Fisheries and Oceans Canada — Pêches et Océans Canada
Science — Sciences

C S A S — **S C C S**

Canadian Science Advisory Secretariat — **Secrétariat canadien de consultation scientifique**

Research Document 2004/103 — **Document de recherche 2004/103**

Not to be cited without
Permission of the authors *

Ne pas citer sans
autorisation des auteurs *

Risk Assessment for Asian Carps in Canada

Évaluation du risque posé par la carpe d'Asie au Canada

Nicholas E. Mandrak, Becky Cudmore

Fisheries and Oceans Canada
Great Lakes Laboratory for Fisheries and Aquatic Sciences
867 Lakeshore Road
Burlington ON L7R 4A6

* This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at:

Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1499-3848 (Printed / Imprimé)

Canada

ABSTRACT

There are five species collectively known as the Asian carps: grass carp, bighead carp, silver carp, largescale silver carp and black carp. Four of these species (grass, bighead, silver, and black carps) have been introduced worldwide for aquaculture purposes. Subsequent to introduction into the southern United States, three species have become established in the wild (grass, bighead and silver carps). Two of these species, bighead and silver carps, have been dispersing rapidly up the Mississippi River basin, wreaking ecological havoc along the way. As there are numerous connections between the Mississippi basin and Canadian watersheds, including the Great Lakes, there is considerable concern about their potential ecological impacts if introduced and established in Canada. In addition to natural dispersal, these species may also be introduced into the Canadian wild through the live food fish trade. Canada represents over 50% of the market for grass and bighead carps cultured in the United States. The Canadian government conducted a risk assessment to determine the ecological risk of Asian carps in Canada. This assessment included evaluating the risk of survival, reproduction and spread of these species, as well as their pathogens, parasites or fellow travelers (e.g. other invasive species) should they be introduced into Canada. These components were assessed in an expert workshop using best available information on their biology, potential vectors of introduction, and impacts in both native and introduced ranges. The assessment concluded that the risk of impact was high in, at least, some parts of Canada, including the southern Great Lakes basin by four Asian carp species.

RÉSUMÉ

Les carpes d'Asie comprennent cinq espèces, soit l'amour blanc, la carpe à grosse tête, la carpe argentée, la carpe miroir et la carpe noire. Quatre de ces espèces (l'amour blanc, la carpe à grosse tête, la carpe argentée et la carpe noire) ont été introduites dans tous les coins du monde aux fins d'aquaculture. À la suite de leur introduction dans le sud des États-Unis, trois espèces se sont établies dans le milieu sauvage (l'amour blanc, la carpe à grosse tête et la carpe argentée). Deux de celles-ci, la carpe à grosse tête et la carpe argentée, remontent rapidement le cours du Mississippi, faisant des ravages écologiques sur leur route. Comme il existe de nombreux lacs et rivières reliant le bassin du Mississippi et les bassins versants du Canada, y compris les Grands Lacs, les incidences écologiques potentielles de leur introduction et de leur établissement dans les eaux canadiennes soulèvent de grandes préoccupations. Outre la dispersion naturelle, ces espèces peuvent aussi être introduites dans le milieu sauvage canadien par le biais du commerce de poissons vivants à des fins alimentaires. Plus de 50 % des carpes de roseau et des carpes à grosse tête issues de l'élevage pratiqué aux États-Unis sont vendues au Canada. Le gouvernement canadien a fait une évaluation du risque en vue d'établir les dangers pour l'écologie que posent les carpes asiatiques au Canada. Le risque de survie, de reproduction et de dissémination de ces espèces a aussi été évalué, ainsi que de leurs agents pathogènes, leurs parasites et leurs compagnons de route (p. ex. d'autres espèces envahissantes) si elles étaient introduites au Canada. Ces éléments ont été évalués lors d'un atelier de travail de spécialistes, qui ont utilisé les meilleures données disponibles sur leur biologie, les vecteurs d'introduction potentiels et leurs incidences dans leurs aires de répartition naturelle et les aires où elles ont été introduites. Ils ont conclu que l'introduction de ces quatre espèces de carpe d'Asie comportait un risque d'incidences élevé, au moins dans certaines parties du Canada, y compris le sud du bassin des Grands Lacs.

INTRODUCTION

This document summarizes the results of a risk assessment conducted to evaluate the risk posed by Asian carps if introduced into Canadian waters. This assessment was undertaken for five species collectively known as the Asian carps: grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), largescale silver carp (*Hypophthalmichthys harmandi*) and black carp (*Mylopharyngodon piceus*). The risk assessment is adapted from the process outlined in the Canadian *National Code on Introductions and Transfers of Aquatic Organisms*. The code outlines a two-part process that evaluates:

Part I - the probability of establishment and consequence of establishment of an aquatic organism, and

Part II - the probability of establishment and consequence of establishment of a pathogen, parasite or fellow traveler of the aquatic organism.

Each part contains two sets of component ratings (two each for probability and consequences of establishment) and are assigned ratings of high (risk is likely, or very likely, to occur), medium (there is probability of negative impact), or low (risk is considered to be insignificant). In addition, a level of certainty is also assigned as a gradient from very certain (scientific basis), reasonably certain, reasonably uncertain, to very uncertain ("best guess"). An overall risk potential is then determined separately for both parts.

The risk assessment process requires the best available biological information for the species of interest. This information was obtained from Nico and Williams (2001) for the black carp, Cudmore and Mandrak (2004) for the grass carp, and Kolar *et al.* (2004) for the bighead, largescale silver and silver carps. A draft risk assessment document was prepared for all five species and reviewed at a two-day workshop by international aquatic invasive species experts in October 2004 (see Appendix A for workshop participants). Rice *et al.* (2004) provides a synopsis of the workshop.

This document is a synthesis of the draft document and input from the workshop participants. For each Asian carp species, a summary of its native distribution, non-native and potential distribution in Canada, and the risk assessment is provided.

Grass Carp (*Ctenopharyngodon idella*)

1. Native Distribution

Grass carp is a sub-tropical to temperate species, native to large rivers and lakes in eastern Asia. Its native range extends from southern Russia to northern Vietnam and from coastal waters inland (Figure 1). In large rivers, like the Amur (border of China and Russia), Yangtze (northern China), Yellow River (central China) and the Min River (crosses the border from Vietnam into China), the grass carp is found only in the lower and middle reaches of the river (Cudmore and Mandrak 2004).

There is a broad range of climatic conditions within the native range of the grass carp. Mean annual air temperatures range from 25C in the southernmost part of its range to -6^{o}C in the northernmost part (Figures 2-3). The distribution of mean annual air temperatures within its range is bimodal, with one mode centred on 0^{o}C, the other on 16^{o}C (Figure 3).

Figure 1. Native distribution of grass carp.

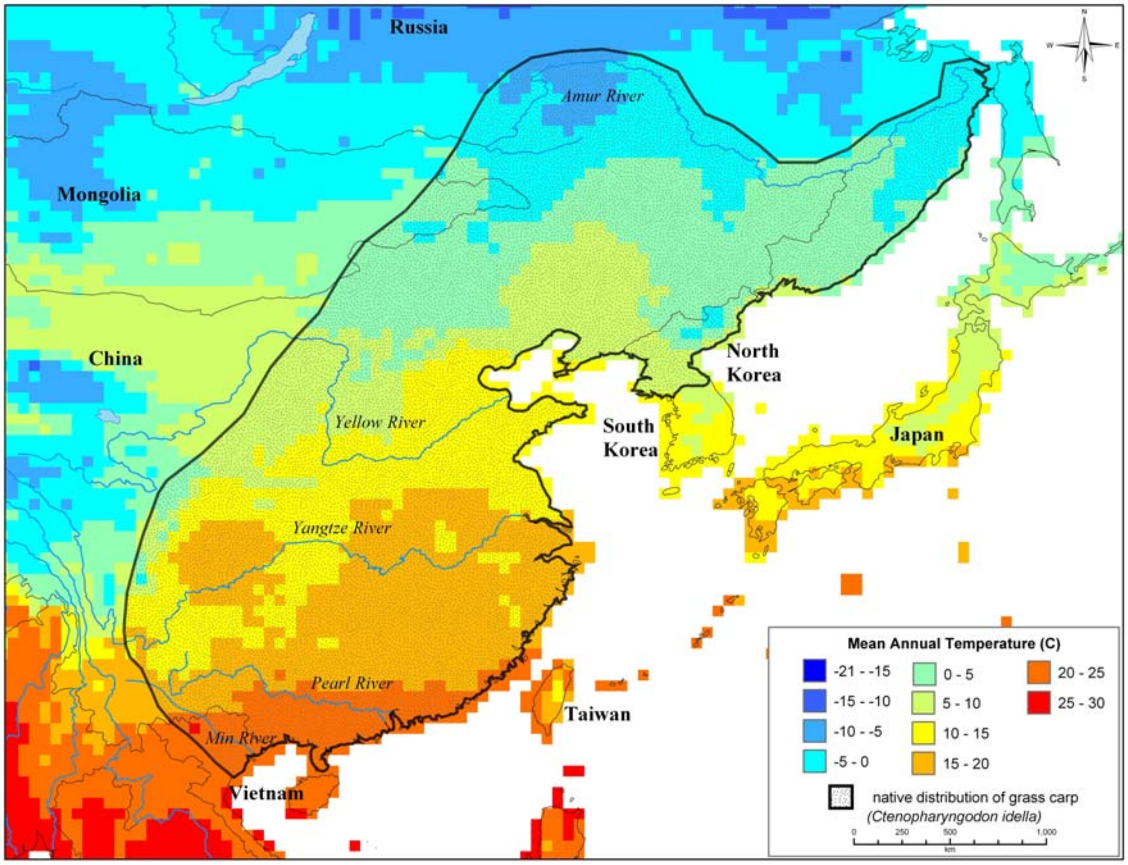

Figure 2. Native distribution of grass carp overlaid onto mean annual air temperature (based on 0.5^{o} latitude x 0.5^{o} longitude grid cells; data from Intergovernmental Panel on Climate Change (IPCC) data distribution center (http:// ipcc.ddc.cru.uea.ac.uk)).

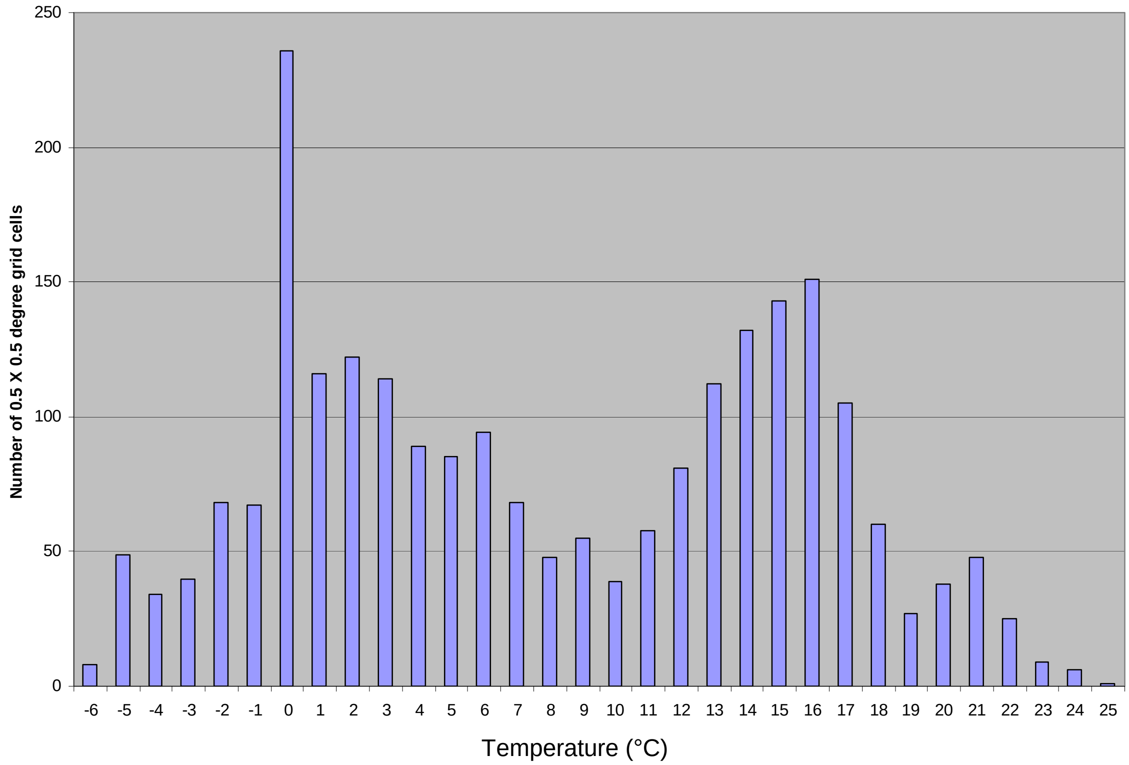

Figure 3. Frequency distribution of mean annual air temperature within the native distribution of grass carp as represented in Figure 2.

2. Non-native Distribution in Canada

Grass carp have been found in the wild in three provinces in Canada: Alberta, Saskatchewan and Ontario (Figure 4). Grass carp was first captured in Canada in the Ontario waters of Lake Erie, west of Point Pelee in 1985. Other single-specimen captures subsequently occurred in three locations in Lake Huron, and a pond and a river tributary of Lake Ontario in Toronto. In 2000, several thousand triploids were released into Loch Leven in Cypress Hills Provincial Park in Saskatchewan for weed control. There are no signs of reproduction (J. Keith, Saskatchewan Conservation Data Centre, pers. comm.). In 2000 or 2001, 50-100 individual triploid grass carp escaped from an irrigation canal into Lake Newell, a large, off-stream irrigation storage reservoir located near Brooks, Alberta. There are no signs of reproduction and it is unknown if any survivors remain (B. MacKay, University of Lethbridge, Aquaculture Centre, pers. comm.).

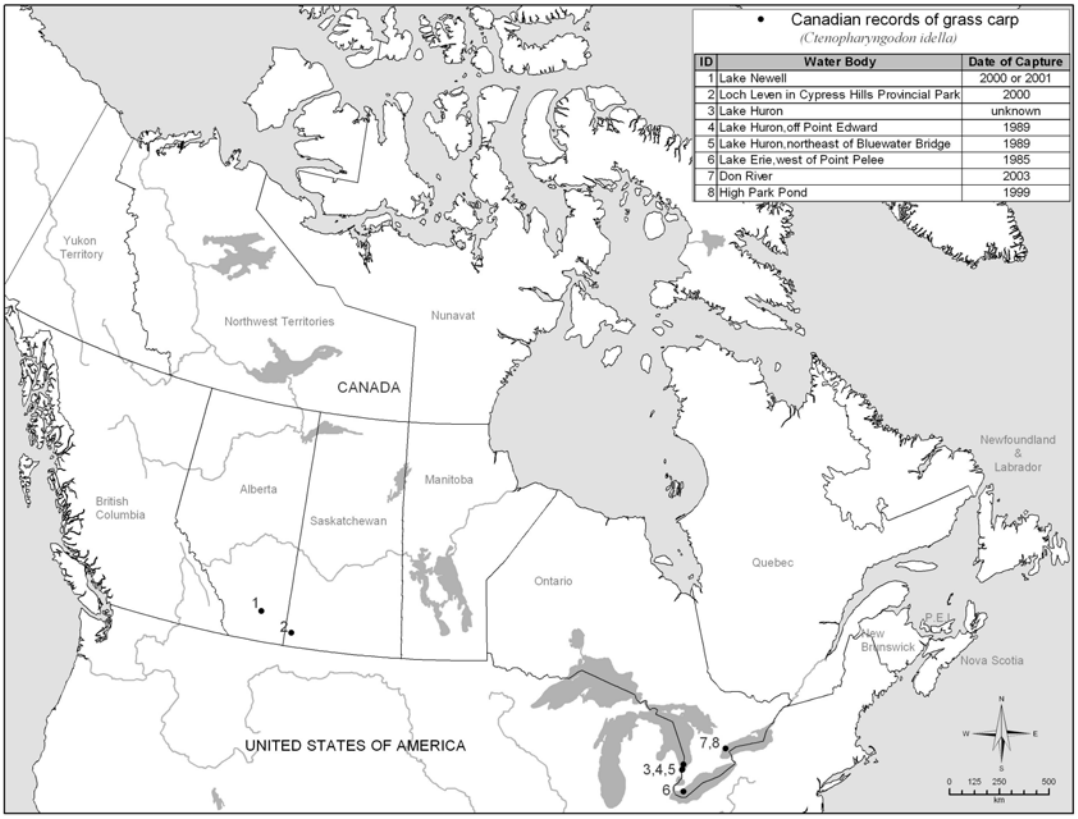

Figure 4. Records of grass carp in Canada. (Data sources: Royal Ontario Museum, Saskatchewan Conservation Data Centre and University of Lethbridge, Aquaculture Centre)

3. Potential Distribution in Canada

Based on the mean annual air temperature range in the native range of grass carp (Figures 2-3), its distribution could be widespread in Canada, north to about 60^{o}N (Figure 5). The potential distribution of grass carp can be further refined based on the distribution and availability of spawning and feeding habitats. An analysis is currently underway to predict its potential distribution within the Great Lakes. The Canadian portion of the Great Lakes contains a large amount of vegetated shoreline (approximately 4,620 km or 5% of entire shoreline, Environment Canada Shoreline Classification) that would provide suitable food (Figure 6). There are many tributaries to the Great Lakes that are at least 50km long and may be suitable spawning rivers (Figures 7-10).

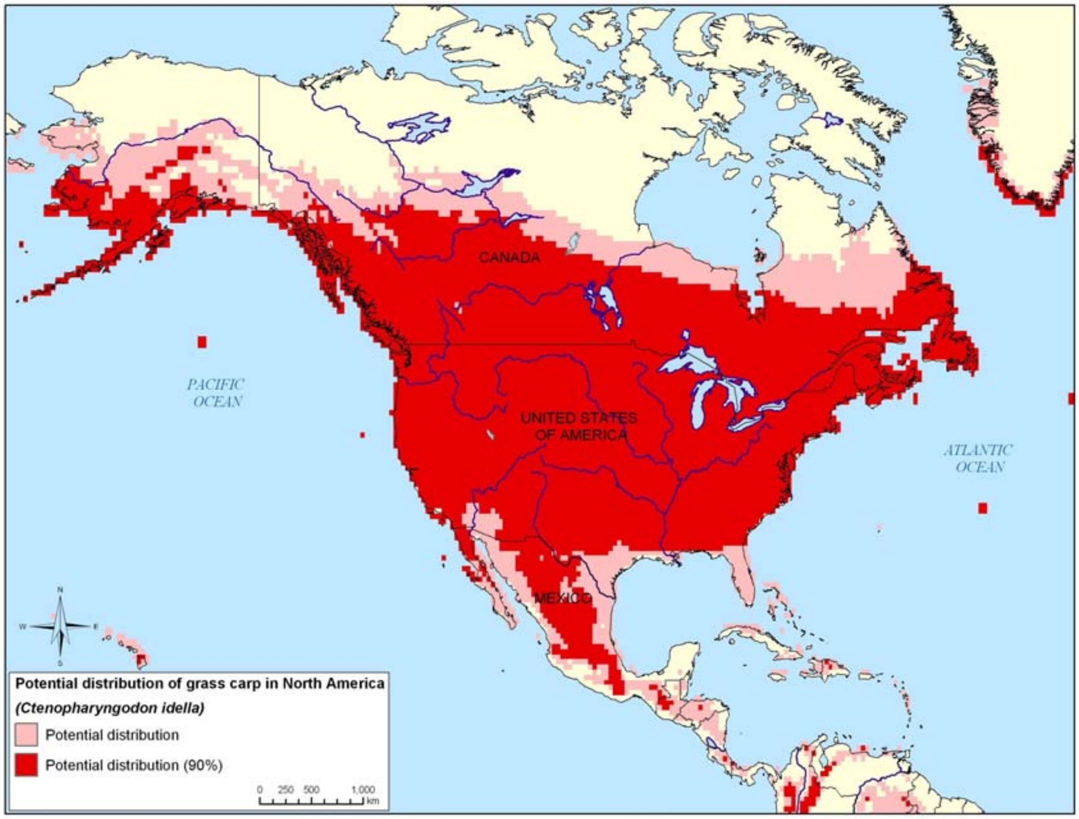

Figure 5. Potential distribution of grass carp in North America based on mean annual air temperature range in native distribution. Dark pink represents the lowest 5% and highest 5% of temperatures in Figure 3.

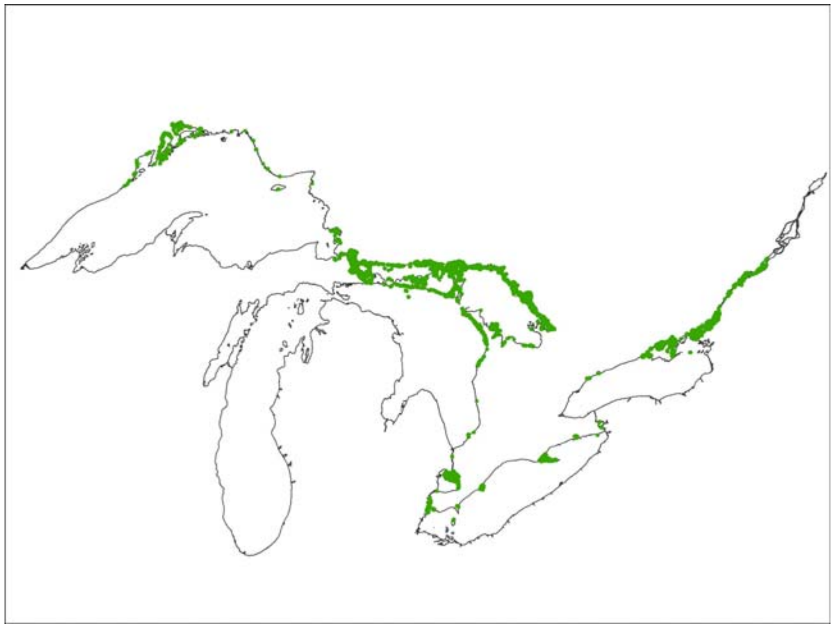

Figure 6. The distribution of vegetated shorelines in the Canadian Great Lakes basin. (Shoreline Classification, Environment Canada)

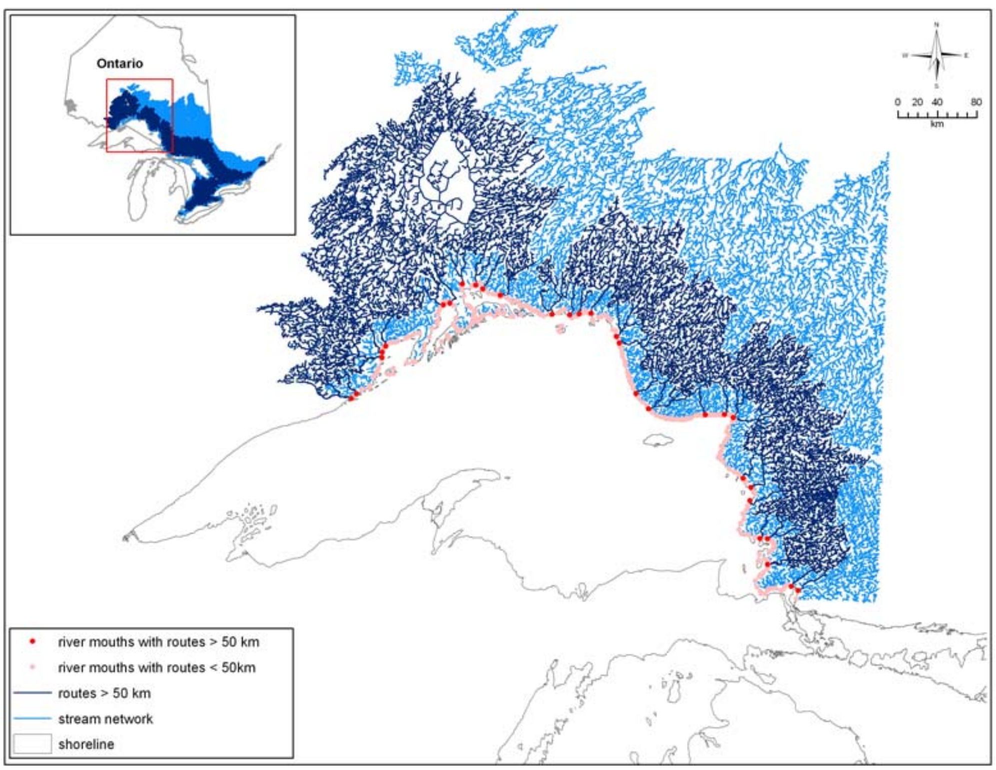

Figure 7. The distribution of Canadian tributaries draining into to Lake Superior which are greater than 50 km long.

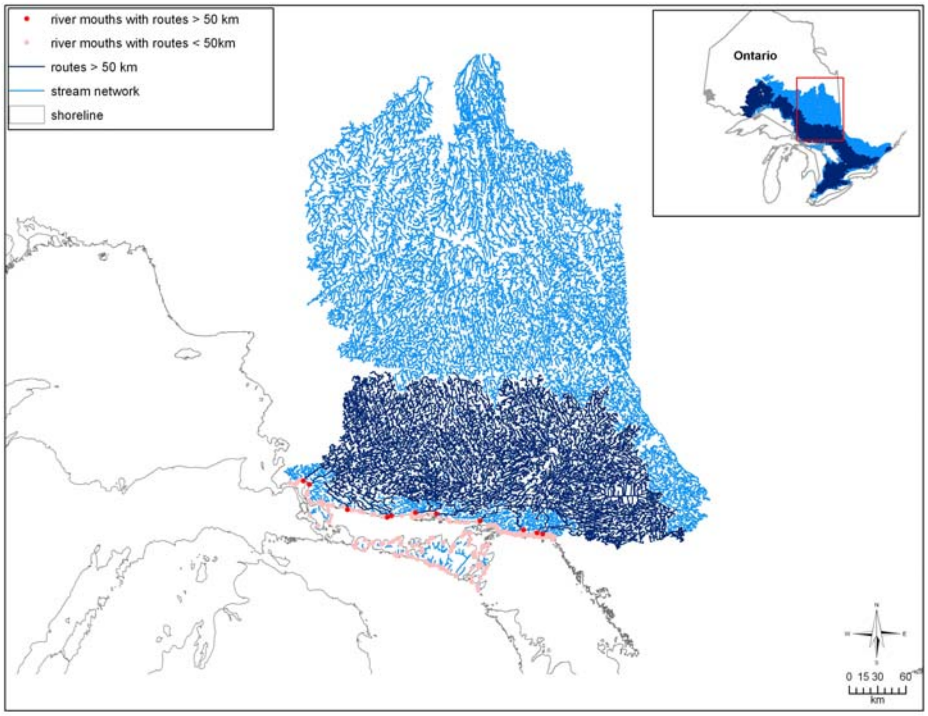

Figure 8. The distribution of tributaries draining into the North Channel of Lake Huron which are greater than 50 km long.

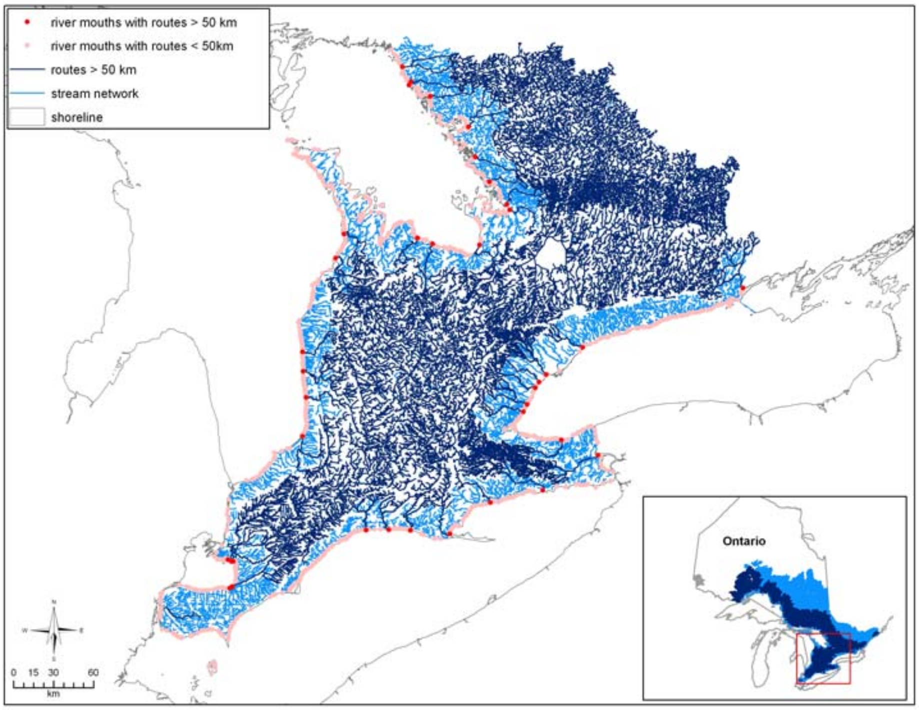

Figure 9. The distribution of tributaries draining into the south shore of Lake Huron, the north shore of Lake Erie and eastern shore of Lake Ontario which are g reater than 50km long.

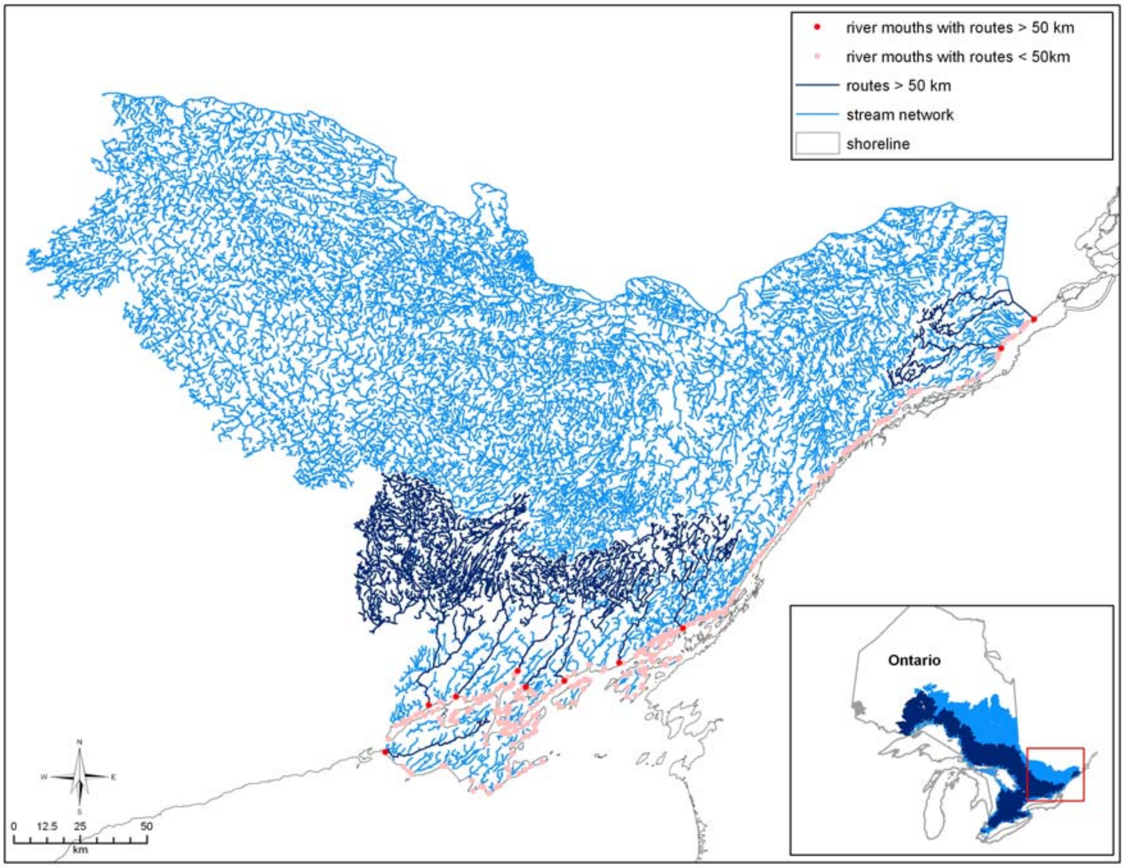

Figure 10. The distribution of Canadian tributaries draining into eastern Lake Ontario and the St. Lawrence greater than 50 km long.

Potential distribution will also depend on the vectors of introduction which may include colonization from the Mississippi River basin, deliberate (e.g. weed control, release for religious (prayer release) or animal rights reasons) or accidental (e.g. escape, tanker spill) release related to weed control and food industries, and subsequent dispersal. A quantitative risk assessment of the possible vectors in the Great Lakes basin is currently underway by Brian Leung (McGill University) and Nicholas Mandrak (Fisheries and Oceans Canada (DFO)).

4. Grass Carp Risk Assessment
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process – Grass Carp

Step 1. Determining the Probability of Establishment

(1) Estimate of probability of the organism successfully colonizing and maintaining a population if introduced. **Survival – High, very certain; Reproduction – High, reasonably certain.**

Vectors of grass carp introduction may include natural colonization from the Mississippi River basin, deliberate (e.g. weed control, prayer fish, animal rights activism) or accidental (e.g. tanker spill) release related to the availability of grass carp in the weed control and live food fish industries. The probability of introduction of grass carp through these vectors is largely unknown; however, the accidental release of grass carp used for weed control into the wild has been documented in Saskatchewan, and the origin of single specimens collected in the Canadian Great Lakes has been attributed to the live food fish industry.

In 1996, over 90,000 kg of grass carp were reported imported by major wholesalers in the Greater Toronto Area (GTA), and over 85,000 kg were reported imported in 1997 (Goodchild 1999). During 2003, close to 50,000 kg were reported by the Canadian Food Inspection Agency (CFIA) as entering Ontario; however, only close to 9,000 kg of grass carp were voluntarily reported sold, primarily live, to retail fish markets in Toronto during the period of April 2003-March 2004 (OMNR, unpubl. data).

If the grass carp does successfully colonize Canada, there is a high probability of it maintaining populations based on its thermal requirements (Figure 5). In addition, suitable feeding (Figure 6) and spawning habitat (Figures 7-10) exist in the Great Lakes basin. The availability of such habitats is largely unknown outside of the Great Lakes basin; however, the preferred spawning habitats of large, turbid rivers with seasonal flow are present in the Prairie provinces.

(2) If the organism escapes from the area of introduction, estimate the probability of its spreading. **High, reasonably certain.**

If the grass carp does successfully colonize the Great Lakes basin, there is a high probability that it could spread throughout the basin based on the presence of natural and man-made connections, and on the widespread distribution of suitable thermal (Figure 5), feeding (Figure 6) and spawning habitat (Figures 7-10). The probability of spreading outside of the Great Lakes basin is unknown largely as a result of the unknown availability of suitable habitats elsewhere. However, the combination of suitable spawning habitat and long stretches of unimpounded rivers, make it likely that grass carp could spread across the Prairies.

(3) Final Rating. **High, reasonably certain.**

Step 2. Determining the Consequences of Establishment of an Aquatic Organism

(1) Ecological impact on native ecosystems both locally and within the drainage basin. **High, very certain.**

Based on the results of its introduction throughout the world (Cudmore and Mandrak 2004), there is little doubt that the grass carp would have significant negative impacts on habitat and the food web and trophic structure of aquatic systems by inducing changes in plant, invertebrate and fish communities.

(2) Genetic impacts on local self-sustaining stocks or populations. **Low, very certain.**

As the grass carp is not closely related to any native cyprinids in Canada, it is highly unlikely to have any genetic impact on the native fauna. However, it may hybridize with other introduced carps (goldfish (*Carassius auratus*) and common carp (*Cyprinus carpio*)).

(3) Final Rating. **High, very certain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **High, reasonably certain.**

(2) Consequences of establishment estimate. **High, very certain.**

(3) Final Risk Estimate. **High, reasonably certain.**

Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process – Grass Carp

Step 1. Determining the Probability of Establishment

(1) Estimate the probability that a pathogen, parasite or fellow traveler may be introduced along with the potential invasive species. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated. **Medium, reasonably certain.**

Little is known about the parasites and pathogens of the grass carp (Cudmore and Mandrak 2004). However, it is a known host of the Asian tapeworm (*Bothriocephalus opsarichthydis*) which has been widely introduced in North America and infected a wide taxonomic variety of native (including endangered species) and introduced fish species (Cudmore and Mandrak 2004).

(2) Estimate the probability that the pathogen, parasite or fellow traveler will encounter susceptible organisms or suitable habitat. **Medium, reasonably certain.**

Based on the Asian tapeworm example, other pathogens or parasites would likely encounter susceptible organisms.

(3) Final Rating. Medium, **reasonably certain.**

Step 2. Determining the Consequences of Establishment of a Pathogen, Parasite or Fellow Traveler

(1) Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc. **Medium, reasonably certain.**

Based on the Asian tapeworm example, the impact may be substantial.

(2) Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite, or fellow traveler affects the genetic characteristics of native stocks or species). **Medium, very uncertain.**

Nothing is known about the potential genetic impacts on local populations. However, there are species related to possible travelers native to Canada; therefore the potential for genetic contamination exists.

(3) Final Rating. **Medium, very uncertain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Medium, reasonably certain.**

(2) Consequences of establishment estimate. **Medium, very uncertain.**

(3) Final Risk Estimate. **Medium, very uncertain.**

Table 1. Summary of risk assessment for grass carp in Canada.

Component Rating	Element Rating	Level of Certainty
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process		
Probability of establishment estimate	High	Reasonably Certain
Consequences of establishment estimate	High	Very Certain
Final Risk Estimate	**High**	**Reasonably Certain**
Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process		
Probability of establishment estimate	Medium	Reasonably Certain
Consequences of establishment estimate	Medium	Very Uncertain
Final Risk Estimate	**Medium**	**Very Uncertain**

Bighead Carp (*Hypophthalmichthys nobilis*)

1. Native Distribution

Bighead carp is a sub-tropical to temperate species, native to large rivers and lakes in eastern China and far eastern Russia (Kolar *et al.* 2004). Its native range extends from southern Russia to southern China and from coastal waters inland (Figure 11). In large rivers, like the Amur (border of China and Russia), Yangtze (northern China), Yellow River (central China) and the Pearl River (southern China), the bighead carp is found only in the lower and middle reaches of the river (Kolar *et al.* 2004). There is a broad range of climatic conditions within the native range of the bighead carp. Mean annual air temperatures range from 22°C in the southernmost part of its range to -2°C in the northernmost part (Figures 12-13). The distribution of mean annual air temperatures within its native range is bimodal, with one mode centred on 2°C, the other on 15°C (Figure 13).

Figure 11. Native distribution of bighead carp (modified from Kolar *et al.* 2004).

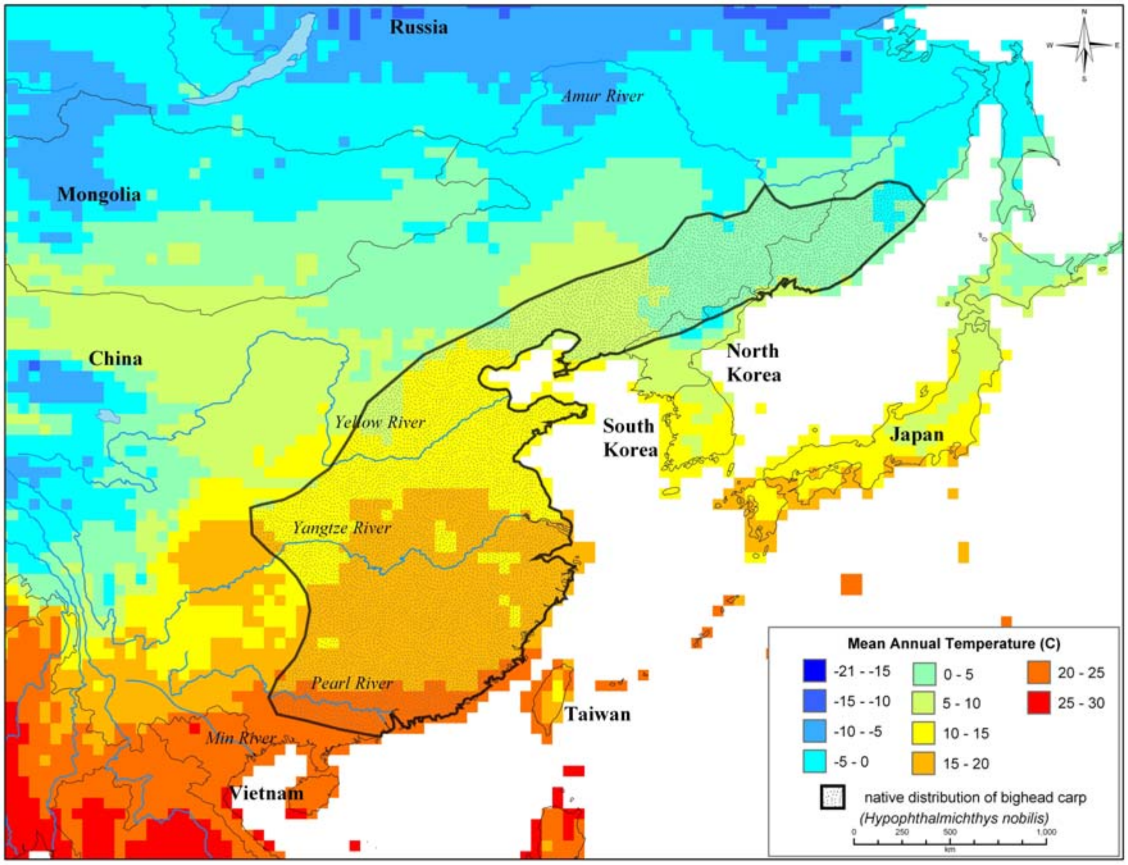

Figure 12. Native distribution of bighead carp overlaid onto mean annual air temperature (based on 0.5° latitude x 0.5° longitude grid cells; data from Intergovernmental Panel on Climate Change (IPCC) data distribution center (http:// *ipcc.ddc.cru.uea.ac.uk)).

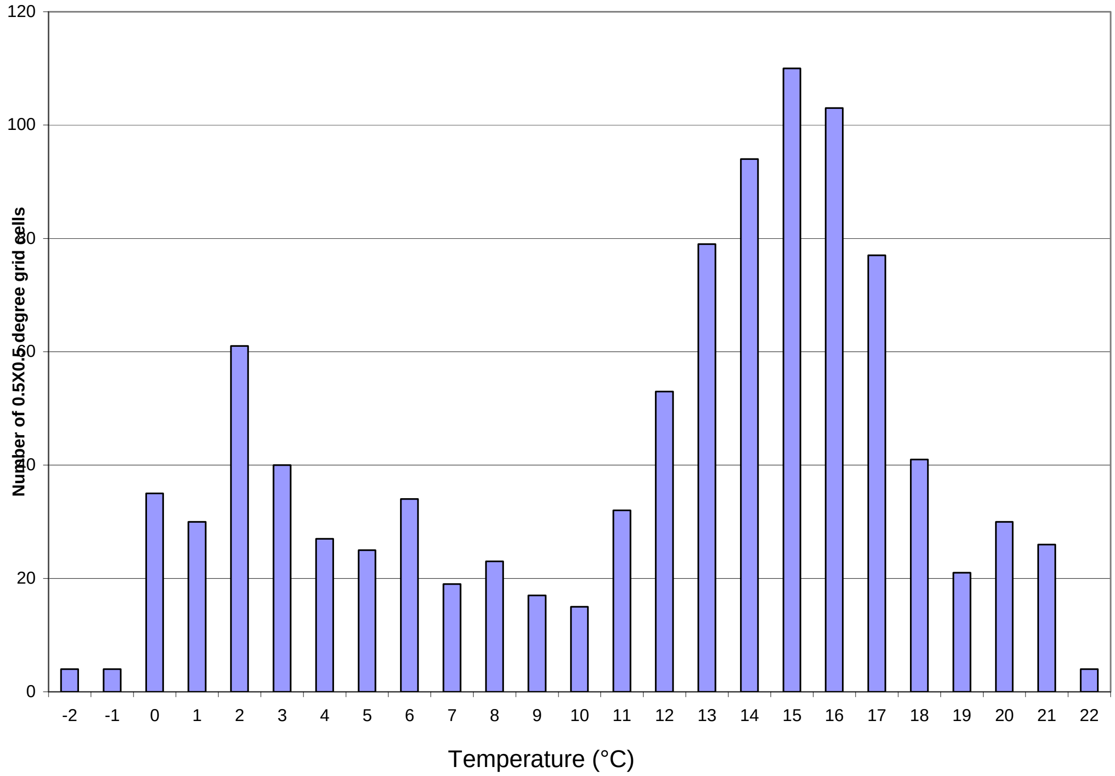

Figure 13. Frequency distribution of mean annual air temperature within the native distribution of bighead carp as represented in Figure 12.

2. Non-native Distribution in Canada

In Canada, single specimens of bighead carp have only been collected in Ontario (Figure 14). The first record of bighead carp, outside of a food market, was from a fountain on University Avenue in Toronto collected in 1991. This fish was undoubtedly purchased from one of the nearby live food fish markets. Only 3 single specimens have subsequently been collected, all in western Lake Erie, between 2000 and 2003.

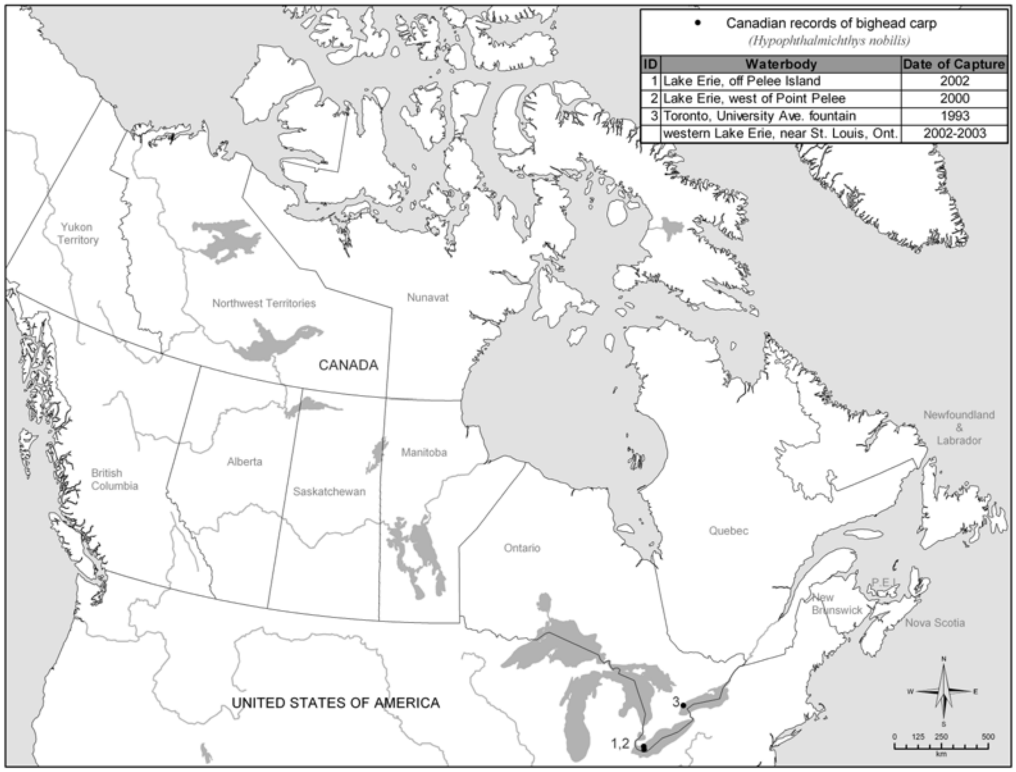

Figure 14. Canadian records of bighead carp.

3. Potential Distribution in Canada

Based on the mean annual air temperature range in the native range of the bighead carp (Figures 12-13), its distribution could be widespread in Canada, north to about 55^{o}N (Figure 15). The potential distribution of bighead carp can be further refined based on the distribution and availability of spawning and feeding habitats. An analysis is currently underway to further refine its potential distribution in the Great Lakes. In their native range, bighead carp generally require zooplankton densities greater than 5mg/L (Kolar *et al.* 2004). Zooplankton densities exceed this level in many areas of the Great Lakes, such as the Bay of Quinte (Lake Ontario; Bay of Quinte RAP Restoration Council 2001). However, established populations in the United States seem to have a broader diet than those in their native range (D. Chapman, United States Geological Survey (USGS), pers. comm.; M. Pegg, Illinois Natural History Survey (INHS), pers. comm.). Diet studies on bighead carp in the Illinois River indicated that algae and detritus were consumed along with zooplankton (M. Pegg, pers. comm.). Initial diet studies on bighead carp from the Missouri River, a system depauperate in zooplankton, showed that zooplankton comprised less than 5% of gut contents, and that detritus and fine particulate organic matter were the predominant gut contents (D. Chapman, pers. comm.). There are many tributaries to the Great Lakes that are at least 50 km long and may be suitable spawning rivers (Figures 7-10). However, bighead carp populations in Illinois have spawned in backwater areas and young were caught in 10-12^{o}C water (M. Pegg, pers. comm.). During a sediment collection study in the Missouri River system, bighead carp eggs were collected with sediment and developed in the collection bags, without flowing water, thought to be a necessary condition for Asian carp egg development (D. Chapman, pers. comm.). These observations indicate broader spawning requirements than previously reported.

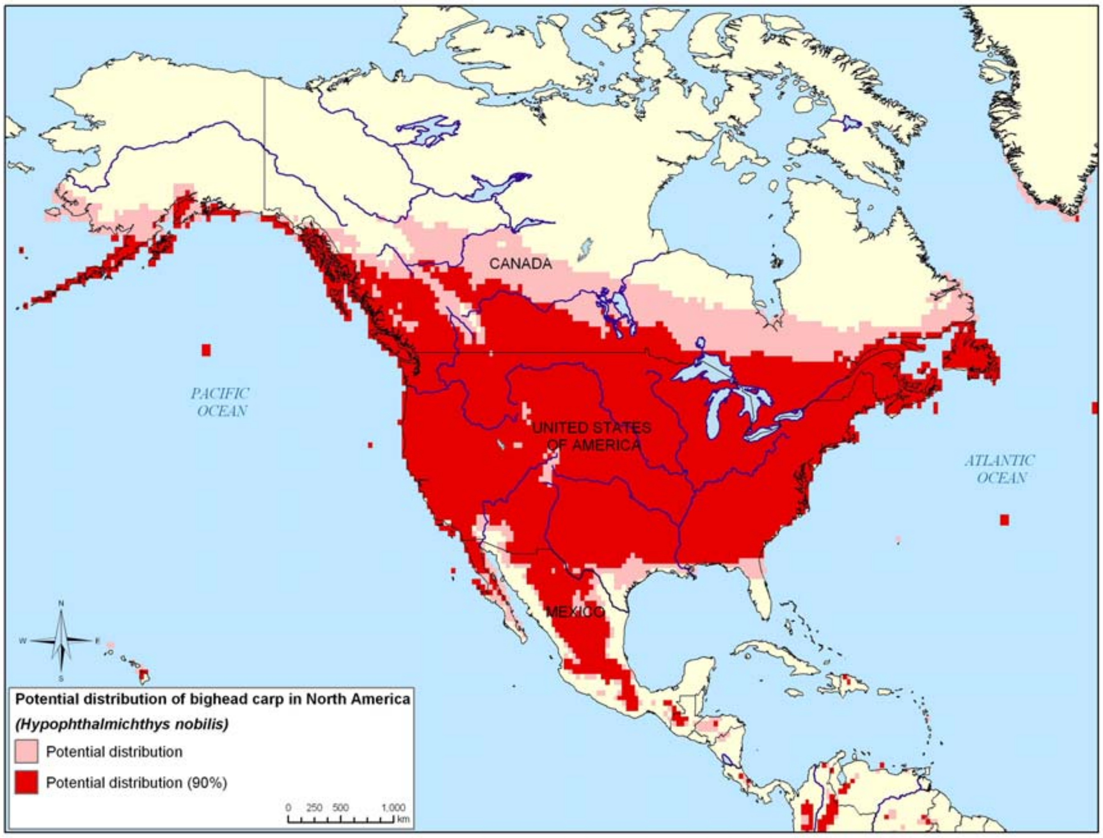

Figure 15. Potential distribution of bighead carp in North America based on mean annual air temperature range in native distribution. Dark pink represents the lowest 5% and highest 5% of temperatures in Figure 13.

Potential distribution will also depend on the vectors of introduction which may include colonization from the Mississippi River basin, deliberate (e.g. prayer fish, animal rights activism) or accidental (e.g. tanker spill) release related to the live food fish industry, and subsequent dispersal. A quantitative risk assessment of the possible vectors is currently underway by Brian Leung (McGill University) and Nicholas Mandrak (DFO).

4. Bighead Carp Risk Assessment

Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process – Bighead Carp

Step 1. Determining the Probability of Establishment

(1) Estimate of probability of the organism successfully colonizing and maintaining a population if introduced. **Survival – High, very certain; Reproduction – High, reasonably certain.**

Vectors of bighead carp introduction may include natural colonization from the Mississippi River basin where introduced populations are present (Kolar *et al.* 2004), deliberate (e.g. prayer fish, animal rights activism) or accidental (e.g. tanker spill) release related to the availability of bighead carp in the live food fish industry. The probability of introduction of bighead carp through these vectors is largely unknown; however, the origin of single specimens collected in the Canadian Great Lakes has been attributed to the live food fish industry.

Over 518,000 kg of bighead carp were imported into the GTA by wholesalers in 1996, and over 378,000 kg in 1997 (Goodchild 1999). Over 14,000 kg of live bighead carp were reported by the Canadian Food Inspection Agency (CFIA) as entering Ontario in 2003 (CFIA, unpubl. data); however, over 100,000 kg were voluntarily reported by wholesalers as sold to fish market retailers in the GTA (Ontario Ministry of Natural Resources, unpubl. data).

If the bighead carp does successfully colonize Canada, there is a high probability of it maintaining populations based on its thermal requirements (Figure 15). In addition, suitable feeding and spawning habitat (Figures 7-10) exists in the Great Lakes basin. The availability of such habitats is largely unknown outside of the Great Lakes basin; however, the preferred spawning habitat, as known from their native range, of large, turbid rivers with seasonal flow, are present in the Prairie provinces. However, the ability of introduced populations in the United States to spawn and have eggs develop in little or no flowing water suggests that many areas of Canada could be potential spawning habitat.

(2) If the organism escapes from the area of introduction, estimate the probability of its spreading. **High, reasonably certain.**

If the bighead carp does successfully colonize the Great Lakes basin, there is a high probability that it could spread throughout the basin based on the presence of natural and man-made connections, and on the widespread distribution of suitable thermal (Figure 15), feeding and spawning habitat (Figures 7-10). Bighead carp populations in the Mississippi River can move 64-81 km (40-50 miles) in one year (M. Pegg, pers. comm.). The probability of spreading outside the Great Lakes basin is unknown, largely as a result of the unknown availability of suitable habitats elsewhere. However, the combination of suitable spawning habitat and long stretches of unimpounded rivers, make it likely that bighead carp could spread across the Prairies.

(3) Final Rating. **High, reasonably certain.**

Step 2. Determining the Consequences of Establishment of an Aquatic Organism

(1) Ecological impact on native ecosystems both locally and within the drainage basin. **High, reasonably certain.**

Based on the results of its introduction throughout the world, there is little doubt that the bighead carp would have significant negative impacts on the food web and trophic structure of aquatic systems by inducing changes in the lower trophic levels. Bighead carp would predate heavily on zooplankton, and strongly compete with the young of most native fish species and all stages of native planktivorous species (Kolar *et al.* 2004). Established populations in the United States seem to have a broader diet spectrum than those in their native range, which would suggest that competition for other food items with native species would also occur. In the Illinois River, bigmouth buffalo (*Ictiobus cyprinellus*) populations have declined while numbers of bighead and silver carps increase (M. Pegg, pers. comm.). Bigmouth buffalo is ranked by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as a species of Special Concern, and is found in Saskatchewan, Manitoba and Ontario (Goodchild 1989). Bighead carp also have a similar diet and feeding style (‘ram-feed’) to gizzard shad (*Dorosoma cepidianum*) (D. Chapman, pers. comm.); therefore, this species, an important forage fish for native species, may also be impacted should bighead carp be found in large numbers in Canada.

(2) Genetic impacts on local, self-sustaining stocks or populations. **Low, very certain.**

As the bighead carp is not closely related to any native cyprinids in Canada, it is highly unlikely to have any genetic impact on the native fauna. However, it may hybridize with other introduced carps (goldfish (*Carassius auratus*) and common carp (*Cyprinus carpio*)).

(3) Final Rating. **High, reasonably certain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **High, reasonably certain.**

(2) Consequences of establishment estimate. **High, reasonably certain.**

(3) Final Risk Estimate. **High, reasonably certain.**

Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process – Bighead Carp

Step 1. Determining the Probability of Establishment

(1) Estimate the probability that a pathogen, parasite or fellow traveler may be introduced along with the potential invasive species. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated. **Medium, reasonably uncertain.**

Many parasites and pathogens, including Asian tapeworm, have been documented to infect the bighead carp (Kolar *et al.* 2004). The probability of introducing these disease-causing agents with bighead carp is unknown, but undoubtedly exists.

Step 2. Determining the Consequences of Establishment of a Pathogen, Parasite or Fellow Traveler

(1) Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc. **Medium, very uncertain.**

Based on the Asian tapeworm example, the impact may be substantial.

(2) Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite, or fellow traveler affects the genetic characteristics of native stocks or species). **Medium, very uncertain.**

Nothing is known about the potential genetic impacts on local populations. However, there are species related to possible travelers native to Canada; therefore, the potential for genetic contamination exists.

(3) Final Rating. **Medium, very uncertain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Medium, reasonably certain.**

(2) Consequences of establishment estimate. **Medium, very uncertain.**

(3) Final Risk Estimate. **Medium, very uncertain.**

Table 2. Summary of risk assessment for bighead carp in Canada.

Component Rating	Element Rating	Level of Certainty
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process		
Probability of establishment estimate	High	Reasonably Certain
Consequences of establishment estimate	High	Reasonably Certain
Final Risk Estimate	**High**	**Reasonably Certain**
Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process		
Probability of establishment estimate	Medium	Reasonably Certain
Consequences of establishment estimate	Medium	Very Uncertain
Final Risk Estimate	**Medium**	**Very Uncertain**

Silver Carp (*Hypophthalmichthys molitrix*)

1. Native Distribution

Silver carp is a sub-tropical to temperate species native to large rivers, canals, reservoirs and lakes in eastern Asia (Kolar *et al.* 2004). Its native range extends from southern Russia and North Korea to southern China, and from coastal waters inland (Figure 16). In large rivers, like the Amur (border of China and Russia), Yangtze (northern China), Yellow River (central China) and the Pearl River (southern China), the silver carp extends further inland than the other Asian carps (Kolar *et al.* 2004). However, the true extent of its native distribution is obscured by the many introductions that have occurred across Asia (Kolar *et al.* 2004).

Figure 16. Native distribution of silver carp (modified from Kolar *et al.* 2004).

There is a broad range of climatic conditions within the native range of the silver carp. Mean annual air temperatures range from 24^oC in the southernmost part of its range to -6^oC in the northernmost part (Figures 17-18). The distribution of mean annual air temperatures within its range is bimodal, with one mode centred on 0^oC, the other on 15^oC (Figure 18).

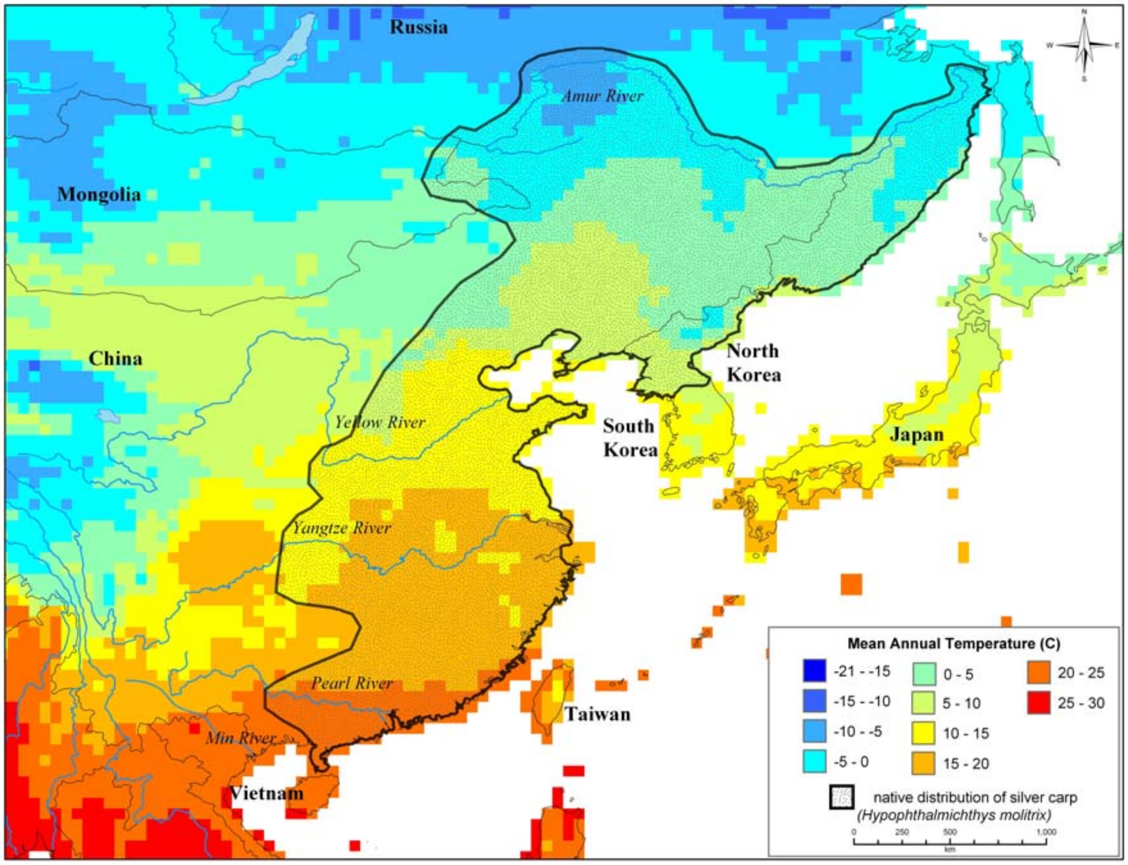

Figure 17. Native distribution of silver carp overlaid onto mean annual air temperature (based on 0.5^o latitude x 0.5^o longitude grid cells; data from Intergovernmental Panel on Climate Change (IPCC) data distribution center (http://ipcc.ddc.cru.uea.ac.uk)).

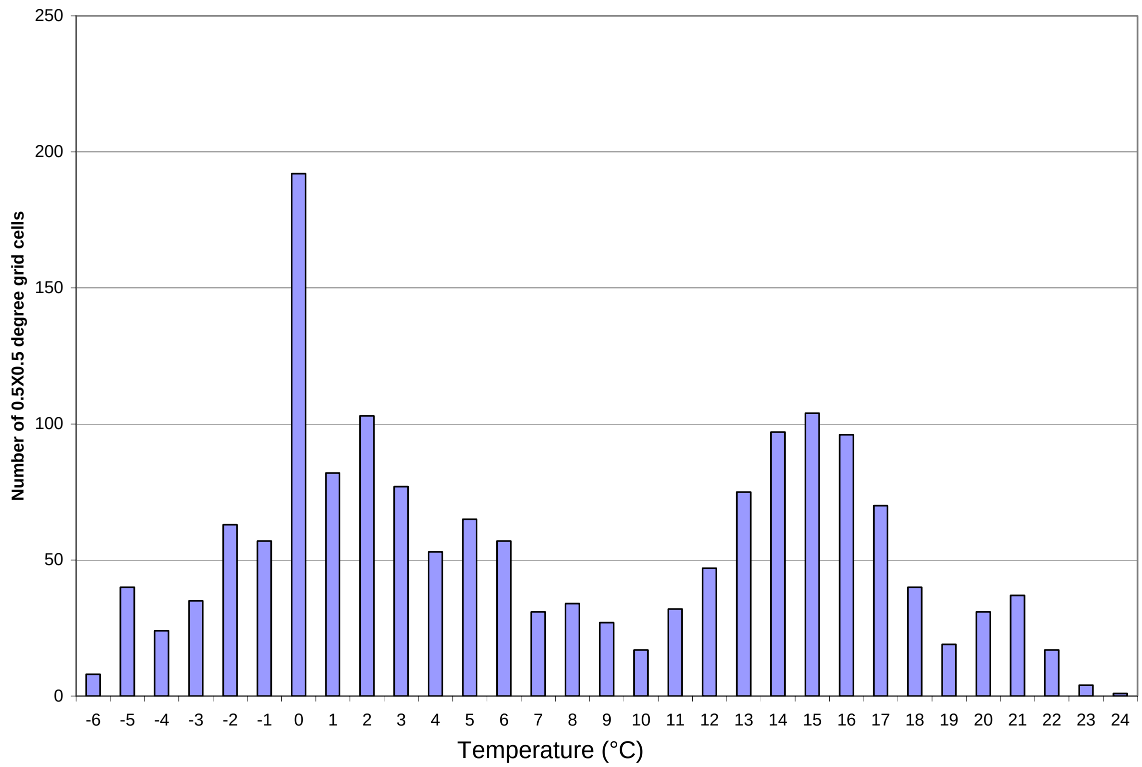

Figure 18. Frequency distribution of mean annual air temperature within the native distribution of silver carp as represented in Figure 17.

2. Non-native Distribution in Canada

The silver carp has not been captured in the wild in Canada. Research on the suitability of silver carp for biological control is being done in dugout ponds in Alberta (B. MacKay, pers. comm.) and, although undocumented, silver carp were observed in 2004 in a live food fish market in Toronto (D. Chapman, pers. comm.).

3. Potential Distribution in Canada

Based on the mean annual air temperature range in the native range of the silver carp (Figures 17-18), its distribution could be widespread in Canada, north to about 65^{o}N (Figure 19). The potential distribution of silver carp can be further refined based on the distribution and availability of spawning and feeding habitats. Silver carp are generally more phytoplanktivorous than bighead carp; however, no studies have indicated a minimum density of plankton required for survival (Kolar *et al.* 2004). Phytoplankton (and zooplankton) densities are quite high in the many embayments around the Great Lakes (e.g. Bay of Quinte, Irondoquoit Bay, Maumee Bay, Green Bay, Saginaw Bay). There are many tributaries to the Great Lakes that are at least 50 km long and may be suitable spawning rivers (Figures 7-10).

Potential distribution will also depend on the vectors of introduction which may include colonization from the Mississippi River basin, deliberate (e.g. prayer fishes, animal rights activism) or accidental (e.g. aquaculture escape, tanker spill) release related to the aquaculture and live food fish industries, and subsequent dispersal. A quantitative risk assessment of the possible vectors is currently underway by Brian Leung (McGill University) and Nicholas Mandrak (DFO).

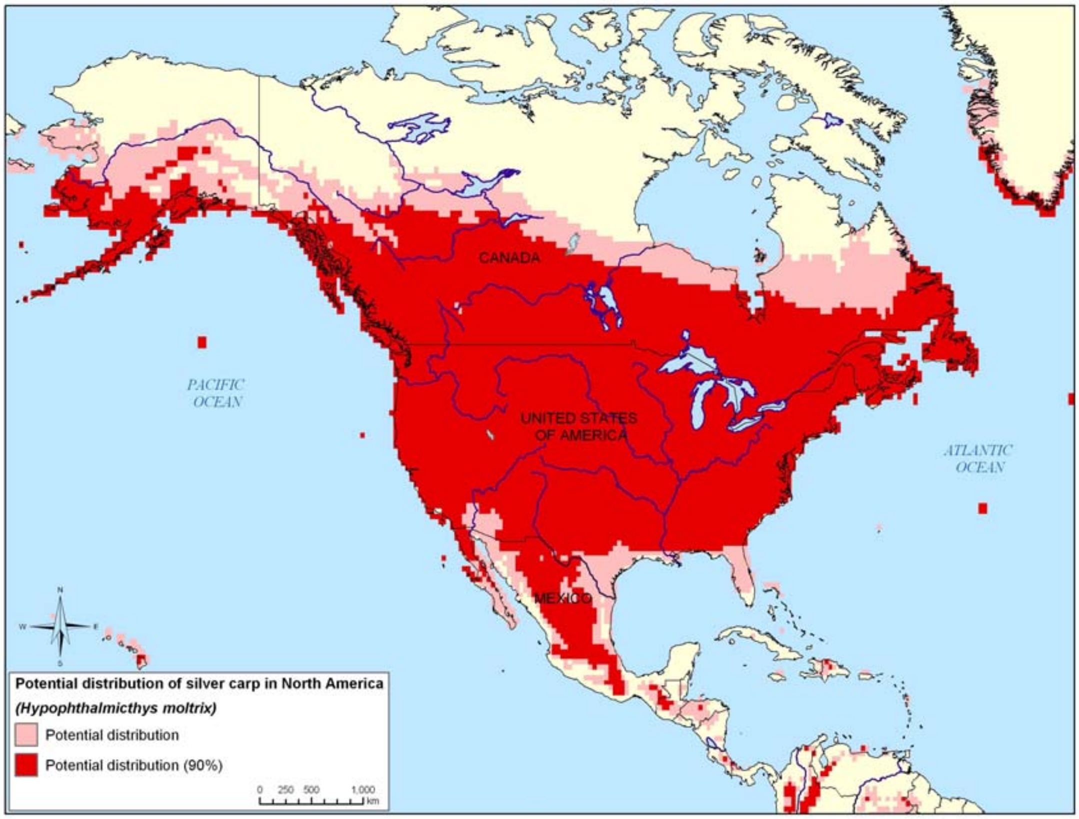

Figure 19. Potential distribution of silver carp in North America based on mean annual air temperature range in native distribution. Dark pink represents the lowest 5% and highest 5% of temperatures in Figure 18.

4. Silver Carp Risk Assessment

Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process – Silver Carp

Step 1. Determining the Probability of Establishment

(1) Estimate of probability of the organism successfully colonizing and maintaining a population if introduced. **Survival – High, very certain; Reproduction – High, reasonably certain.**

Vectors of silver carp introduction may include natural colonization from the Mississippi River basin where introduced populations are present (Kolar *et al.* 2004), and deliberate (e.g. prayer fish, animal rights activism) or accidental (e.g. aquaculture escape, tanker spill) release related to the availability of silver carp in the aquaculture and live food fish industries. The use and value of silver carp in Canada is unknown. Silver carp is undocumented in the live food fish industry, but has been observed to be available for sale in a live food fish market (D. Chapman, pers. comm.). The probability of introduction of silver carp through these vectors is largely unknown,

If the silver carp does successfully colonize Canada, there is a high probability of it maintaining populations based on its thermal requirements (Figure 19). In addition, suitable feeding and spawning habitat (Figures 7-10) exist in the Great Lakes basin. The availability of such habitats is largely unknown outside of the Great Lakes basin; however, the preferred spawning habitat of large, turbid rivers with seasonal flow is present in the Prairie provinces.

(2) If the organism escapes from the area of introduction, estimate the probability of its spreading. **High, reasonably certain.**

If the silver carp does successfully colonize the Great Lakes basin, there is a high probability that it could spread throughout the basin based on the presence of natural and man-made connections, and on the widespread distribution of suitable thermal (Figure 19), feeding and spawning habitat (Figures 7-10). The probability of spreading outside of the Great Lakes basin is unknown largely as a result of the unknown availability of suitable habitats elsewhere. However, the combination of suitable spawning habitat and long stretches of unimpounded rivers, make it likely that silver carp could spread across the Prairies.

(3) Final Rating. **High, reasonably certain.**

Step 2. Determining the Consequences of Establishment of an Aquatic Organism

(1) Ecological impact on native ecosystems both locally and within the drainage basin. **High, very certain.**

Based on the results of its introduction throughout the world, there is little doubt that the silver carp would have significant negative impacts on the food web and trophic structure of aquatic systems by inducing changes in the lower trophic levels (Kolar *et al.* 2004). Silver carp would predate heavily on phytoplankton and zooplankton, and strongly compete with the young of most native fish species and all stages of native planktivorous species (Kolar *et al.* 2004). Silver carp has been shown to change the structure of the phytoplankton and zooplankton community toward smaller sizes (W. Shelton, Oklahoma University, pers. comm.; D. Chapman, pers. comm.).

(2) Genetic impacts on local self-sustaining stocks or populations. **Low, very certain.**

As the silver carp is not closely related to any native cyprinids in Canada, it is highly unlikely to have any genetic impact on the native fauna. However, it may hybridize with other introduced carps (*Carassius auratus*) and common carp (*Cyprinus carpio*)).

(3) Final Rating. **High, very certain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **High, reasonably certain.**

(2) Consequences of establishment estimate. **High, very certain.**

(3) Final Risk Estimate. **High, reasonably certain.**

Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process – Silver Carp

Step 1. Determining the Probability of Establishment

(1) Estimate the probability that a pathogen, parasite or fellow traveler may be introduced along with the species proposed for introduction. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated. **Medium, reasonably certain.**

Many parasites and pathogens, including Asian tapeworm, have been documented to infect the silver carp (Kolar *et al.* 2004). The probability of introducing these disease-causing agents with silver carp is unknown, but undoubtedly exists. Spring viremia of carp (SVC) is caused by the virus *Rhabdovirus carpio*). Although this virus was first reported in North America from a commercial operation rearing koi in North Carolina, silver carp are highly susceptible to this infection. Also susceptible are the other Asian carp species and several native cyprinids as well, including fathead minnow, *Pimephales promelas*, and golden shiner, *Notemigonus crysoleucas*) (Chalmers 2003).

(2) Estimate the probability that the pathogen, parasite or fellow traveler will encounter susceptible organisms or suitable habitat. **Medium, reasonably certain.**

Based on the Asian tapeworm example, other pathogens or parasites would likely encounter susceptible organisms.

(3) Final Rating. **Medium, reasonably certain.**

Step 2. Determining the Consequences of Establishment of a Pathogen, Parasite or Fellow Traveler

(1) Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc. **Medium, very uncertain.**

Based on the Asian tapeworm example, the impact may be substantial.

(2) Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite, or fellow traveler affects the genetic characteristics of native stocks or species). **Medium, very uncertain.**

Nothing is known about the potential genetic impacts on local populations. However, there are species related to possible travelers native to Canada; therefore the potential for genetic contamination exists.

(3) Final Rating. **Medium, very uncertain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Medium, reasonably certain.**

(2) Consequences of establishment estimate. **Medium, very uncertain.**

(3) Final Risk Estimate. **Medium, very uncertain.**

Table 3. Summary of risk assessment for silver carp in Canada.

Component Rating	Element Rating	Level of Certainty
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process		
Probability of establishment estimate	High	Reasonably Certain
Consequences of establishment estimate	High	Very Certain
Final Risk Estimate	**High**	**Reasonably Certain**
Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process		
Probability of establishment estimate	Medium	Reasonably Certain
Consequences of establishment estimate	Medium	Very Uncertain
Final Risk Estimate	**Medium**	**Very Uncertain**

Largescale Silver Carp (*Hypophthalmichthys harmandi*)

1. Native Distribution

Largescale silver carp is a sub-tropical species, native to the Nandu Jiang River of Hainan Island, China, and the Hong Ha (Red) River of northern Vietnam (Figure 20) (Kolar *et al.* 2004).

Figure 20. Native distribution of largescale silver carp (modified from Kolar *et al.* 2004).

There is a narrow range of climatic conditions within the native range of the largescale silver carp. Mean annual air temperatures range from 26°C in the southernmost part of its range to 21°C in the northernmost part (Figures 21-22). The distribution of mean annual air temperatures within its native range is unimodal with the mode centred on 24°C (Figure 22).

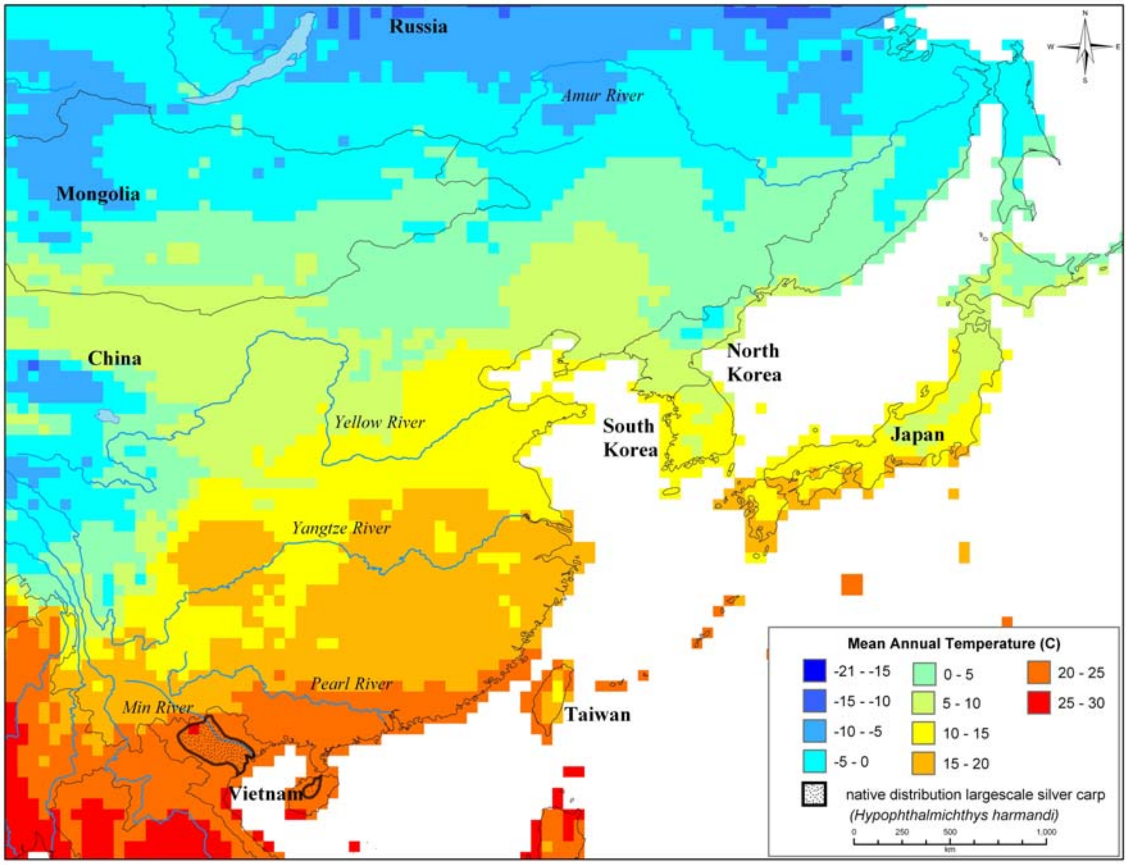

Figure 21. Native distribution of largescale silver carp overlaid onto mean annual air temperature (based on 0.5^o latitude x 0.5^o longitude grid cells; data from Intergovernmental Panel on Climate Change (IPCC) data distribution center (http://ipcc.ddc.cru.uea.ac.uk)).

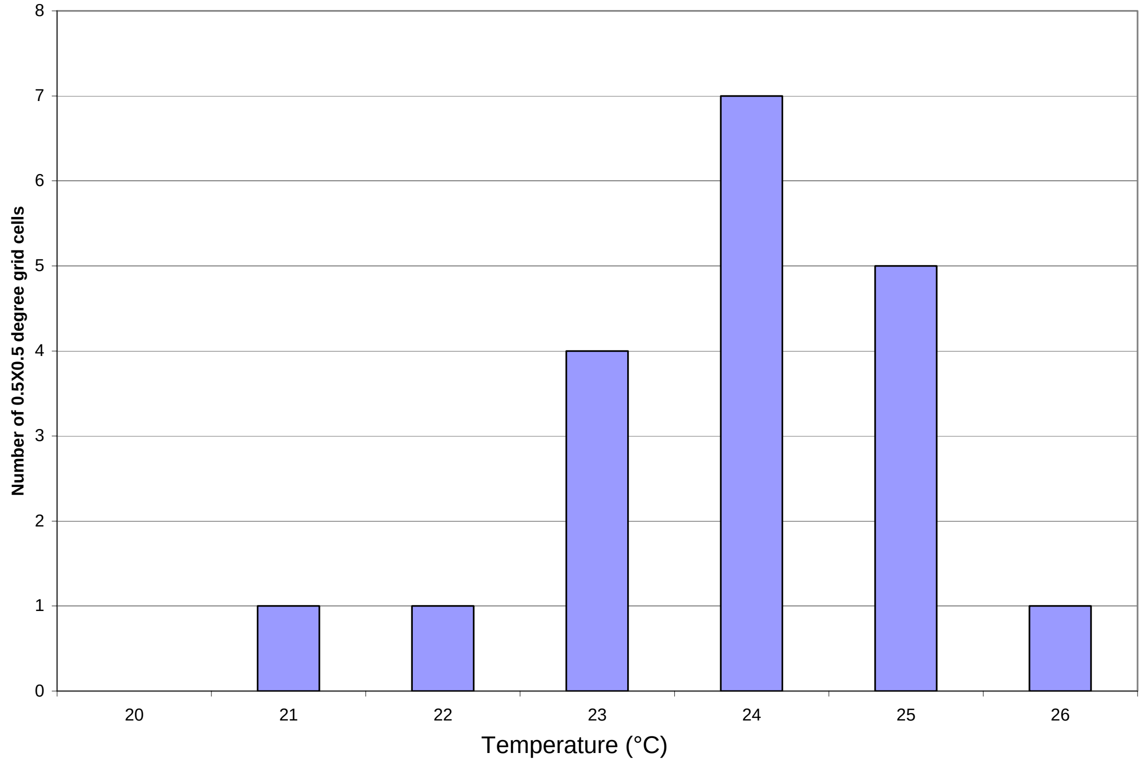

Figure 22. Frequency distribution of mean annual air temperature within the native distribution of largescale silver carp as represented in Figure 21.

2. Non-native Distribution in Canada

The largescale silver carp has not been captured in the wild, nor has it been found in the live fish food industry, in Canada.

3. Potential Distribution in Canada

Based on the mean annual air temperature range in the native range of the largescale silver carp (Figures 21-22), this species could not survive long-term in Canada (Figure 23).

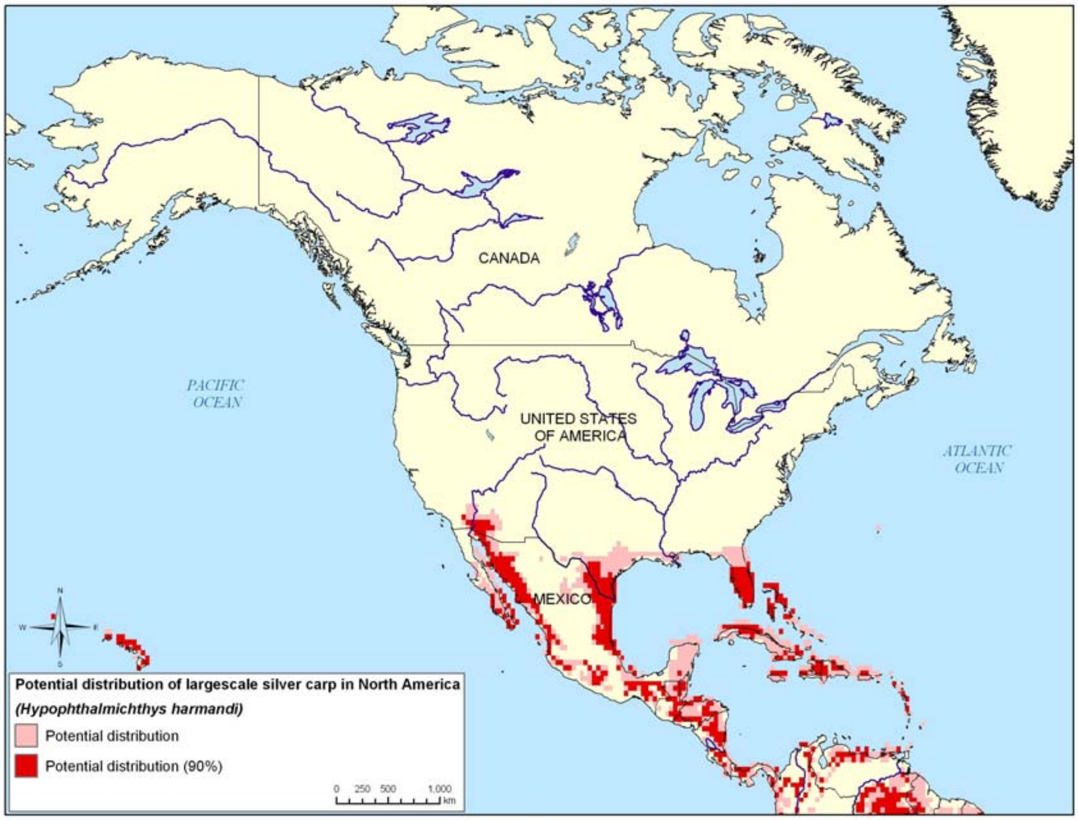

Figure 23. Potential distribution of largescale silver carp in North America based on mean annual air temperature range in native distribution. Dark pink represents the lowest 5% and highest 5% of temperatures in Figure 22.

4. Largescale Silver Carp Risk Assessment

Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process – Largescale Silver Carp

Step 1. Determining the Probability of Establishment

(1) Estimate of probability of the organism successfully colonizing and maintaining a population if introduced. **Survival – Low, reasonably certain; Reproduction – Low, very certain.**

(2) If the organism escapes from the area of introduction, estimate the probability of its spreading. **Low, very certain.**

If the largescale silver carp is introduced into Canada, it is unlikely to survive due to lack of suitable thermal habitat (Figure 23). Largescale silver carp have not yet been found in North America (Kolar *et al.* 2004).

(3) Final Rating. **Low, reasonably certain.**

Step 2. Determining the Consequences of Establishment of an Aquatic Organism

(1) Ecological impact on native ecosystems both locally and within the drainage basin. **High, reasonably certain.**

Based on the results of the introduction of the closely-related silver carp throughout the world, there is little doubt that the largescale silver carp would have significant negative impacts on the food web and trophic structure of aquatic systems by inducing changes in the lower trophic levels (Kolar *et al.* 2004). Largescale silver carp would predate heavily on phytoplankton and zooplankton, and strongly compete with the young of most native fish species and all stages of native planktivorous species (Kolar *et al.* 2004).

(2) Genetic impacts on local self-sustaining stocks or populations. **Low, very certain.**

As the largescale silver carp is not closely related to any native cyprinids in Canada, it is highly unlikely to have any genetic impact on the native fauna. However, it may hybridize with other introduced carps (*Carassius auratus*) and common carp (*Cyprinus carpio*)).

(3) Final Rating. **High, reasonably certain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Low, reasonably certain.**

(2) Consequences of establishment estimate. **High, reasonably certain.**

(3) Final Risk Estimate. **Medium, reasonably certain.**

Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process – Largescale Silver Carp

Step 1. Determining the Probability of Establishment

(1) Estimate the probability that a pathogen, parasite or fellow traveler may be introduced along with the species proposed for introduction. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated. **Medium, reasonably uncertain.**

Little is known about the parasites and pathogens that infect the largescale silver carp (Kolar *et al.* 2004). The probability of introducing disease-causing agents with largescale silver carp is unknown, but undoubtedly exists.

(2) Estimate the probability that the pathogen, parasite or fellow traveler will encounter susceptible organisms or suitable habitat. **Medium, reasonably certain.**

Based on the Asian tapeworm example in silver carp, other pathogens or parasites would likely encounter susceptible organisms.

(3) Final Rating. **Medium, reasonably uncertain.**

Step 2. Determining the Consequences of Establishment of a Pathogen, Parasite or Fellow Traveler

(1) Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc. **Medium, very uncertain.**

(2) Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite, or fellow traveler affects the genetic characteristics of native stocks or species). **Medium, very uncertain.**

(3) Final Rating. **Medium, very uncertain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Medium, reasonably certain.**

(2) Consequences of establishment estimate. **Medium, very uncertain.**

(3) Final Risk Estimate. **Medium, very uncertain.**

Table 4. Summary of risk assessment for largescale silver carp in Canada.

Component Rating	Element Rating	Level of Certainty
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process		
Probability of establishment estimate	Low	Reasonably Certain
Consequences of establishment estimate	High	Reasonably Certain
Final Risk Estimate	**Medium**	**Reasonably Certain**
Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process		
Probability of establishment estimate	Medium	Reasonably Certain
Consequences of establishment estimate	Medium	Very Uncertain
Final Risk Estimate	**Medium**	**Very Uncertain**

Black Carp (*Mylopharyngodon piceus*)

1. Native Distribution

Black carp is a sub-tropical to temperate species, native to large rivers and lakes in eastern Asia (Nico and Williams 2001). It has a disjunct native range extending from southern Russia to southern China or Vietnam, and is absent from China in the vicinity of the Korean peninsula (Figure 24).

There is a broad range of climatic conditions within the native range of the black carp. Mean annual air temperatures range from 23^{o}C in the southernmost part of its range to -4^{o}C in the northernmost part (Figures 25-26). The distribution of mean annual air temperatures within its range is bimodal, with one mode centred on 0^{o}C, the other on 15^{o}C (Figure 26).

Figure 24. Native distribution of black carp (from Nico and Williams 2001).

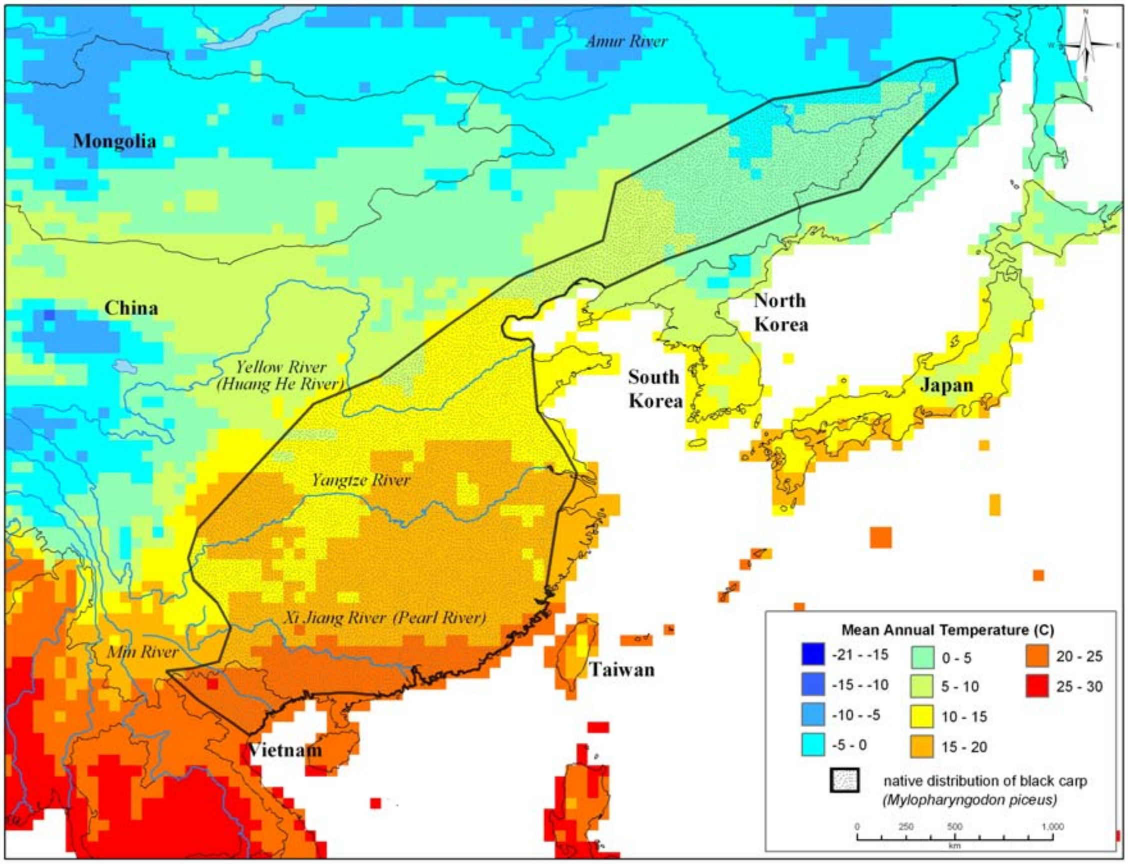

Figure 25. Native distribution of black carp overlaid onto mean annual air temperature (based on 0.5^o latitude x 0.5^o longitude grid cells; data from Intergovernmental Panel on Climate Change (IPCC) data distribution center (http://ipcc.ddc.cru.uea.ac.uk)).

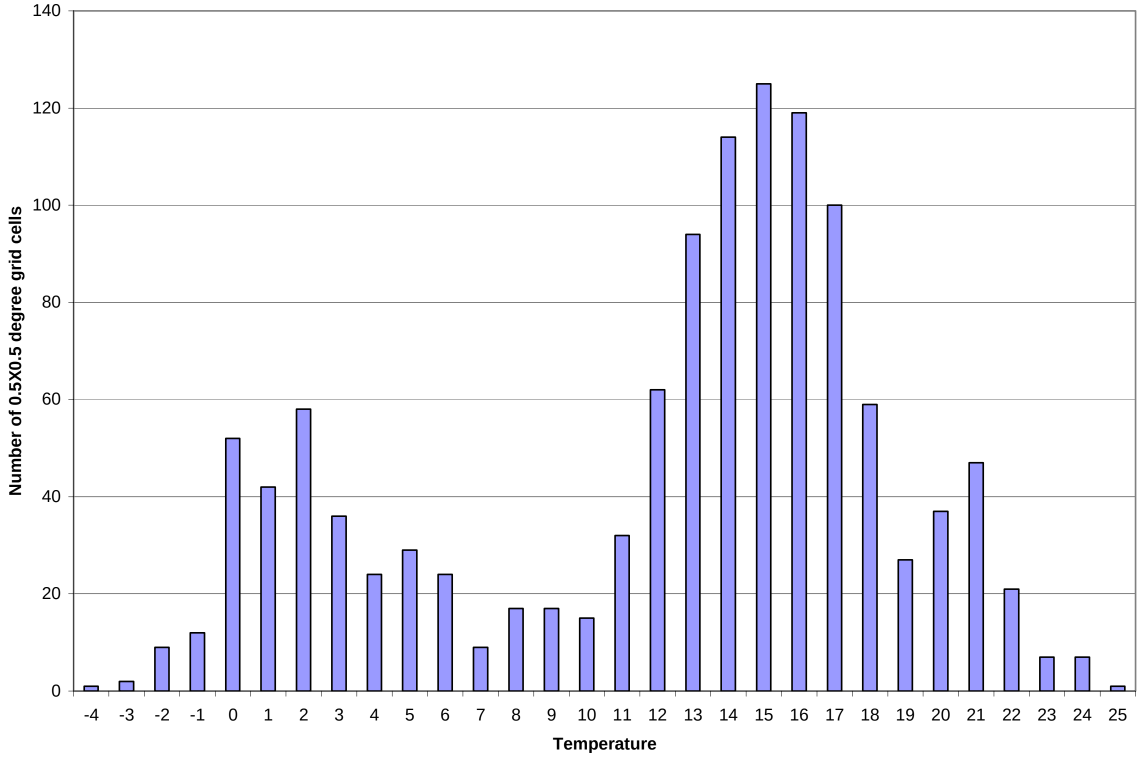

Figure 26. Frequency distribution of mean annual air temperature within the native distribution of black carp as represented in Figure 25.

2. Non-native Distribution in Canada

The black carp has not been captured in the wild in Canada.

3. Potential Distribution in Canada

Based on the mean annual air temperature range in the native range of the black carp (Figures 25-26), its distribution could be widespread in Canada, north to about 60^{o}N (Figure 27). The potential distribution of black carp can be further refined based on the distribution and availability of spawning and feeding habitats. There are many tributaries to the Great Lakes that are at least 50 km long and may be suitable spawning rivers (Figures 7-10). Black carp are molluscivores and are known to prey on *Dreissena* mussels (Nico and Williams 2001). Introduced *Dreissena* mussels are found throughout the Great Lakes (Vanderploeg *et al.* 2002) and would likely be an ideal food source for the black carp, unless encrusted. As black carp are gape limited (gape less than 25 mm; Nico and Williams 2001), it may also feed on small native mussels (i.e. juveniles or small adults) which are also found in the Great Lakes, their tributaries and elsewhere.

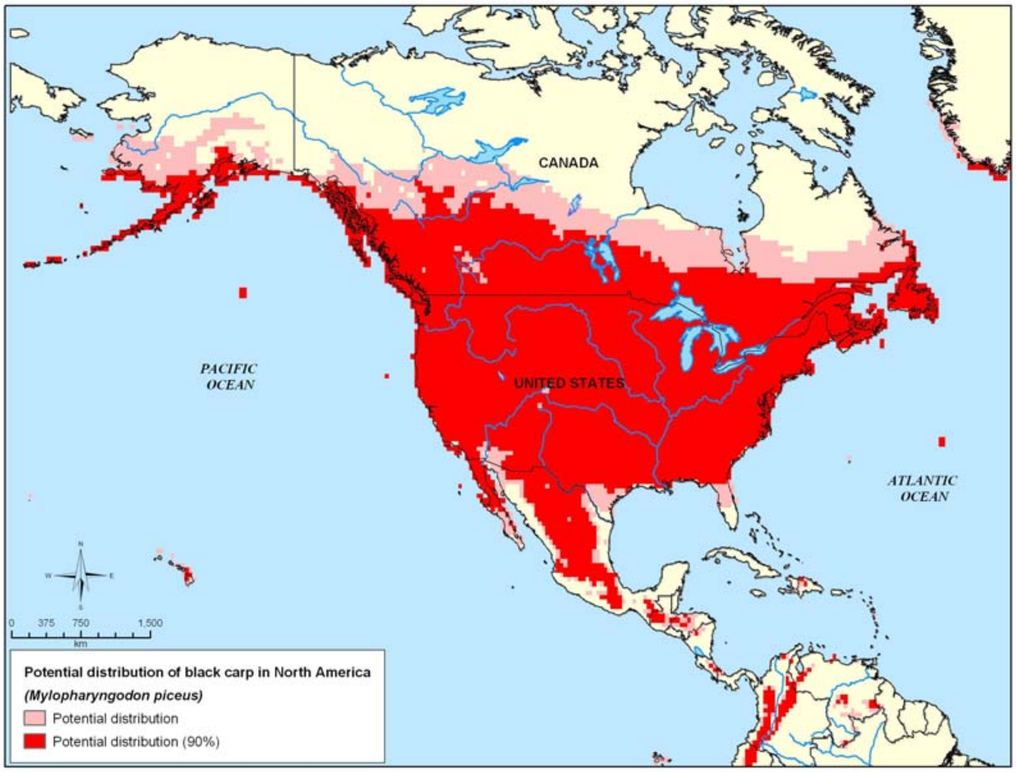

Figure 27. Potential distribution of black carp in North America based on mean annual air temperature range in native distribution. Dark pink represents the lowest 5 %, and highest 5%, of temperatures in Figure 26.

Potential distribution will also depend on the vectors of introduction which may include colonization from the Mississippi River basin, deliberate (e.g. prayer fish, animal rights activism) or accidental (e.g. tanker spill) release related to a potential biological control or live food fish industries, and subsequent dispersal. A quantitative risk assessment of the possible vectors is currently underway by Brian Leung (McGill University) and Nicholas Mandrak (DFO).

4. Black Carp Risk Assessment

Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process – Black Carp

Step 1. Determining the Probability of Establishment

(1) Estimate of probability of the organism successfully colonizing and maintaining a population if introduced. **Survival – High, very certain; Reproduction – High, reasonably certain.**

Vectors of black carp introduction may include natural colonization from the Mississippi River basin where introduced populations are present (Nico and Williams 2001), and deliberate (e.g. prayer fish, animal rights activism) or accidental (e.g. tanker spill) release related to a potential biological control or live food fish industries. The probability of introduction of black carp through these vectors is largely unknown.

Over 3,500 kg of black carp were imported into the GTA by wholesalers in 1996, and only 191 kg in 1997 (Goodchild 1999); however, there is some question regarding the identity and origin of those records as there was no American production of black carp for the live fish food industry in these years (W. Shelton, pers. comm.). Recent import statistics do not list black carp (CFIA, unpubl. data; OMNR, unpubl. data).

If the black carp does successfully colonize Canada, there is a high probability of it maintaining populations based on its thermal requirements (Figure 27). In addition, suitable feeding and spawning habitat (Figures 7-10) exist in the Great Lakes basin. Black carp are also less impeded by gradient than other Asian carp species (H. Jelks, USGS, pers. comm.). Black carp are found lower in the water column compared to the other Asian carps and feed in depths up to 30 m (H. Jelks, pers. comm.). The availability of such habitats is largely unknown outside of the Great Lakes basin; however, the preferred spawning habitat of large, turbid rivers with seasonal flow is present in the Prairie provinces.

(2) If the organism escapes from the area of introduction, estimate the probability of its spreading. **High, reasonably certain.**

If the black carp does successfully colonize the Great Lakes basin, there is a high probability that it could spread throughout the basin based on the presence of natural and man-made connections, and on the widespread distribution of suitable thermal (Figure 27), feeding and spawning habitat (Figures 7-10). The probability of spreading outside of the Great Lakes basin is unknown largely as a result of the unknown availability of suitable habitats elsewhere. However, the combination of presence of available food sources, suitable spawning habitat and long stretches of unimpounded rivers, make it likely that black carp could spread across the Prairies.

(3) Final Rating. **High, reasonably certain.**

Step 2. Determining the Consequences of Establishment of an Aquatic Organism

(1) Ecological impact on native ecosystems both locally and within the drainage basin. **High, reasonably certain.**

The black carp would likely have significant impacts directly on native molluscs (mussels and snails), and indirectly on native molluscivores (e.g. various fish, bird and mammal species), and algal growth currently controlled by snails (Nico and Williams 2001). The black carp could seriously threaten the many species of endangered mussels found in the Great Lakes basin. Currently, almost 50% of the freshwater mussels in the Great Lakes basin are considered at risk (Metcalfe-Smith and Cudmore-Vokey 2004). In Lake Erie, quagga mussels (*Dreissena bugensis*) are very abundant in single layers at depths greater than 15 m (H. MacIssac, University of Windsor, pers. comm.).

(2) Genetic impacts on local self-sustaining stocks or populations. **Low, very certain.**

As the black carp is not closely related to any native cyprinids in Canada, it is highly unlikely to have any genetic impact on the native fauna. However, it may hybridize with other introduced carps (*Carassius auratus*) and common carp (*Cyprinus carpio*)).

(3) Final Rating. **High, reasonably certain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **High, reasonably certain.**

(2) Consequences of establishment estimate. **High, reasonably certain.**

(3) Final Risk Estimate. **High, reasonably certain.**

Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process – Black Carp

Step 1. Determining the Probability of Establishment

(1) Estimate the probability that a pathogen, parasite or fellow traveler may be introduced along with the species proposed for introduction. Note that several pathways may exist through which pathogens or accompanying species can enter fish habitat. Each must be evaluated. **Medium, reasonably certain.**

Many parasites and pathogens, including fish lice and hemorrhagic viruses, have been documented to infect black carp (Nico and Williams 2001). The probability of introducing these disease-causing agents with black carp is unknown, but undoubtedly exists.

(2) Estimate the probability that the pathogen, parasite or fellow traveler will encounter susceptible organisms or suitable habitat. **Medium, reasonably certain.**

It is likely that other pathogens or parasites would likely encounter susceptible organisms.

(3) Final Rating. **Medium, reasonably certain.**

Step 2. Determining the Consequences of Establishment of a Pathogen, Parasite or Fellow Traveler

(1) Ecological impacts on native ecosystems both locally and within the drainage basin including disease outbreak, reduction in reproductive capacity, habitat changes, etc. **Medium, very uncertain.**

(2) Genetic impacts on local self-sustaining stocks or populations (i.e. whether the pathogen, parasite, or fellow traveler affects the genetic characteristics of native stocks or species). **Medium, very uncertain.**

(3) Final Rating. **Medium, very uncertain.**

Step 3. Estimating Aquatic Organism Risk Potential

(1) Probability of establishment estimate. **Medium, reasonably certain.**

(2) Consequences of establishment estimate. **Medium, very uncertain.**

(3) Final Risk Estimate. **Medium, very uncertain.**

Table 5. Summary of risk assessment for black carp in Canada.

Component Rating	Element Rating	Level of Certainty
Part I – Aquatic Organism Ecological and Genetic Risk Assessment Process		
Probability of establishment estimate	High	Reasonably Certain
Consequences of establishment estimate	High	Reasonably Certain
Final Risk Estimate	**High**	**Reasonably Certain**
Part II – Pathogen, Parasite or Fellow Traveler Risk Assessment Process		
Probability of establishment estimate	Medium	Reasonably Certain
Consequences of establishment estimate	Medium	Very Uncertain
Final Risk Estimate	**Medium**	**Very Uncertain**

CONCLUSIONS

- Individual specimens of grass carp and bighead carp have been caught in the wild in Canada. They are likely releases related to the live food fish trade (Ontario) or vegetation control (grass carp; Saskatchewan, Alberta). There are no known established, reproducing populations in Canada.

- Grass, bighead and silver carps are known to be sold in the live food fish market in Canada. Black carp may have been sold in the past, but there is no evidence of recent sales (since 1999).

- The probability of grass, bighead, silver and black carps to survive in Canada is high with high certainty (very certain); to reproduce is high with reasonable certainty (reasonably certain); and, to spread is high with reasonable certainty (reasonably certain). Overall, the probability of establishment is high with reasonable certainty (reasonably certain).

- The consequences of the establishment of grass and silver carps in Canada on the ecology of native ecosystems are high with high certainty (very certain). For bighead and black carps, the rating was high with reasonable certainty (reasonably certain). The consequences of establishment of grass, bighead, silver and black carps on the genetics of native species was rated low with high certainty (very certainty). Overall, the consequences of establishment are high with high certainty (very certain) for grass and silver carps and high with reasonable certainty (reasonably certain) for bighead and black carps.

- The probability that a parasite, pathogen or fellow traveler may be introduced with grass, bighead, silver and black carps and encounter susceptible organisms or suitable habitat is medium with reasonable certainty (reasonably certain). Overall, the probability of establishment is medium with reasonable certainty (reasonably certain).

- The consequences of the establishment of a parasite, pathogen or fellow traveler introduced with grass, bighead, silver and black carps in Canada on the ecology of native ecosystems is medium with reasonable certainty (reasonably certain), and medium with high uncertainty (very uncertain) on the genetics of native species. Overall, the consequences of establishment are medium with high uncertainty (very uncertain).

- The probability of largescale silver carp to survive in Canada is low with reasonable certainty (reasonably certain); to reproduce is low with high certainty (very certain); and, to spread is low with high certainty (very certain). Overall, the probability of establishment is high with reasonable certainty (reasonably certain).

LITERATURE CITED

Bay of Quinte RAP Restoration Council. 2001. The big cleanup. Project Quinte Annual Report 1999-2000. Monitoring Report #11. Bay of Quinte Remedial Action Plan. Kingston, ON.

Chalmers, G.A. 2003. Infectious diseases of silver carp, *Hypophthalmichthys molitrix* (Valenciennes, 1844). Report to the University of Lethbridge, Aquaculture Centre, Lethbridge AB. 37pp.

Cudmore, B. and N.E. Mandrak. 2004. Biological synopsis of grass carp (*Ctenopharyngodon idella*). Can. MS Rpt. Fish. Aquat. Sci. 2705:v+44pp.

Goodchild, C.D. 1989. Status report on the bigmouth buffalo, *Ictiobus syprinellus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. 49pp.

Goodchild, C.D. 1999. Non-indigneous freshwater fish utilized in the live food fish industry in Ontario: a summary of information. Ontario Ministry of Natural Resources. 79pp.

Kolar, C., W.R. Courtenay Jr., D. Chapman, C.M. Housel, J.D. Williams and D.P. Jennings. 2004. Asian carps of the genus *Hypophthalmichthys* (Pisces, Cyprinidae) – a biological synopsis and risk assessment. August 2004 draft. United States Geological Survey.

Metcalfe-Smith, J.L. and B. Cudmore-Vokey. 2004. National general status assessment of freshwater mussels (Unionacea). National Water Research Institute Report No.04-027. Environment Canada.

Nico, L.G., J.D. Williams, J.J. Herod. 2001. Black carp (*Mylopharyngodon piceus*) – a biological synopsis and updated risk assessment. Report to the Risk Assessment and Management Committee of the Aquatic Nuisance Species Task Force. United States Geological Survey, Gainesville, FL.

Rice, J., N.E. Mandrak and B. Cudmore. 2004. Asian carp status report. Can. Sci. Adv. Sec. Status Report. Fisheries and Oceans Canada. 11pp.

Vanderploeg, H.A., T.F. Nalepa, D.J. Jude, E.L. Mills, K.T. Holeck, J.R. Liebig, I.A. Grigorovich and H. Ojaveer. 2002. Dispersal and emerging ecological impacts of Ponto-Caspian species in the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. 59: 1209–1228.

Appendix A.

International Workshop on Risk Assessment for Asian Carps in Canada

Toronto Eaton Centre Marriott Hotel
Toronto, Ontario
October 7-8, 2004

Participant	Affiliation
Janet Beardall	Fisheries and Oceans Canada (DFO)
Beth Brownson	Ontario Ministry of Natural Resources (OMNR)
Duane Chapman	United States Geological Survey (USGS)
Walter Courtenay	USGS
Becky Cudmore	DFO
Pam Fuller	USGS
Bill Ingham	OMNR (Conservation Officer)
Howard L. Jelks	USGS
Brian Leung	McGill University
Francine MacDonald	Ontario Federation of Anglers and Hunters
Hugh MacIsaac	University of Windsor
Bill MacKay	University of Lethbridge, Aquaculture Centre
Jim MacLean	OMNR
Nicholas E. Mandrak	DFO
Phil Moy	University of Wisconsin
S. Jerrine Nichols	USGS
Sylvain Paradis	DFO
Mark Pegg	Illinois Department of Natural Resources
Robert Randall	DFO
Jake Rice	DFO
William L. Shelton	University of Oklahoma
Darlene Smith	DFO
Joseph Tortorelli	DFO
Dennis Wright	DFO
Paul Zajicek	Florida Department of Agriculture and Consumer Services