Northern Range Expansion and Invasion by the Common Carp, *Cyprinus carpio,* of the Churchill River System in Manitoba

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Recent fisheries data from northern Manitoba indicates that the Common Carp (*Cyprinus carpio*) has extended the northern limit of its range. Additionally, it also appears that carp have invaded and established viable populations in the Manitoba portion of the Churchill River. Habitat degradation and altered flow regimes as result of hydroelectric development in northern Manitoba may have facilitated the expansion of carp in the region.

Key Words: Common Carp, *Cyprinus carpio*, exotic species, range expansion, invasion, habitat disturbance, Manitoba.

The Common Carp (*Cyprinus carpio*) was introduced intentionally to Manitoba, Canada, when fish from Minnesota were stocked in the Assiniboine River watershed southeast of Brandon in 1886 (Stewart and Watkinson 2004). These early attempts at introduction failed, and carp only became established after populations from the northern U.S. entered the province through the Red River (Atton 1959). In fact, the Common Carp was largely unknown in Manitoba until 1938, when it was positively identified in the Red River near Lockport (Hinks 1943). Today, the Common Carp is found throughout most of the southern and central regions of the province, but particularly in the Red and Assiniboine rivers, and lakes Manitoba, Winnipeg, and Winnipegosis. Common Carp do not appear to have expanded into the eastern portion of the province, likely due to the fact that they cannot easily migrate upstream in this region because of the many obstructions they would encounter (i.e., Beaver dams). Additionally, lakes in this portion of the province are characterized by rocky substrates and clear deep waters typical of the Precambrian Shield and do not provide suitable habitat for viable populations of the Common Carp.

Benthivorous fish such as the Common Carp can have profound effects in aquatic ecosystems by increasing turbidity through sediment resuspension while foraging and spawning (Breukelaar et al. 1994; Zambrano et al. 2001). Carp are known to uproot submerged macrophytes during spawning and accidentally consume them while foraging for benthic invertebrates (Kolterman 1990; Roberts et al. 1995; Lougheed et al. 1998; Zambrano and Hinojosa 1999). Sediment resuspension and excretion by carp can increase water column nutrient concentrations, thereby causing phytoplankton to flourish (Lamarra 1975; Breukelaar et al. 1994; King et al. 1997). A shading effect results from these blooms, further suppressing submerged macrophytes and creating an ecological feedback mechanism that perpetuates the turbid state (Scheffer 1998). Carp physically disturb the sediment-water interface and the algae associated with sediment. These algae play a major role in the stabilization of the bottom sediments (Taylor et al. 1998) and the regulation of nutrient fluxes across the sediment-water interface (Goldsborough and Robinson 1985; Carlton and Wetzel 1988; Woodruff et al. 1999). It is thought that many of the once clear, shallow lakes and wetlands in southern Manitoba have switched to the turbid state due to the loss of submerged macrophyte cover which, in turn, was caused by the proliferation of Common Carp (Badiou 2005).

Before 1940, carp were found only in the waters of the Red River (Figure 1a). After invading the province from the south, the Common Carp spread quickly throughout the Red and Assiniboine River watersheds prior to the 1950s and established themselves in the south basins of lakes Winnipeg and Manitoba (Figure 1b). However, the greatest range expansion occurred between 1950 and 1970 when carp were easily able to access the northern and western portions of the province after successfully invading Lake Winnipeg, Lake Manitoba, and Lake Winnipegosis, the largest lakes in the province (Figure 1c). Swain (1979) indicated that by 1976 the Common Carp was found in most large lakes and virtually all major rivers in Manitoba, with the exception of the Churchill River system.

A specimen collected from Split Lake (Figure 1d) in 1963 was considered to be the most northerly record for the distribution of carp in the world (McCrimmon 1968). These original reports stated that carp caught from Split Lake appeared emaciated and unhealthy. According to Atton (1959), cold summer temperatures prevented the carp from invading the Churchill River system. However, as shown in Figure 1d, the Common Carp has migrated northward through the Nelson River system and, in the last decade, has become established in the Churchill River system according to carp production data spanning the period from 1970 to 2004.

On the Nelson River system, carp have become established in Split Lake where commercial catches (3–74 kg per year) have been reported starting in 1996. Fish monitoring studies for the Limestone Generating Station (C. Barth, personal communication) and the proposed Gull Generating Station (D. J. Pisiak, unpublished data) documented Common Carp in Stephens Lake and in the forebay of the Limestone Generating Station (Figure 1d). Furthermore, during the course of fish studies for the proposed Conawapa Generating Station, a large, approximately 4 kg, Common Carp was caught in a backwater area near the lower Limestone Rapids (P. Nelson, personal communication). This is the first report of Common Carp downstream of the Limestone Generating Station and the most northerly location documented for the Nelson River.

More important than the northward expansion of carp on the Nelson River system is the invasion of the Churchill River system in the last decade. Recent fisheries records for northern Manitoba provided by the Freshwater Fish Marketing Corporation indicate that the Common Carp is now established in and around the Churchill River system with commercial catches reported from Britton, Guthrie, Highrock, Loon, Sisipuk, and Southern Indian lakes (Figure 1d). Commercial catches in these lakes were much higher (range 8–1184 kg per year) relative to those from Split Lake on the Nelson River system. Carp were likely introduced into the Churchill River system from the Saskatchewan River system, either by fishers using them as bait or by birds that may have inoculated carp eggs from one system into the other. A thorough search of the primary literature and government documents revealed that Common Carp have not been reported in the Saskatchewan portion of the Churchill River. The fact that carp have not been reported in the Churchill River in Saskatchewan indicates that the transfer of the Common Carp between the Saskatchewan River and Churchill River systems must have occurred within the province of Manitoba in the vast wetland area that occurs between these two watersheds along the Manitoba/Saskatchewan border.

Based on the fact that carp were found in Split Lake as early as 1963, it is not surprising that they have continued to migrate northward through the Nelson River system. However, given the poor condition of carp in Split Lake in 1963, a change must have occurred, which has allowed them to persist in this system. The two basic habitat requirements necessary to sustain carp populations are: (1) a shallow marsh environment with abundant aquatic vegetation for spawning and, (2) an area of deep water where carp can overwinter (McCrimmon 1968). We hypothesize that the construction of the Kettle Generating Station in 1974 at the outlet of Stephens Lake on the Nelson River provided the necessary habitat requirements to allow the establishment and sustain viable populations of Common Carp in Split Lake and Stephens Lake. Construction of this generating station increased the size of Stephens Lake by 242 km^2 and resulted in the flooding of 192 km^2 of land (Environment Canada / Fisheries and Oceans 1992a). This created an extensive area of shallow marsh-like habitat where carp could spawn in the summer. This was the case in Ontario where Swee and McCrimmon (1966) reported that Lake St. Lawrence near Cornwall, formed as the result of flooding during hydroelectric development on the St. Lawrence River, provided ideal spawning habitat for the Common Carp. However, it was also noted that fluctuations in lake level associated with hydroelectric activities caused many of the eggs attached to vegetation to be exposed and destroyed. More importantly, the construction of the Kettle Generating Station, with a forebay head of 30 meters (Environment Canada / Fisheries and Oceans 1992a), created a deep basin with warmer profundal zone waters to which carp can escape during cold winter months.

The completion of the Churchill River Diversion in 1976 raised the water level in Southern Indian Lake by approximately 3 m and flooded 187 km^2 of surrounding land (Environment Canada / Fisheries and Oceans 1992a). Like the flooding experienced on Stephens Lake after the construction of the Kettle Generating Station, flooding on Southern Indian Lake would have also provided ideal spawning habitat for carp. The extensive flooding on Southern Indian Lake increased shoreline erosion and drastically increased suspended sediment concentrations in the lake from 5 $mg{\cdot}L^{-1}$, pre-impoundment, to 30-50 $mg{\cdot}L^{-1}$, post-impoundment (Environment Canada / Fisheries and Oceans 1992b). This anthropogenic increase in suspended sediments would have conferred a competitive advantage on carp which can feed more efficiently in highly turbid waters due to their superior olfactory senses, relative to sight-feeders (Panek 1987).

Water flows on the Churchill and Nelson river systems have been altered dramatically as a result of the Churchill River Diversion, which has diverted 80% of the flow from the Churchill River at Southern Indian Lake into the Nelson River system. Carp are found in large, slow-moving rivers as well as fast flowing streams (Panek 1987). Due to the ability of carp to inhabit waters of varying flow, the increased flow on the Nelson and decreased flow on the Churchill, as well as the increased variability in flows in both systems as a result of hydroelectric development, would also have conferred an advantage on the Common Carp relative to native fish that may be less tolerant of variations in flow regime.

Overall, it is not surprising that Common Carp are invading northern Manitoba in step with hydroelectric development, as many authors have demonstrated the link between anthropogenic habitat alteration and invadability of ecosystems (Moyle and Light 1996; Keith and James 1999; Byers 2002). Keith and James (1999) showed a positive correlation between the num-

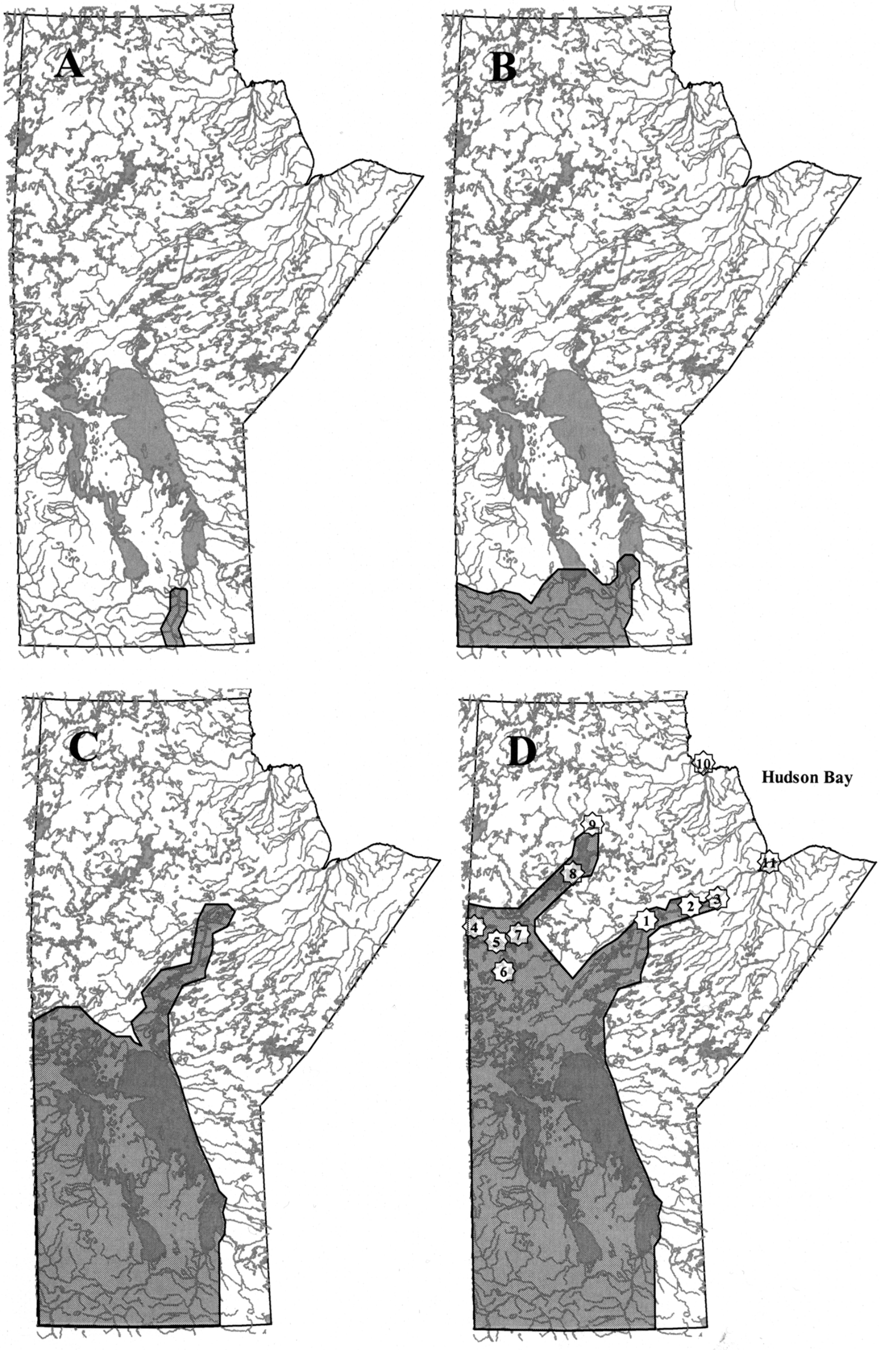

FIGURE 1. Range expansion of the Common Carp (*Cyprinus carpio*) in Manitoba (A) prior to 1940, (B) prior to 1950, (C) prior to 1970, and (D) prior to 2000. Carp distributions prior to 1970 were estimated based on date of first occurrences reported in Swain (1979), while the range expansion between 1970 and 2000 was estimated from carp production data provided by Manitoba Conservation and the Freshwater Water Fish Marketing Corporation for the period from 1970 to 2000. Numbers in D indicate locations discussed in the text: (1) Split Lake, (2) Stephens Lake, (3) Limestone Generating Station, (4) Britton Lake, (5) Sisipuk Lake, (6) Guthrie Lake, (7) Highrock Lake, (8) Southern Indian Lake, (9) Loon Lake, (10) Churchill River Estuary, and (11) Nelson River Estuary.

ber of reservoirs and the number of introduced species in North American drainages. Given that the Common Carp has already been reported in subarctic regions (Lukin 1999) and is tolerant of a wide range of salinity levels (Lam and Sharma 1985) it is a matter of time before the populations of carp established on the Nelson and Churchill river systems reach the Churchill River and Nelson river estuaries.

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Literature Cited

Atton, F. M. 1959. The invasion of Manitoba and Saskatchewan by carp. Transactions of the American Fisheries Society 88: 203-205.

Badiou, P. H. J. 2005. Ecological impacts of an exotic benthivorous fish in wetlands: a comparison between common carp (*Cyprinus carpio* L.) additions in large experimental wetlands and small mesocosms in Delta Marsh, Manitoba. Ph.D. dissertation, Department of Botany, University of Manitoba, Winnipeg, Manitoba.

Breukelaar, A. W., E. H. R. R. Lammens, J. G. P. Klein Breteler, and **I. Tátrai.** 1994. Effects of benthivorous bream (*Abramis brama*) and carp (*Cyprinus carpio*) on sediment resuspension and concentrations of nutrients and chlorophyll a. Freshwater Biology 32: 113-121.

Byers, J. E. 2002. Impact of non-indigenous species on natives enhanced by anthropogenic alteration of selection regimes. Oikos 97: 449-458.

Carlton, R. G., and **R. G. Wetzel.** 1988. Phosphorus flux from lake sediments: Effects of epipelic algal oxygen production. Limnology and Oceanography 33: 562-570.

Environment Canada / Fisheries and Oceans. 1992a. Federal Ecological Monitoring Program (FEMP) Final Report. Volume 2.

Environment Canada / Fisheries and Oceans. 1992b. Federal Ecological Monitoring Program (FEMP) Final Report. Volume 1.

Goldsborough, L. G., and **G. G. C. Robinson.** 1985. Effect of an aquatic herbicide on sediment nutrient flux in a freshwater marsh. Hydrobiologia 122: 121-128.

Hinks, D. 1943. The Fishes of Manitoba. Department of Mines and Natural Resources, Winnipeg.

Keith, B. G., and **H. B. James.** 1999. Invasion of North American drainages by alien fish species. Freshwater Biology 42: 387-399.

King, A. J., A. I. Robertson, and **M. R. Healey.** 1997. Experimental manipulations of the biomass of introduced carp (*Cyprinus carpio*) in billabongs. I. Impacts on water-column properties. Marine and Freshwater Research 48: 435-443.

Kolterman, B. F. 1990. Effects of common carp and black bullheads on sago pondweed. M.Sc. dissertation, South Dakota State University.

Lam, T. J., and **R. Sharma.** 1985. Effects of salinity and thyroxine on larval survival, growth and development in the carp, *Cyprinus carpio*. Aquaculture 44: 201-212.

Lamarra, V. A. 1975. Digestive activities of carp as a major contributor to the nutrient loading of lakes. Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie 19: 2461-2468.

Lougheed, V. L., B. Crosbie, and **P. Chow-Fraser.** 1998. Predictions on the effect of common carp (*Cyprinus carpio*) exclusion on water quality, zooplankton, and submergent macrophytes in a Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55: 1189-1197.

Lukin, A. A. 1999. Occasional introduction of carp *Cyprinus carpio* into a subarctic water body. Journal of Ichthyology 39: 419-420.

McCrimmon, H. R. 1968. Carp in Canada. Fisheries Research Board of Canada. Bulletin 165.

Moyle, P. B., and **T. Light.** 1996. Fish invasions in California: do abiotic factors determine success. Ecology 77: 1666-1670.

Panek, F. M. 1987. Biology and ecology of carp. Pages 1-16 *in* Carp in North America. *Edited by* E. L. Cooper. American Fisheries Society, Bethesda, Maryland.

Roberts, J., A. Chick, L. Oswald, and **P. Thompson.** 1995. Effect of carp, *Cyprinus carpio* L., an exotic benthivorous fish, on aquatic plants and water quality in experimental ponds. Marine and Freshwater Research 46: 1171-1180.

Scheffer, M. 1998. Ecology of shallow lakes. Chapman & Hall, Toronto.

Stewart K. W., and **D. A. Watkinson.** 2004. The freshwater fishes of Manitoba. University of Manitoba Press, Winnipeg.

Swain D. P. 1979. Biology of the carp (*Cyprinus carpio* L.) in North America and its distribution in Manitoba, North Dakota and neighbouring U.S. waters. Manuscript Report Number 79-73. Manitoba Department of Mines, Natural Resources and Environment, Winnipeg.

Swee, U. B., and **H. R. McCrimmon.** 1966. Reproductive biology of the carp, *Cyprinus carpio* L., in Lake St. Lawrence, Ontario. Transactions of the American Fisheries Society 95: 372-380.

Taylor, I. S., D. M. Paterson, and **A. Mehlert.** 1998. The quantitative variability and monosaccharide composition of sediment carbohydrates associated with intertidal diatom assemblages. Biogeochemistry 45(3): 303-327

Woodruff, S. L., W. A. House, M. E. Callow, and **S. C. Leadbeater.** 1999. The effects of biofilms on chemical processes in surficial sediments. Freshwater Biology 41: 73-89.

Zambrano, L., and **D. Hinojosa.** 1999. Direct and indirect effects of carp (*Cyprinus carpio* L.) on macrophyte and benthic communities in experimental shallow ponds in central Mexico. Hydrobiologia 408/409: 131-138.

Zambrano, L., M. Scheffer, and **M. Martinez-Ramos.** 2001. Catastrophic response of lakes to benthivorous fish introduction. Oikos 94: 344-350.

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