The news, past to present, and into the future on managing the Okanagan Basin's aquatic ecosystems

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Introduction

My focus will be mainly on the Canadian (British Columbia) portion of the Okanagan Basin which makes up slightly more than half of its length draining into the middle Columbia River system (Fig. 1). In terms of managing and where necessary restoring large aquatic ecosystems it would be useful to first make some general comparisons between the Okanagan Basin and the Kootenay Basin, both of which are major tributaries to the middle Columbia River, but have important geographical and other differences (Table 1).

Okanagan Lake, the largest in its basin, is only slightly smaller than the one large lake in the Kootenay Basin. Both have low head dams at their outlets which allow regulation of their water level at less than 2 m in elevation. But their watershed areas are very different in size, that of Kootenay being over eight times that of Okanagan. For a large lake, Okanagan has a relatively small catchment area (only about 16 times its surface area), whereas Kootenay's is well over 100 times its surface area (Table 1). Furthermore, Okanagan Lake lies in the driest region of Canada with mean annual precipitation under 30 cm whereas Kootenay Lake geographically is in the Columbia rainforest with over double the precipitation (Table 1; see also Farley 1979). The human resident population in the

Okanagan Basin, now approaching 30 per km^2, is nearly 10 fold higher than in the Kootenay Basin, and the tourist annual equivalent population of the Okanagan Basin, now in the order of 70,000 must be several times that in the Kootenay Basin.

To gain an appropriate perspective for management and restoration of the Okanagan Basin's aquatic ecosystems, one should look back to the beginnings of major human activity and alteration within the region, as has been done for the largest river basin in North America, the Mississippi (Turner and Rabalais 2003). Indeed lake basin alteration in mid 1800 by impoundment in the English Lake District is said to have sparked the origins of modern environmental activism (Ritvo 2003). But hopes for effective conservation strategies in the face of humanity's relentless push for growth and "development" do not seem bright (Rosenzweig 2003).

With these considerations, I review the abundance of "bad news" for management and restoration of aquatic ecosystems within the Okanagan Basin since the late 1800s, consider the present efforts being made to cope with this legacy of problems, and make some concluding comments about hopes for the future.

The bad news from the past

1. Species introductions

The known sequence of introductions of non-native species to the Okanagan Basin, either "advertently" (by direct human introduction locally) or inadvertently (by invasion from human introduction elsewhere in the lower Okanagan or Columbia River system), starts with fish and is followed later by aquatic invertebrates and plants (Table 2). At least 12 different species of fish have been introduced to the Okanagan Basin waters, ten of them probably inadvertently by invasion from lower in the system. In addition non-native stocks of rainbow trout (*Oncorhynchus mykiss*) have been widely introduced from other sources, largely in south and mid-central B.C. waters from hatchery egg collections and rearing. The first advertent introduction of non-native fish began in 1894 with lake whitefish (*Coregonus clupeaformis*) from Lake Winnipeg, Manitoba with hopes of establishing

commercial fisheries for this species (McHugh 1939), which never materialized. Lake whitefish as adults are mainly bottom feeders in deeper waters. They have spread downstream to all of the mainstem basin lakes below Okanagan (Skaha, Vaseux, Osoyoos; Northcote et al. 1972) though they did not survive in Kalamalaka Lake where they were also stocked at the same time as in Okanagan. Their competitive interactions with native salmonids in the basin lakes are not well known though in recent years are feeding heavily on the introduced invertebrate *Mysis relicta* in both Okanagan and Skaha lakes (G.B. Northcote data). Many of the other introduced fishes are potential competitors and some may be predators on native salmonids in the basin lakes. With further climate warming and removal of barriers to upstream movement another potential predator, the walleye (*Stizostedion vitreum*), may gain access to mainstem Okanagan Basin lakes from further downstream, as could other non-native species.

In the mid 1960s a macro-invertebrate *Mysis relicta* was advertently introduced to Kalamalka and Okanagan lakes (Lasenby et al. 1986). For the latter site, some 15 years after introduction, adult kokanee (*Oncorhynchus nerka*) increased in size (Northcote 1991), but subsequently declined greatly both in size and abundance in part no doubt because of mysid-induced declines in the cladoceran food supply for sub-adult stages. Mysids now have spread downstream into all basin lakes below Okanagan Lake and probably will have serious effects on at least their kokanee populations.

Eurasian milfoil (*Myriophyllum spicatum*) first appeared in the mainstem Okanagan Basin lakes in the early 1970s and rapidly established extensive populations along their littoral zones, especially in Vaseux Lake. Despite major and costly efforts to eradicate this macrophyte, all attempts have failed and at best only local reductions can be made by mechanical cutting at bathing areas. Its presence must favour non-salmonid fish species but little work apparently has been done on its overall effects on aquatic ecosystems in the Okanagan Basin. Spiked (purple) loosestrife (*Lythrum alatum*) appeared in riparian areas of the Okanagan Basin more recently and now lines much of the Okanagan River banks,

especially between Okanagan and Skaha lakes. Again its effects on other aquatic biota of the system have not been studied but because of its pervasivness these cannot be insignificant.

2. Aquatic ecosystem manipulations

(1) Tributary dams and diversions

Starting in the late 1800s, small headwater lakes and streams tributary to the main Okanagan Basin lakes began to be impounded, mainly to provide irrigational water for agricultural development. By the early 1900s there were eleven such impoundments (Fig. 2A), and some 45 by the mid 1950s (Fig. 2B). Near the close of the 20th century over 80% of all tributaries to the main basin lakes had dams or diversions on them (Fig. 2D), many to provide potable water supplies to the expanding human population, in addition to further needs for agricultural irrigation water. Since 1900 there has been a steady increase in the cumulative volume of impounded waters within the Okanagan Basin (Fig. 3). The summer of 2003 has been particularly hot and dry after a 50% lower winter snowpack and minimal spring precipitation in the Okanagan Basin. Its second largest catchment - Trout Creek - a once important salmonid producer as its name implies, now has been reduced to very minimal flow in its lower reaches with summer water temperatures approaching 30° C. The upper lethal temperature for most salmonids is below 25°C. But the mayor of nearby Summerland announced in late July that the water of Trout Creek is for people and the economy rather than for fish which can be replaced if necessary!

Other major tributaries to the middle Columbia River system are in little better state, and some such as the Wenachee with reduced flows and high temperatures have recently suffered severe moralities of salmon spawners. The US government's plan to help Columbia Basin salmon stocks recover from decades of overfishing and habitat destruction of inland waters has been rejected by a federal judge in Oregon according to a recent report in Science.

(2) Lake level manipulations

As noted previously, most higher elevation lakes tributary to the Okanagan Basin have been impounded for water supply purposes and are subject each year to large-scale drawdowns. This inevitably results in severe effects on their shoreline littoral regions, the most productive area of lakes (Lindstom 1973, Northcote and Atagi 1997).

The largest basin lake - Okanagan - and the third largest - Skaha - both have outlet dams which subject them to manipulations in water level, mainly to prevent flooding of lakeshore property and of boat docks (many of them illegally installed) in years when high runoff and lake water level is anticipated. Such drawdown and release can seriously reduce survival of lake-shore spawned eggs of kokanee salmon, especially in Okanagan Lake, and also of sockeye salmon eggs spawned in the downstream Okanagan River above Osoyoos Lake.

(3) Lake nutrient manipulations

Before the 1970s many of the larger communities around the Okanagan Basin discharged sewage effluent into basin lake waters with minimal effective nutrient treatment. Thereafter some communities such as Vernon, Kelowna, and Penticton (Fig. 1) started phosphate reduction of effluent waters, and this gradually became more and more effective. Then an efficient and not too costly means of nitrate reduction in sewage waters became available. Concentrations of these two primary nutrients (P and N) now may have reached the level where careful and balanced nutrient additions may be required in some of the main basin lakes such as Okanagan to support appropriate forms and abundance of primary producer populations.

(4) Whole watershed manipulations

Other human-induced manipulations of watersheds tributary to Okanagan Basin lakes have had serious negative effects on their use by fish populations. The combined effects of two of the more serious impacts - middle to upper reach forestry operations and lower reach channelization - have occurred in the two largest watersheds to Okanagan Lake, Mission Creek, and especially Trout Creek (Fig. 4), as well as in many other smaller catchments. Clear-cut logging has taken place on both sides of major sections of Trout

Creek headwater reaches, and its lower reaches have been completely straightened and channelized with dykes where all riparian vegetation is periodically removed to protect dyke integrity during the short period of high water discharge in late spring. But during low flow from summer to autumn these lower reaches are fully exposed to intense sunshine with no riparian shade so water temperatures may rise to above lethal levels for salmonid fish.

3. Aquatic ecosystem studies

The waters of the Okanagan Basin have been subject to a long series of well documented publications by a series of Canadian limnologists and other specialists. That most surely is good, not bad news. The latter arises from the minimal use to which many of these seem to have been put in management of the basin's aquatic ecosystems.

One of the earliest large-scale studies was organized by Dr. W.A. Clemens, then Director of the Pacific Biological Station , Nanaimo, and included Dr. Donald Rawson, Head of the Department of Zoology, University of Saskatchewan, an outstanding limnologist of the time, as well as Dr. J. Laurie McHugh. Together they worked mainly on Okanagan Lake but included investigations of other mainstem and headwater tributary lakes. Their results, published in 1939 by the Fisheries Research Board of Canada still have considerable comparative value (Clemens et al. 1939).

In the late 1940s Dr. Clemens, then Head of the Department of Zoology, UBC, organized a study on Skaha Lake, conducted by R.G. Ferguson and formed the basis of his B.A. thesis in Zoology at UBC (Ferguson 1949).

The next aquatic study in the Okanagan Basin was that in the early 1950s, directed from the B.C. Game Commission offices at UBC by Dr. Peter Larkin, and conducted in the field largely by myself and George E. Stringer. We reworked Okanagan Lake itself and also Kalamalka Lake in the mainstem basin, along with many headwater lakes tributary to those of the Okanagan Basin. Results on some of the lakes are included in the publication on indices of productivity in B.C. lakes (Northcote and Larkin 1956), and those for other lakes are on file in regional fisheries offices. The data from this study, and their

modifications, have been among the most extensively used in fisheries management of the region, setting trout stocking practices in relation to lake productivity for example.

Probably the most comprehensive study of the whole Okanagan Basin and its watershed was that conducted over several years in the early 1970s with a high level of funding from both federal and provincial government sources (Anonymous 1974, Stockner and Northcote 1974). It included extensive limnological studies on all of the mainstem basin lakes and also most of the headwater tributary lakes. In addition hydrological, water quality, land use, fisheries, and a range of economic and sociological studies were made. In my opinion it set an ecosystem landmark as one of the first such studies to involve in a meaningful manner the whole human population of a Canadian watershed basin.

Rather than just ask a range of different people with various backgrounds for their opinion on most of the major issues involved, and get a "knee-jerk" reaction, we set up a series of public meetings to acquaint a broad spectrum of interested participants with the basic facts involved as we best saw them, near the completion of the first set of studies being conducted. At these public sessions, where costs to attend were supported, we gave talks as well as question and answer periods and handouts on the current conditions dealing with limnology, water quantity and quality, fish and fisheries, and so on. Near the end of this three year study and public involvement, we then asked for opinions on relevant key issues, giving several options for future progress and management. Those strongly supported were then tried to be followed, at least for a few years thereafter. Most certainly shelves full of information brochures, progress reports, final reports, major publications, summary publications, and a wide range of other material and data were amassed from the study. Surprising to many developers, the clear consensus of the general population of the Okanagan Basin then, including representatives from most walks of life, was that for a moderately slow population growth and a strong maintenance of the pervasive agricultural character in the basin. But within a decade or so later this consensus was pushed aside by an imposed entrepreneuristic drive for increased population and economic growth.