff National Park, appeared to be unusual because the lake trout exhibited high concentrations of organochlorines, particularly toxaphene, compared to other mountain lake trout populations. Toxaphene concentrations in lake trout were higher than the levels of those of mountain whitefish in the same lake, and 10 - 20 times higher than levels found in nearby fish populations.

Toxaphene is present in diverse aquatic ecosystems around the world including Lake Michigan, USA and Lake Baikal, Russia. This complex mix of chlorinated hydrocarbons was not only used as a insecticide to protect argricultural crops from nuisance pests, but was also used in fisheries programs to kill "unwanted" fish to prepare lakes for sport fishing. Toxaphene has been banned or severely restricted in much of the world for about two decades, but many countries in South America, Africa and Asia still use toxaphene as a part of their agricultural programs. Toxaphene is a persistent compound which is easily transported around the globe atmospherically.

This study examines the levels, sources and effects of toxaphene and other organochlorines in Bow Lake trout, and explores the possibility that unusually high levels are the result of contaminant bioacccumulation. "Bioaccumulation" is a general term describing processes by which chemicals accumulate in organisms by exposure or through consumption. Toxaphene easily enters aquatic food webs because of its highly "lipophilic" nature. (It accumulates in adipose tissue: fats and lipids.) As the main pathway of toxaphene bioaccumulation is through diet, biota and food web relationships in Bow Lake were studied to determine bioaccumulation patterns of toxaphene.

BOW LAKE FOOD WEB STRUCTURE AND ECOLOGY

Mountain whitefish feed primarily in the littoral zone of the lake, and their diet consists mainly of benthic invertebrates. Lake trout are more opportunitistic predators, and can feed throughout the lake, consuming large numbers of zooplankton as well as some benthic invertebrates.

A fish's size may directly affect its diet composition and its lipid content. On average, lake trout are larger than mountain whitefish, and are able to feed wherever food is richest without risk of being preyed upon by other fish. Bigger fish tend to have better reproductive and overwintering success. Hence, high energy, lipid-rich prey such as *Hesperodiaptomus arcticus* and *Gammarus* are highly sought. As toxaphene bioaccumulates in lipid tissue, it is likely that toxaphene will be highly concentrated in lipid-rich invertebrates and larger fish.

TOXAPHENE IN THE FOOD WEB

High levels of toxaphene were found in all lake trout, *H. arcticus* and mixed zooplankton. *Gammarus* had intermediate levels of taxaphene, comparable to mountain whitefish. Snails, fly larvae and other benthic invertebrates had lower concentrations of toxaphene. The zooplankter, *H. arcticus* had high toxaphene concentrations compared to other zooplankton and benthic invertebrates. This result is interesting because *H. arcticus* comprises approximately 60% of the zooplankton population, and is the main prey item for lake trout, suggesting that *H. arcticus* is an important factor in toxaphene bioaccumulation in Bow Lake, and may be the main source of contamination in lake trout. Mountain whitefish had lower toxaphene levels, although they are nearly equivalent to those of the species' main prey source, *Gammarus*.

HOW DID TOXAPHENE ENTER THE FOOD WEB?

A possible source of toxaphene in Bow Lake is airborne organochlorine compounds deposited on Bow Glacier. Contaminants can accumulate on the glacier over decades before a particularly warm spring melt flushes them into the lake. Organochlorines, including toxaphene, are "hydrophobic" meaning that they do not mix well in water. As it will not bind to the ice or the glacial melt-off water, toxaphene could be carried in to the lake on dirt and minute rock particles washed off the glacier. The "rock flour" is extremely fine, and will not immediately settle into the lake bottom sediments. Suspended in the water, it refracts sunlight, giving Bow Lake its intense blue colour.

Zooplankton depend on diatoms, rotifers, and nauplii (zooplankton offspring) for nutrients. Zooplankton including *H. arcticus* filter relatively large volumes of water to obtain enough food, and in the process, they take in large amounts of fine rock flour. In addition, *H. arcticus* is predatory and feeds on other zooplankton, including tiny rotifers which are prolific filter feeders. It is possible that toxaphene on rock flour particles is absorbed into the lipid reserves of the zooplankton, prior to the rock flour being discharged with fecal matter. During examination of *H. arcticus* gut contents, it was noted that guts of all individuals were packed with fine sediment particles. A previous Bow Lake study (Smith and Syvitski, 1982) found that *H. arcticus* strongly affect fine sediment distribution on the lake. Through microscopic analyses of lake sediments, the authors discovered that a large proportion of rock flour was in the form of *H. arcticus* fecal pellets, indicating that *H. arcticus* ingest suspended rock flour in search of food items.

It is not yet known how *Gammarus* accumulate toxaphene, but it is possible that *Gammarus* ingest sediment while searching for digestible nutrients and may absorb toxaphene in the process. *Gammarus* have also been documented to prey on zooplankton in some fishless mountain lakes, and may be doing so in Bow Lake, thereby ingesting contaminated zooplankton.

CONCLUSIONS

The pivotal role of *H. arcticus* in toxaphene bioaccumulation in lake trout has implications for understanding zooplankton ecology in the mountain aquatic ecosystems. The lack of this species in neighbouring Hector Lake may explain low toxaphene levels in those fish. In-depth studies of *H. arcticus* and other zooplankton species have just begun in mountain lakes, as we are coming to realize the importance of these organisms in mountain aquatic ecosystems (Parker and Schindler 1995).

A combination of food web dynamics and selective feeding contribute to toxaphene bioaccumulation in lake trout. Lipid-rich invertebrates such as *H. arcticus* readily accumulate organochlorines,

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The Aldo Leopold Wilderness Research Institute

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published studies include: *Ecological Manipulation in Wilderness - An Emerging Management Dilemma,* David Cole; *Opportunities for Solitude in the Boundary Waters Canoe Area Wilderness,* Alan Watson; *Wilderness Recreation Use Trends, 1965 Through 1994,* David Cole; *The Limits of Acceptable Change (LAC) System for Wilderness Planning,* George Stankey, et al.; *Threats to Wilderness Ecosystems: Impacts and Research Needs,* David Cole and Peter Landres;*Disturbance of Natural Vegetation by Camping: Experimental Applications of Low-LevelStress,* David Cole.

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and their high energy potential and high numbers, make them the main prey source of larger lake trout. In addition, mountain whitefish had higher concentrations of organochlorines than the majority of their benthic prey sources (*Gammarus* excepted), suggesting that bioaccumulation is also a concern for this species.

Empirical results regarding the implications for toxaphene bioaccumulation in fish-eating grizzlies, osprey and people who fish are not available at this time. However, it is known that toxaphene can accumulate in terrestrial animals. Contaminant levels are not likely to pose a serious threat to most wildlife and humans because, apart from the fish in Bow Lake and a few other isolated lakes, mountain fish have very low levels of toxaphene. It is recommended that a monitoring program be established to ensure that organochlorine contaminants, including toxaphene, remain at low levels in mountainous environments. Studies are currently being planned to compare the levels of *Gammarus*between lakes, the distribution patterns of organochlorines in other mountain aquatic food webs, and the atmospheric transport of organochlorines in snow and precipitation. This study of Bow Lake provides an indication of what may be occurring in other lakes. An on-going survey of mountain lakes shows that the atmospheric contamination of Bow Lake is not a isolated event, and the effects of this type of contamination may be cause for concern in mountain parks over time.

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Research Links

A Forum for Natural, Cultural and Social Studies

Park Prisoners

Historical Account of internment camps is more than a documentary

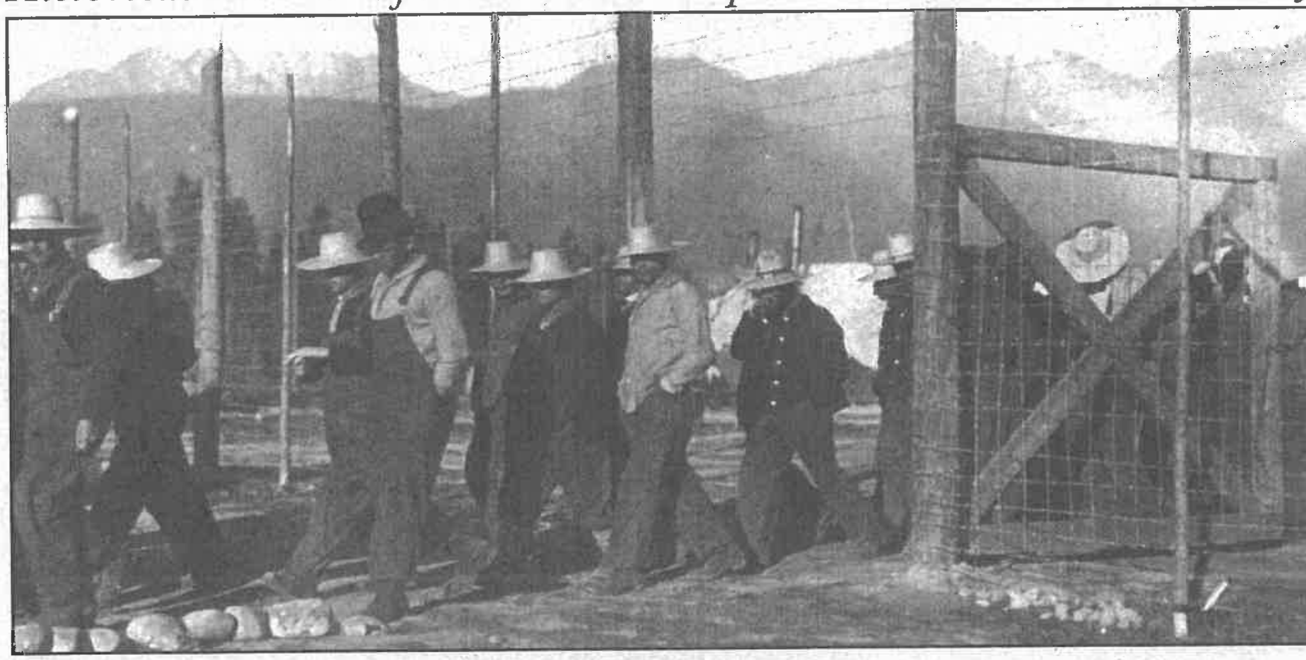

Photo: Glenbow Archives, Carothers Collection

Men leaving the stockade at the Castle Mountain camp, 1915

Park Prisoners: The Untold Story of Western Canada's National Parks, 1915-1946. by Bill Waiser

Graham MacDonald

The use of national parks as settings for internment and relief camps is a fact not well known by Canadians, even those with keen interest in park matters. Bill Waiser, Chair of the Department of History at the University of Saskatchewan, Saskatoon, is in a good position to write about the controversial topic, having worked as a public historian for Parks Canada, Winnipeg. Waiser, author of "Park Prisoners: The Untold Story of Western Canada's National Parks, 1915-1946," recalls that the idea for the book came about during a days trek around Prince Albert National Park with a group of friends in 1989. Looking for remains of the old internment camps, one of the party kept asking: "Who were these guys, Bill?" This book gives a good number of answers to that question by tracing the rise and fall of the types of camps which came under national park administration. While there were many other internment camps spread across the country, those in the national parks of Manitoba, Saskatchewan, Alberta and British Columbia are the focal points of Waiser's book.

Waiser describes four categories of camps. Camps which fall into the first category housed so-called enemy "aliens" and were established during the First World War. The second category consists of unemployment and relief camps set up in the mid-1930s as a response to the great depression. Camps of a third kind were put in place during World War II and were called "alternate service camps" oriented towards "conscientious objectors," and the fourth type of camp housed formal prisoners of war.

The outbreak of war in 1914 became the occasion for the passage of the Aliens Registration Act, designed to identify landed immigrants working in Canada, who retained their European citizenship. Of particular concern were citizens of countries engaged in battle against Canada and the British Empire. The act most notably affected central and east European "aliens" in Canada: people of Austrian, Hungarian, German, Polish and Ukrainian background. National parks became involved after General Sir William Otter approached the Commissioner of Dominion Parks, J.B. Harkin, requesting the use of parks as settings for detention camps. The two men met in 1915 in Rocky Mountain National Park (now, Banff) to make the necessary arrangements. Waiser takes us through the workings of Castle Mountain Camp and others in Yoho, Jasper and Revelstoke. The photos, many drawn from the Webster Collection of the Banff Engineering Service, indicate that much of the work on familiar sites, such as the Cave and Basin Hot Pools and the Banff-Lake Louise road, was completed by internees.

The author also addresses the depression years, when relief worker camps became familiar sites in national parks across the west, including Mount Revelstoke, Yoho, Elk Island, Prince Albert and Riding Mountain. These camps were quite different from "enemy alien" camps in origin and context. Nobody knew, in 1930, that the depression would be long and severe, but it indirectly provided the solution to Harkin's dilemma of decreasing park funds (in part, the result of the dissolving relationship between parks and the railways), – *continued on page 7* –