2009

Common carp abundance, biomass, and removal from Dewey and Clear lakes on the Valentine National Wildlife Refuge: Does trapping and removing carp payoff?

Greg A. Wanner
U.S. Fish and Wildlife Service

Melvin P. Nenneman
U.S. Fish and Wildlife Service

Mark A. Kaemingk
South Dakota State University, mkaemingk2@unl.edu

Common carp abundance, biomass, and removal from Dewey and Clear lakes on the Valentine National Wildlife Refuge: Does trapping and removing carp payoff?

Prepared by

Greg A. Wanner
U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office
Pierre, South Dakota

Melvin P. Nenneman and Mark Lindvall
U.S. Fish and Wildlife Service, Valentine National Wildlife Refuge
Valentine, Nebraska

Mark A. Kaemingk
Department of Wildlife and Fisheries Sciences, South Dakota State University
Brookings, South Dakota

December 2009

Introduction

Common carp *Cyprinus carpio* is a nonnative invasive nuisance species to North America. Many authors have documented the detrimental affects of common carp invasions on waterfowl habitats (Chamberlain 1948; Robel 1961), game fish habitat (Cahn 1929), and the overall decline in native fishes (Bernstein and Olson 2001; Koehn 2004). Common carp reduce water quality by mobilizing nutrients and increasing turbidity; therefore, increasing phytoplankton biomass and reducing zooplankton biomass and rooted aquatic vegetation (Lougheed et al. 1998). Common carp are capable of rapidly colonizing shallow lakes and altering a body of water from a clear stable state, dominated by submergent vegetation to a more turbid state, dominated by phytoplankton (Northcote 1988; Parkos et al. 2003).

Management and control of common carp has been well documented through much of North America (Meronek et al. 1996; Wydoski and Wiley 1999) with millions of dollars invested on research and control (Pimentel et al. 2000). Removal projects included mechanical harvest by netting (Ritz 1987; Pinto et al. 2005), water level manipulation to disrupt spawning (Summerfelt 1999), exclusion from spawning habitat (Lougheed and Chow-Fraser 2001), and piscicide application (Meronek et al. 1996). Northern pike *Esox lucius* have additionally been used as a biological tool to control common carp recruitment in the Sandhill lakes in Nebraska (Paukert et al. 2003). All methods of carp control have had varying degrees of success (Meronek et al. 1996).

Common carp gained access to the U.S. Fish and Wildlife Service (USFWS), Valentine National Wildlife Refuge (NWR) lake system through Gordon Ditch, which was dug during the 1930's (Wanner 2009). The ditch was plugged shortly after completion to eliminate fish movement onto the Refuge. Refuge lakes have a long history of chemical renovation to remove common carp (Wanner 2009). For approximately five years after renovation and the re-stocking of game fish, angling is excellent, waterfowl use is high; however, both decline soon after carp recolonization and subsequent habitat degradation (M. Lindvall, Valentine NWR, personal communication). Fisheries biologists from the USFWS and Nebraska Game and Parks Commission (NGPC) have also experimented with the use of northern pike and largemouth bass *Micropterus salmoides* to control common carp recruitment. Early attempts were unsuccessful because northern pike were introduced after carp populations were well established and subsequently the population and individual fish were too large to be controlled by predation (Wanner 2009). Common carp recruitment in the Refuge lakes is low due to predation or other abiotic factors (Phelps et al. 2008).

Common carp have also been physically removed on Valentine NWR lakes by releasing water through control structures between lakes, luring fish into ditches during spawning migrations where they are subsequently trapped. In the ditches between Whitewater and Dewey lakes and Dewey and Clear lakes (Figure 1), thousands of common carp, with an estimated biomass of several tons, were trapped in 1993 and 2008 (Wanner 2009). Trapping was also attempted in 2003 with little success due to scour holes around the trap that allowed carp to escape (M. Nenneman, unpublished data). These methods of controlling common carp have never been thoroughly evaluated; therefore, the objectives of this study were to 1) estimate abundance, biomass, and size structure of common carp in Dewey Lake, 2) estimate the proportion of the abundance, biomass, and size structure of the common carp removed from the lake during the trapping operation, and 3) monitor water quality and carp relative abundance before and after carp removal.

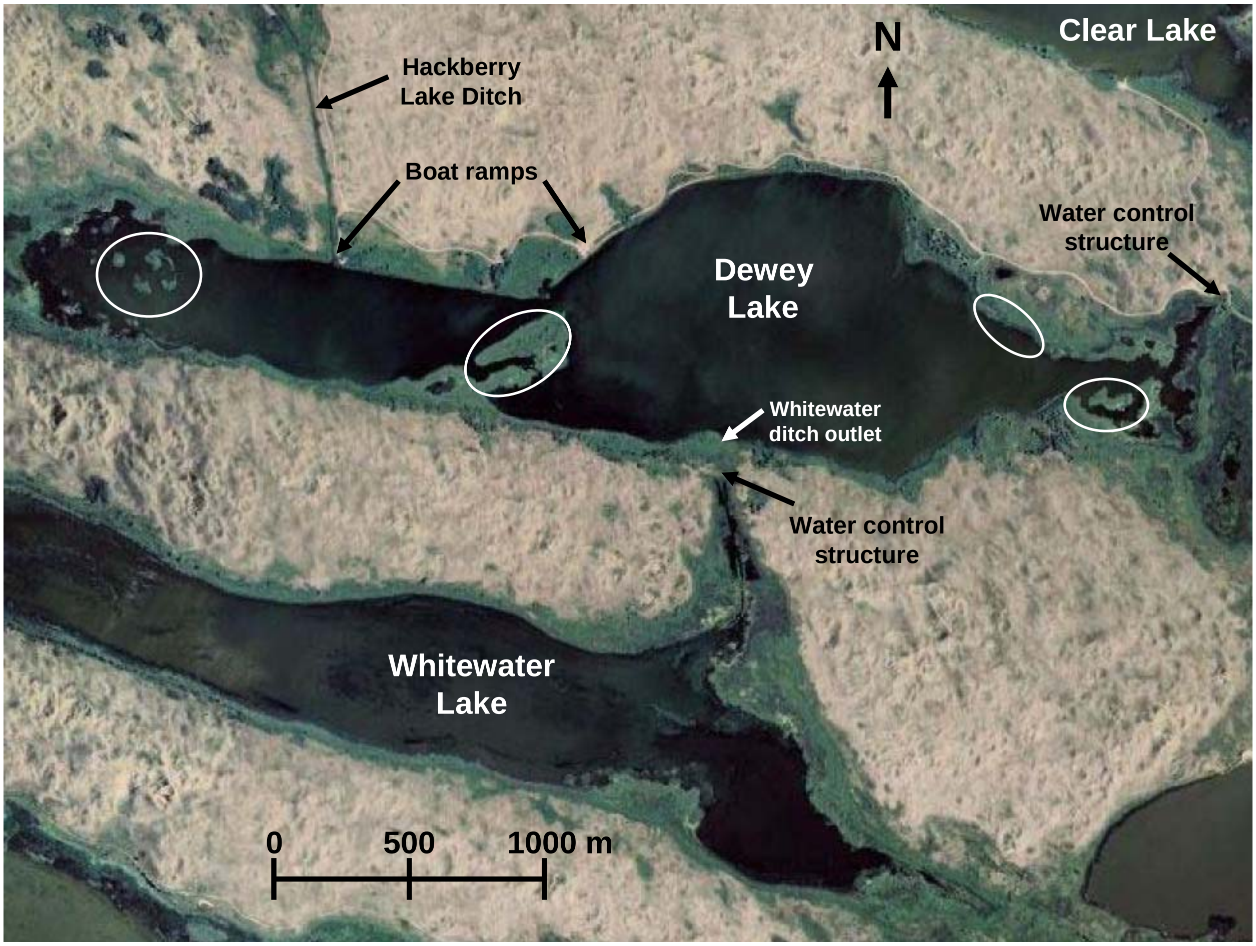

Figure 1. Dewey, Whitewater, and Clear lakes with water control structures and ditches that connect the lakes on the Valentine NWR. White circles indicate areas dominated by *Phragmites* where most common carp were collected in April 2009.

Study area

Dewey Lake is located on the Valentine NWR in the Sandhills of Cherry County, Nebraska. The lake is in the middle of a series of four lakes connected by natural drainages and man-made ditches (Figure 1). A dike was constructed and a ditch was dug to connect Dewey Lake to Clear Lake and Whitewater Lake to Dewey Lake to allow for some water level manipulation within these lakes to increase waterfowl habitat. The surrounding shorelines are predominately cattails *Typha spp.*, *Phragmites*, and bulrushes S*cirpus spp.* Dewey Lake has broad expanses of emergent and submergent vegetation, especially on the shallower west and east ends of the lake.

Dewey Lake is 223 surface ha with a maximum depth of 2.7 m and a mean depth of 1.4 m. Dewey Lake was last chemically renovated with rotenone in 1981 and restocked with game fish the following year (Wanner 2009). However, the renovation was either not 100% successful or common carp migrated into Dewey Lake from other lakes as anglers reported catching adult common carp in 1984. The fish community in Dewey Lake includes common carp, northern pike, largemouth bass, bluegill *Lepomis macrochirus*, yellow perch *Perca flavescens*, black bullhead *Ameiurus melas*, and grass pickerel *Esox americanus*.

Methods

Sampling and trapping

Common carp were collected on 27-28 April 2009 using daytime electrofishing with a Smith and Root 5.0 GPP electrofishing system rated at 5,000 watts of output power, using pulsed DC at 4-8 amps, and 30 or 60 pulses per second. Electrofishing was conducted along the entire shoreline and concentrated in areas of heavy common carp infestation primarily in *Phragmites* (Figure 1). All common carp collected were measured to total length (TL; mm) and 10 fish per 10 mm length group were weighed (g). All common carp captured were marked with an upper caudal fin clip. On 30 April 2009, the entire shoreline of Dewey Lake was electrofished as the “recapture event” to estimate common carp population size (N) and biomass (B). All common carp captured during the recapture event were identified as either a marked or unmarked fish. All unmarked fish were marked before being released to increase the sample size of marked fish in the population to estimate the proportion of fish captured in the Whitewater-Dewey ditch. On 30 April 2009, stop logs were removed at the Whitewater Lake control structure and water flowed into Dewey Lake. A fish trap was placed into the ditch between the control structure and Dewey Lake the following week. The trap was designed to allow fish to enter the ditch and blocked fish from returning to Dewey Lake. Once a large number of common carp had entered the ditch, the stop logs would be replaced and water flow into the ditch would be stopped or greatly reduced, which would reduce the amount of water available to the common carp trapped in the ditch.

Immediately following the dewatering, all common carp captured in the ditch were to be counted and measured, and 10 fish per 10 mm length group were to be weighed. The first 100 common carp collected in the ditch would have had the entire right pectoral fin ray, including the knuckle, removed for further age and growth analysis.

Data analysis

Single marking period and single recapture period assumptions are: 1) population is closed with no immigration or emigration, 2) no births or deaths, 3) no marks are lost or missed, 4) marking does not change behavior or vulnerability to capture, 5) marked fish mix at random with unmarked fish in the population, and 6) all fish have an equal probability of being captured (Hayes et al. 2007). Common carp abundance (N) was estimated with a Chapman estimator:

$$N = [(n_1 + 1)(n_2 + 1) / (m_2 + 1)] - 1$$

where n_1 = number caught and marked in the marking event; n_2 = number caught in the recapture event; and m_2 = number of marked fish in the recapture event (Seber 1982). Variance was estimated using a Chapman approximation (Seber 1982):

$$V(N) = [(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2) / (m_2 + 1)^2(m_2 + 2)] - 1.$$

95% confidence intervals (CI) was developed for N using a normal approximation if $m_2 > 50$. ([100 – α]%) confidence intervals was calculated as (Seber 1982):

$$N \pm Z_{\alpha/2} \sqrt{(V(N)}$$

for a 95% CI, $\alpha = 0.05$, and $Z_{\alpha/2} = 1.96$.

Common carp biomass was estimated in each lake as:

$$B = N * w$$

where B = estimated biomass (g); N = estimated abundance; and w = mean weight of fish in the population (g). The number of common carp and their biomass trapped in the ditches were to be compared with the estimated abundance and biomass calculated in their respective lakes.

A Kolmogorov-Smirnov (KS) test was to be used to compare length frequency distributions of common carp marked in Dewey Lake and the fish trapped and removed from the Whitewater-Dewey ditch. Length frequency distribution analysis would have been performed with Number Cruncher Statistical Software (NCSS; Hintze 2006).

Pectoral fin rays would have been used to estimate age and growth. Age assessment techniques followed procedures describe by Phelps et al. (2007). Age-frequency histograms would have described the age structure and recruitment patterns. Growth was described with von Bertalanffy growth curves (von Bertalanffy 1938; Van Den Avyle and Hayward 1999).

Results and Discussion

A total of 563 common carp were collected, marked, and released on 27-28 April 2009 during 12.4 h of electrofishing in Dewey Lake. A total of 181 common carp were collected on 30 April in 6.1 h of electrofishing of which 22 were marked. The mean length of all fish captured was 760.2 mm (SD = 69.5) (Figure 2) and mean weight was 7.1 kg (SD = 3.0). The population abundance and biomass estimates for common carp in Dewey Lake were (N) = 4,462 ± 1,635 and (B) = 31,790 kg ± 11,723.

Common carp were first observed moving into the Whitewater-Dewey ditch on 18 May 2009 with an estimated number of 20 fish trapped. 40 carp were observed in the trap on 15 June and 400 carp were observed entering the ditch, but not through the trap on 18 June following 10 cm of precipitation (M. Lindvall, USFWS, personal communications). On 19 June 2009, the trap was checked and only 20-30 carp were found and therefore subsequent trapping efforts ceased.

Aging structures would have been removed from carp captured in the trap for age and growth analysis. Length frequency distributions were to be compared between the Dewey Lake population and the fish captured in the trap, and the proportion of the Dewey Lake population trapped would have been estimated. Because the trapping operation was unsuccessful, no further analyses were conducted.

Standard spring trap nets and fall gill net surveys were conducted in Dewey Lake. Both trap and gill net indices indicated low relative abundance of common carp in Dewey Lake compared to previous years (G. Wanner, unpublished data). No marked carp were observed during trap or gill netting operations and only 1 of 22 carp observed were marked during the 18 May 2009 standardized electrofishing surveys. Differences in length frequency distributions of common carp collected during this study (mean length = 760 mm; SE = 2.6; Figure 2) and the standard spring trap nets (mean length = 614 mm; SE = 13.8) and fall gill nets surveys (mean length = 676 mm; SE = 42.0)(Figure 3) were observed. The marking event may have selected large individuals that were foraging prior to spawning or already initiated spawning activities in the *Phragmites*. Electrofishing was not effective at collecting common carp in deep water (> 2 m); therefore, smaller fish that were located in the middle of Dewey Lake may have not had an opportunity to be marked. Standardized gill nets (mesh sizes 19-76 mm) may not effectively capture large common carp and therefore common carp collected using this method may not reflect the true size structure of the population.

Many factors may have contributed to the unsuccessful attempt at trapping common carp in the Whitewater-Dewey ditch. Spring 2009 was unusually cool, which likely affected the timing and protracted nature of common carp spawning. Although spawning activity was observed 27-30 April, more spawning activity was observed during standard electrofishing operations on 18 May. Elevated water levels in Dewey Lake provided abundant spawning habitat, likely reduced the need to migrate, and therefore, less carp moved into the ditch to seek spawning habitat. High water levels across the Refuge facilitated fish marking efforts and gave the perception there would be an increased probability of trapping success. However, precipitation during May was low; therefore, water moving through the ditch into Dewey Lake was reduced and as a result more stop logs could have been removed at the Whitewater water control structure to increase flow. The only major thunderstorm occurred 13 June 2009 (10 cm). This rain event did increase water discharge and attracted carp to the Whitewater-Dewey ditch; however, either the design of the trap was not conducive to allow fish to easily pass upstream through the trap or the spawning drive or desire to move upstream was weak. Although the finger-style trap was well made to allow fish to pass upstream with few issues from vegetation clogging, the placement of the trap may have affected the upstream passage of fish (Figure 4). One side of the trap would scour out directing water flow away from the fingers. This may have confused and redirected the carp away from the finger-style opening. A more permanent (e.g., rip-rap, revetment, concrete) structure placed in the ditch along with the trap may be needed to increase trap effectiveness.

Management recommendations

Although the marking operations went well, the unusually cool spring likely reduced the number of common carp collected. In 2009, fish marking should have been conducted no earlier than the first week of May. Future mark-recapture operations should consider spring climate conditions. Several tons of common carp were trapped and removed in the Whitewater-Dewey ditch during April 1993 and common carp were observed entering the ditch by 29 April 2003 and by 15 May 2008 (M. Nenneman, unpublished data). This indicates that common carp migrations into the ditch are highly variable from year to year. Temperature loggers should be deployed in the lake to monitor water temperatures to correlate common carp spawning observations and migrations upstream into the Whitewater-Dewey ditch.

The time period between the marking and recapture event was only two to three days apart and therefore likely met the assumptions of migrations, births or deaths, or lost marks within the population. One assumption that was likely violated included random mixing because common carp appeared to congregate in shallow areas of the lake and were most likely not given enough time to redistribute to other areas (i.e., deeper water) of the lake. A two week interval would increase random mixing of the entire population.

To increase trapping success of common carp in the Whitewater-Dewey ditch, stop logs need to be removed at the appropriate water temperature and discharge rate; however, these two variables are unknown. Based only on the 2009 climate, stop logs should have been removed around 15 May with a higher discharge of water moving through the ditch. However, previous data (i.e., 1993 and 2003; M. Nenneman, USFWS, unpublished data) indicated that earlier dates would be recommended to increase water discharge out of Whitewater Lake. Water discharge entering Dewey Lake should be monitored and correlated with common carp migrations upstream into the Whitewater-Dewey ditch.

The finger-style trap opening height may not be high enough to allow common carp > 30 cm (12 in.) in depth observed during this study to enter the trap. The finger-style opening may need to be enlarged. The placement of the trap needs to be modified to direct most of the flow through the fingers of the trap. More rip-rap or a concrete structure would help reduce scouring away from the trap and direct discharge through the fingers. Scour holes around the trap have been a major issue in the effectiveness of the trap in previous years. In 2003, > 500 carp were observed in the trap, but escaped when a scour hole formed around the trap. A more permanent structure would increase the effectiveness of the trap and reduce the amount of time and effort to monitor trap conditions.

All these recommendations should be considered for further analysis on the effectiveness of trapping and removing common carp from Dewey Lake. Once trapping operations are successful and the proportion of the common carp population trapped and removed is estimated, further analyses can then be performed on the viability of trapping efforts (i.e., how many years of successful carp removal and at what percent of the population each year needs to be removed to improve water quality and habitat). If the common carp trap and removal is successful on Dewey Lake, this design could then be deployed on other Refuge lakes.

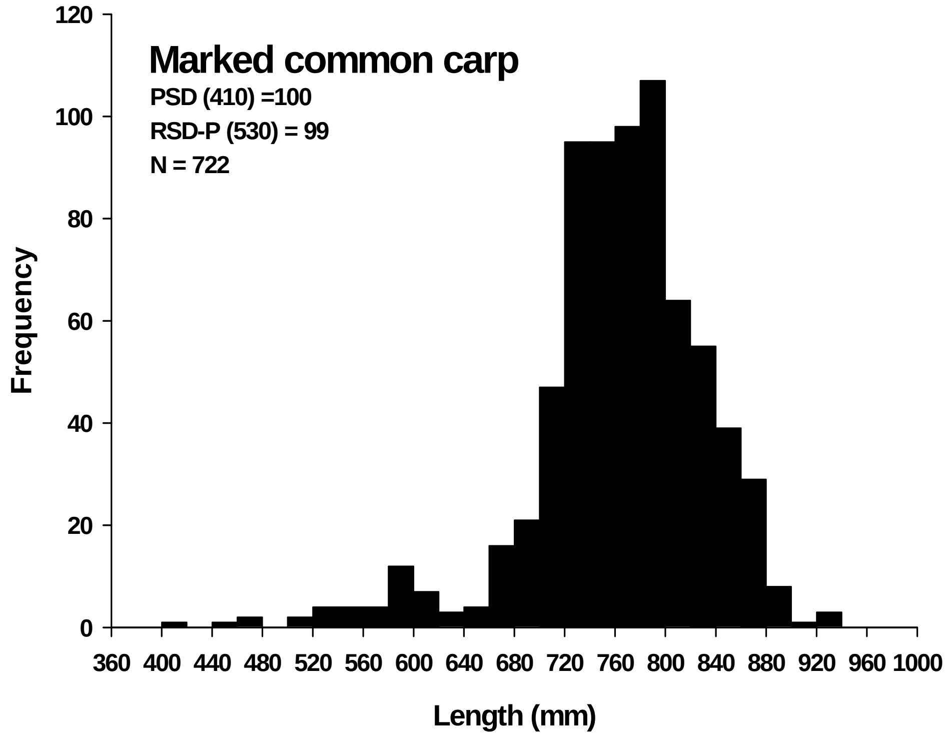

Figure 2. Length frequency distribution of all common carp marked in Dewey Lake, April 2009.

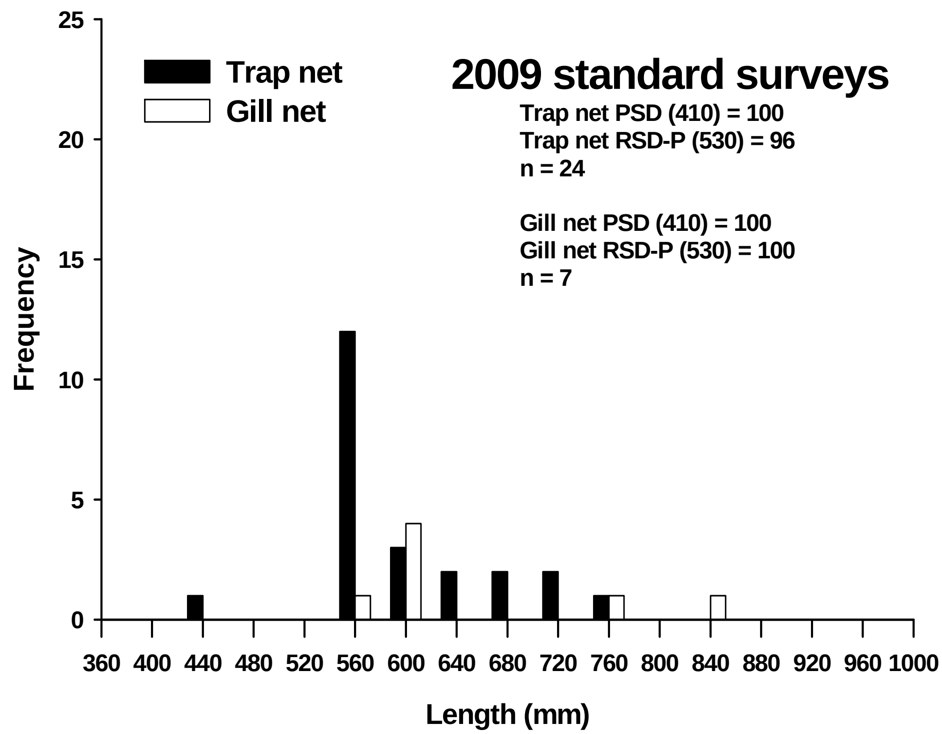

Figure 3. Length frequency distribution of common carp collected during standard spring trap nets and fall gill nets in Dewey Lake during 2009.


Figure 4. Fish trap in the Whitewater-Dewey ditch looking upstream, May 2009.

Acknowledgements

For field assistance we thank Kevin Pope from Nebraska Cooperative Fish and Wildlife Unit - U.S. Geological Survey, Paul McKenna and Nathan Kuntz from South Dakota State University, Andrew Glidden, Zac Brashears, and Shane Hamilton from the Nebraska Game and Parks Commission (A-team), and Levi Feltman from the USFWS, Valentine NWR. We also thank Robert Klumb, Dane Shuman, and Kristen Grohs from the USFWS, Great Plains Fish and Wildlife Conservation Office for reviewing early drafts of the proposed research.

References

Berstein, N. P., and J. R. Olson. 2001. Ecological problems with Iowa's invasive and introduced fishes. Journal of the Iowa Academy of Science 108:185-209.

Cahn, A. R. 1929. The effect of carp on a small lake: the carp as a dominant. Ecology 10:271-274.

Chamberlain, E. B. 1948. Ecological factors influencing the growth and management of certain waterfowl foods plants on Back Bay National Wildlife Refuge. Transactions of the North American Wildlife Conference 13:347-356.

Fritz. A. W. 1987. Commercial fishing for carp. Pages 17-30 *in* E. L. cooper, editor. Carp in North America. American Fisheries Society, Bethesda, Maryland.

Hayes, D. B., J. R. Bence, T. J. Kwak, and B. E. Thompson. 2007. Abundance, biomass, and production. Pages 327-374 *in* C. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Koehn, J. D. 2004. Carp (*Cyprinus carpio*) as a powerful invader in Australian waterways. Journal of Freshwater Biology 49:882-894.

Lougheed, V. L., and P. Chow-Fraser. 2001. Spatial variability in the response of lower trophic levels after carp exclusion from a freshwater marsh. Journal of Aquatic Ecosystem Stress and Recovery 9:21-34.

Lougheed, V. L., B. C. 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.

Meronek, T. g., P. M. Bouchard, E. R. Buckner, T. M. Burri, K. K. Demmerly, D. C. Hateli, R. A. Klumb, S. H. Schmidt, and D. W. Coble. 1996. A review of fish control projects. North American Journal of Fisheries Management 16:63-74.

Northcote, T. G. 1988. Fish in the structure and function of freshwater ecosystems: a "top-down" view. Canadian Journal of Fisheries and Aquatic Sciences 45:361-379.

Parkos, J. J., V. J. Santucci, and D. H. Wahl. 2003. Effects of adult common carp (*Cyprinus carpio*) on multiple trophic levels in shallow mesocosms. Canadian Journal of Fisheries and Aquatic Sciences 60:182-192.

Paukert, C. P., W. Stancill, T. J. DeBates, and D. W. Willis. 2003. Predatory effects of northern pike and largemouth bass: bioenergetic modeling and ten years of fish community sampling. Journal of Freshwater Ecology. 18:13-24.

Phelps, Q. E., K. R. Edwards, and D. W. Willis. 2007. Precision of five structures for estimating age of common carp. North American Journal of Fisheries Management 27:103-105.

Phelps, Q. E., B. D. S. Graeb, and D. W. Willis. 2008. Influence of the Moran effect on spatiotemporal synchrony in common carp recruitment. Transactions of the American Fisheries Society 137:1701-1708.

Pimentel, D., l. Lach, r. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigineous species in the United States. BioScience 50:53-65.

Pinto, L., N. Chandrasena, J. Pera, P. Hawkins, D. Eccles, and R. Sim. 2005. Managing invasive carp (*Cyprinus carpio* L.) for habitat enhancement at Botany Wetlands, Australia. Aquatic Conservation: Marine and Freshwater Ecosystems 15:447-462.

Robel, R. J. 1961. the effect of carp populations on the production of waterfowl plant foods on a western waterfowl marsh. Transactions of the North American Wildlife Conference 26:147-159.

Seber, G. A. F.. 1982. The estimation of animal abundance and related parameters. Edward Arnold, London.

Summerfelt, R. C. 1999. Lake and reservoir management. Pages 285-320 *in* C.C. Kolhler and W. A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.

Van Den Avyle, M. J., and R. S. Hayward. 1999. Dynamics of exploited fish populations. Pages 127-166 *in* C.C. Kolhler and W. A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.

von Bertalanffy, L. 1938. A quantitative theory of organic growth. Human Biology10:181-213.

Wanner, G. A. 2009. 2008 Fisheries surveys conducted on the Valentine National Wildlife Refuge. U.S. Fish and Wildlife Service, Great Plains Fish and Wildlife Conservation Office, Pierre, South Dakota.

Wydoski, R. S., and R. W. Wiley. 1999. Management of undesirable fish species. Pages 403-430 *in* C.C. Kolhler and W. A. Hubert, editors. Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.