Species at Risk Act
Management Plan Series

Management Plan for Kiyi, Upper Great Lakes (*Coregonus kiyi kiyi*) in Canada

2016

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the *Species at Risk Act* Management Plan Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is "*to manage species of special concern to prevent them from becoming endangered or threatened*."

What is a species of special concern?

Under SARA, a species of special concern is a wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats. Species of special concern are included in the SARA List of Wildlife Species at Risk.

What is a management plan?

Under SARA, a management plan is an action-oriented planning document that identifies the conservation activities and land use measures needed to ensure, at a minimum, that a species of special concern does not become threatened or endangered. For many species, the ultimate aim of the management plan will be to alleviate human threats and remove the species from the List of Wildlife Species at Risk. The plan sets goals and objectives, identifies threats, and indicates the main areas of activities to be undertaken to address those threats.

Management plan development is mandated under Sections 65–72 of SARA.

A management plan has to be developed within three years after the species is added to the List of Wildlife Species at Risk. Five years is allowed for those species that were initially listed when SARA came into force.

What's next?

Directions set in the management plan will enable jurisdictions, communities, land users, and conservationists to implement conservation activities that will have preventative or restorative benefits. Cost-effective measures to prevent the species from becoming further at risk should not be postponed for lack of full scientific certainty and may, in fact, result in significant cost savings in the future.

The series

This series presents the management plans prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as plans are updated.

To learn more

To learn more about the *Species at Risk Act* and conservation initiatives, please consult the SAR Public Registry.

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Additional copies:

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Preface

The Kiyi is a freshwater fish and is under the responsibility of the federal government. The Minister of Fisheries and Oceans is a "competent minister" for aquatic species under the *Species at Risk Act* (SARA)[1]. The Kiyi (Upper Great Lakes) was listed as a species of Special Concern under SARA in May, 2005. Lake Ontario populations were assessed as Extinct; hence, are not included in this document. SARA (Section 65) requires the competent minister(s) to prepare management plans for species listed as Special Concern. The development of this management plan was led by Fisheries and Oceans Canada, Central and Arctic Region, in cooperation and consultation with many individuals, organizations and government agencies, including the province of Ontario. The plan meets SARA requirements in terms of content (SARA sections 65–67).

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Fisheries and Oceans Canada and Parks Canada Agency or any other party alone. This plan provides advice to jurisdictions and organizations that may be involved or wish to become involved in activities to conserve this species. In the spirit of the Accord for the Protection of Species at Risk, the Ministers of Fisheries and Oceans and of the Minister responsible for Parks Canada Agency invite all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada and Parks Canada Agency in supporting and implementing this plan for the benefit of the Kiyi and Canadian society as a whole. The competent Ministers will report on progress within five years of the posting of the final version of the plan on the Species at Risk Public Registry.

Acknowledgments

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[1] Kiyi (Upper Great Lakes) are also located in the Lake Superior National Marine Conservation Area (LS NMCA), an area administered by the Parks Canada Agency. In 2015, modifications to the *Canada National Marine Conservation Areas Act* ensure that the Lake Superior National Marine Conservation Area will be scheduled in the near future. Once the LS NMCA is scheduled under this Act, the Minister responsible for Parks Canada Agency will become an additional competent minister under SARA within the NMCA. Until such time, the Minister of Fisheries and Oceans remains the competent minister under SARA for this area.

Strategic environmental assessment

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general; however, it is recognized that plans may also inadvertently lead to environmental effects beyond the intended benefits. The planning process is based on national guidelines and directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan will clearly benefit the environment by promoting the conservation of the Kiyi. The potential for the plan to inadvertently lead to adverse effects on other species was considered. The reader should refer to the following sections of the document in particular: Description of the species' habitat and biological needs (Section 1.4.1.), Ecological role (Section 1.4.2.); Limiting factors (Section 1.4.3.); Description of threats (Section 1.5.2.); Management actions (Section 2.3.); and, Effect on other species (Section 2.5.). The SEA concluded that this plan will clearly benefit the environment and will not entail any significant adverse effects.

Executive summary

In 2005, the Kiyi (Upper Great Lakes) was designated a species of Special Concern in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and was listed on Schedule 1 of the *Species at Risk Act* in 2007. The COSEWIC designation was based on the loss of the species from Lake Huron (also lost from Lake Michigan in the U.S.), reducing its range to only Lake Superior. It appears that exploitation and introduced invasive species were the principal culprits for its diminished range, while habitat destruction, eutrophication, and toxic discharges may have also played a role. A separate subspecies, formerly resident in Lake Ontario, was designated Extinct by COSEWIC and will not be considered in this management plan.

The Kiyi is a deepwater cisco from the family Salmonidae. Other deepwater cisco species present in Lake Superior include the Bloater and Shortjaw Cisco, while the Cisco or Lake Herring is a shallow water form. The Kiyi's predominately silver elongate body can reach lengths in excess of 300 mm and weights in excess of 125 g, while typical measurements are 100 to 200 mm and 20 to 40 g. The Kiyi is more abundant in offshore waters and can be encountered at any depth, but is often most abundant at depths of 100 to 200 m during the day and less than 75 m at night. In pursuit of its main prey, *Mysis* spp., and to avoid its foremost predator, the siscowet Lake Trout, Kiyi exhibits a pattern of diurnal vertical migrations, moving upward in the water column during the nighttime, and returning to greater water depths during the daytime. In general, Kiyi biomass has not been well quantified because there has not been a comprehensive targeted survey and cisco species can be difficult to differentiate. Long-term trends in Kiyi abundance are difficult to ascertain, but the species appears to have a wide distribution within Lake Superior.

In Lake Superior, the establishment of invasive species, especially the Sea Lamprey, Rainbow Smelt, and Alewife, has resulted in a fundamentally altered fish community and may pose a threat to the Kiyi in the form of competition and predation. Although knowledge of Kiyi is limited, information on other, better understood, coregonines (e.g., Stockwell et al. 2009 on the Cisco) can be used to complement understanding of Kiyi where life history characteristics are thought to be similar. For example, cross-lake comparisons of other coregonids (Kiyi was not included in the analysis) have shown concordance in the appearance of strong year-classes in lakes Huron, Michigan, and Superior (Gorman and Bunnell 2011), suggesting a commonality in cisco early life history requirements and variation in regional climatic factors, with phenology similarly influencing age-1 recruitment success (Stockwell et al. 2009).

There is a pronounced need to develop an overarching research framework to better understand Kiyi population dynamics and ecology within the context of sustainable management of the species. The long-term goal of this management plan is to ensure the long-term persistence of the Kiyi throughout its current range in Lake Superior. The following short-term management objectives have been identified to assist in meeting this goal over a five-year period:

i. To understand the health and extent of existing populations and to determine population and habitat trends;
ii. To improve knowledge of the species' biology, ecology, and habitat requirements;
iii. To evaluate and mitigate threats to the species and its habitat;
iv. To maintain and expand existing populations, where applicable;

v. To ensure the efficient use of resources in the management of this species; and,
vi. To improve awareness of the Kiyi and engage the public in the conservation of this species.

Approaches to reach the objectives listed above have been organized thematically into the following five categories, each of which is associated with key actions:

Monitoring and assessment

- Develop consistent protocols for surveying and monitoring Kiyi populations.
- Integrate the long-term monitoring requirements of Kiyi with existing fish community survey efforts.
- Monitor the status of *Mysis* populations.
- Monitor the existence and potential arrival of invasive species in Kiyi habitat. Where possible, this should be coordinated with relevant ecosystem-based programs.

Management

- Collaborate through existing networks and relevant groups, initiatives and recovery/management teams (e.g., Ontario Ministry of Natural Resources and Forestry) to coordinate implementation of management actions of benefit to Kiyi.
- Collaborate with U.S. researchers involved in management actions benefiting Lake Superior and those involved in regular surveys capturing Kiyi (e.g., United States Geological Survey).
- Integrate knowledge in a central database, including habitat parameters, to facilitate Kiyi data synthesis and transfer.

Research and protection

- Ensure expansion of general Kiyi knowledge, including biology and ecology, to inform conservation planning efforts, particularly in areas where data gaps exist.
- Determine the quantity and quality of habitat required to ensure long-term conservation of Kiyi and to support the long-term management goal.
- Gather information on population dynamics of Kiyi and the associated fish community, including clarifying the role of Kiyi in the Lake Superior fish community and offshore food web.
- Conduct a threat assessment to evaluate threat factors that may be impacting the Kiyi (e.g., invasive invasive species, eutrophication, disease), and develop mitigation plans to address these factors, updating as new information becomes available.
- Develop and implement a compliance monitoring plan for activities potentially affecting Kiyi (Upper Great Lakes) to improve awareness of Kiyi and engage people in conservation efforts for this species.
- Determine the mechanisms that have led to the loss of Kiyi from lakes Huron, Ontario, and Michigan to inform conservation efforts for remaining Kiyi populations.

Stewardship and restoration

- Coordinate stewardship activities with existing programs and initiatives that promote aquatic invasive species awareness, reporting, and monitoring (e.g., Ontario's Invading Species Awareness Program).
- Promote stewardship initiatives (e.g., federal/provincial funding programs) related to Kiyi conservation, and ensure that information related to funding opportunities for stewardship and restoration actions is available to interested groups.

Outreach and communication

- Include Kiyi in ecosystem-based recovery plans and promote aquatic invasive species awareness, prevention, and control programs through existing and future communication and outreach programs.
- Engage Aboriginal communities to include traditional knowledge into current understanding of Kiyi biology, ecology, and distribution.
- Promote awareness with industry (e.g., shipping, commercial fishers), user groups (e.g., recreational boaters), and landowners to adopt best management practices for land and water activities, to minimize impacts on Kiyi.
- Develop educational materials that provide the key characteristics to distinguish the cisco species and distribute to key groups, stakeholders (e.g., shipping companies, recreational boaters, commercial fishers) that visit or reside within the Lake Superior watershed.

Table of contents

1

1. Species information

1.1. Species assessment information from COSEWIC

Date of assessment: May 2005
Common name (population): Upper Great Lakes Kiyi
Scientific name: *Coregonus kiyi kiyi* Koelz, 1929
COSEWIC status: Special Concern
Reason for designation: Currently found only in Lake Superior, the subspecies has been extirpated from lakes Huron and Michigan, as the result of a complex of factors, which included exploitation and introduced exotic [invasive] species. The extirpation in lakes Huron and Michigan occurred more than three generations in the past. The remaining population in Lake Superior appears to be stable, and supports a small, regulated fishery. Other threats, such as the introduction of exotic species[2], which impacted populations in the lower lakes, do not appear to be important in Lake Superior.
Canadian occurrence: Ontario
COSEWIC status history: Designated Special Concern in April 1988. Split into two subspecies (Upper Great Lakes Kiyi and Lake Ontario Kiyi) in May 2005. The Upper Great Lakes Kiyi was designated Special Concern in May 2005. Last assessment based on an update status report.

1.2. Description

The Kiyi (*Coregonus kiyi* Koelz, 1921) is a member of the subfamily Coregoninae of the family Salmonidae. It is characterized by an elongate, laterally compressed body with a large eye and a terminal mouth with the lower jaw typically projecting beyond the upper (Figure 1). Body colouration is predominately silver, with pink to purple iridescence, darker dorsally (including the dorsal and caudal fins) to white ventrally, including the anal, pelvic, and pectoral fins. Kiyi can be most readily differentiated from other deepwater cisco species, which also include the Bloater (*C. hoyi*) and Shortjaw Cisco (*C. zenithicus*), by the unique combination of large eyes and long paired fins; however, confident species discrimination can be difficult and requires assessment of various morphometric and meristic characteristics (Pratt and Mandrak 2007). Of the three deepwater cisco species, the Kiyi tends to have the deepest distribution, followed by the Shortjaw Cisco, with the Bloater having the shallowest distribution (Gorman and Todd 2005).

Upper Great Lakes Kiyi (Kiyi from this point forward) total length (TL) can reach in excess of 300 mm (Yule et al. 2013). A recent survey covering nine disparate stations in Lake Superior recorded a range of 41 to 254 mm TL for 845 captured Kiyi (Gamble et al. 2011a), while another study found a similar size range and a bimodal length-frequency distribution with modes at 130 mm and 190–210 mm TL (Stockwell et al. 2010a). Body mass is typically in the 10 to 60 g range and can reach in excess of 125 g (calculated from Isaac 2010). Sexual development in Kiyi is rapid, with sexual maturity rarely reached at age two and three, but complete by age five

[2] Exotic species' (more recently termed invasive species') impacts on food webs in the other Great Lakes completely altered the offshore ecosystem. If a similar change was to occur in Lake Superior, Kiyi would likely disappear as well. Consequently, though the threat of invasive species was considered less of a threat at the time of COSEWIC assessment, the potential establishment of invasive mussels and fishes is now considered a serious threat.

(O. Gorman, United States Geological Survey [USGS], pers. comm., 2012). Although the life span of the Kiyi is poorly known, few individuals have been recorded at ages greater than 13 years (O. Gorman, USGS, pers. comm., 2012), while recent surveys in Canadian waters have revealed males up to 16 years of age and females up to 22 years of age (Pratt and Chong 2012). Further preliminary findings from this work, which compared Kiyi to three other cisco species, include findings that Kiyi was the smallest (TL and mass) and shortest lived (up to 22 years old) species, had the most skewed sex ratio (77% female), the highest annual mortality estimate, and the lowest growth coefficient.

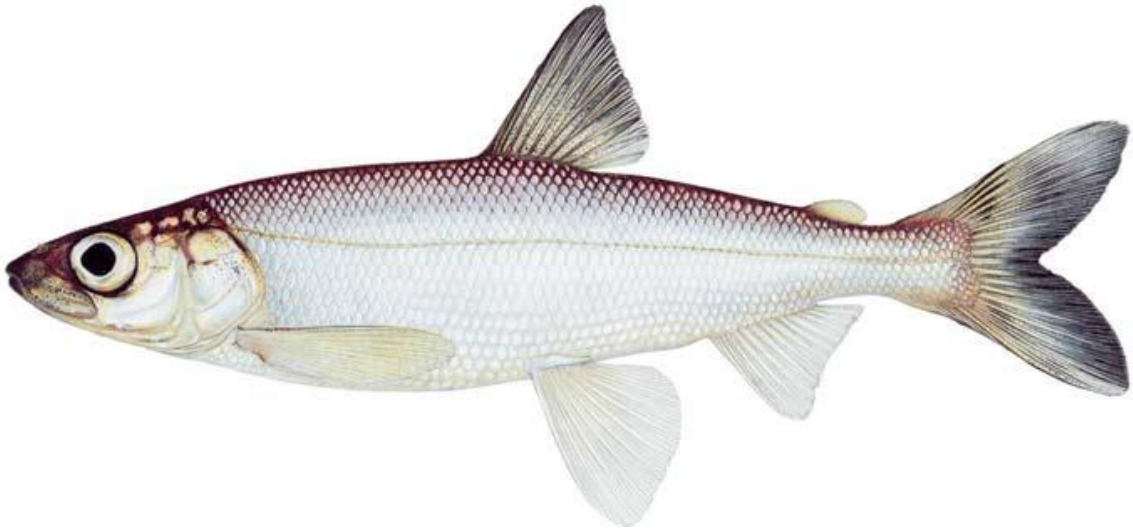

Figure 1. Kiyi (*Coregonus kiyi kiyi*)
(copyright Joseph Tomelleri)

1.3. Populations and distribution

Distribution

Global range: Kiyi is restricted to Lake Superior (Figure 2). In the past, populations were present in lakes Michigan and Huron, while a subspecies (*Coregonus kiyi orientalis*) was resident to Lake Ontario.

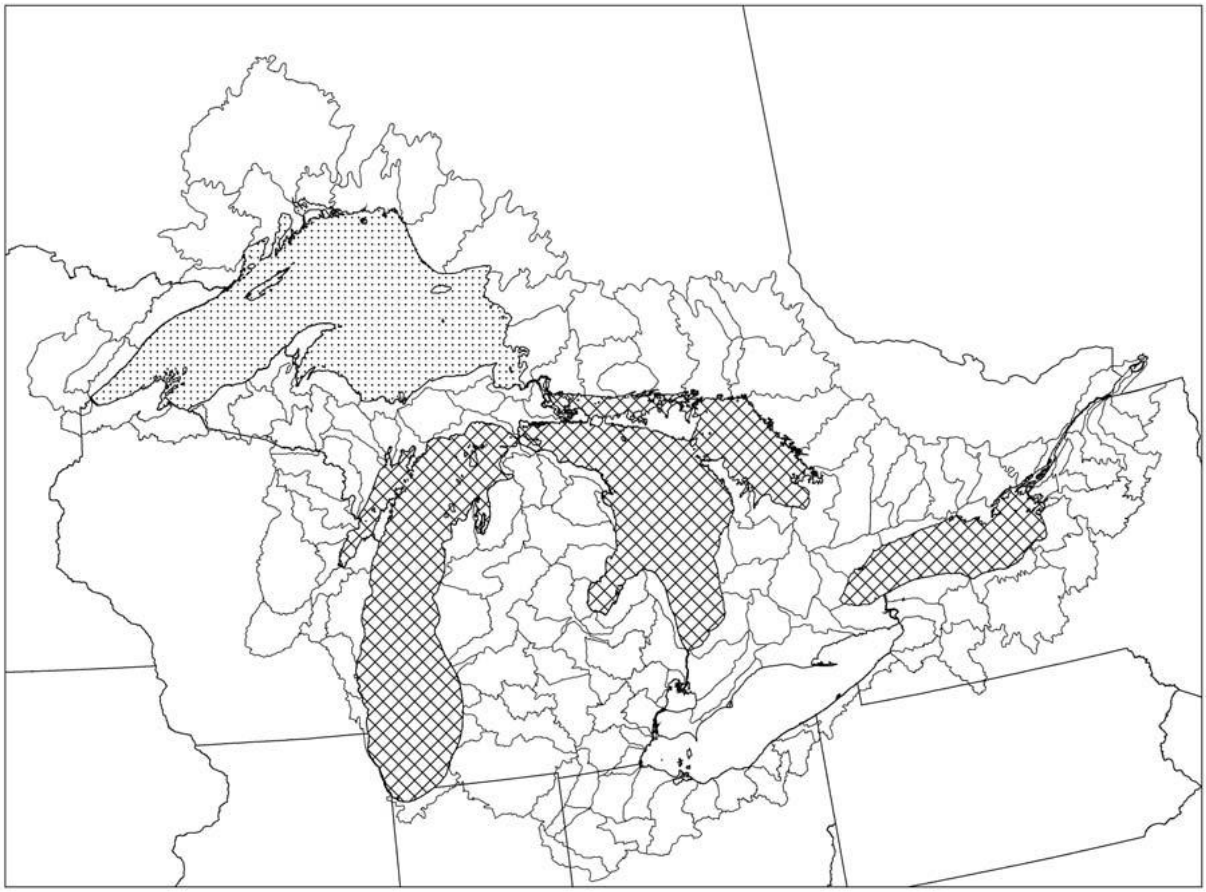

Figure 2. Global distribution of Kiyi
Cross-hatching represents lakes in which it is extirpated, while the fine dots represent its current distribution in Lake Superior (from COSEWIC 2005).

Canadian range: The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) subdivided Kiyi in Canada into two designatable units (DUs), one that encompasses the Upper Great Lakes and one that includes Lake Ontario (COSEWIC 2005). The contents of this management plan are restricted to the Upper Great Lakes DU, which only contains the subspecies *Coregonus kiyi kiyi* found in Lake Superior (Figure 3), as the Lake Huron populations appear to be extirpated. The subspecies *Coregonus kiyi orientalis*, formerly found in Lake Ontario, which composed the Lake Ontario DU, is extinct and will not be dealt with in this management plan.

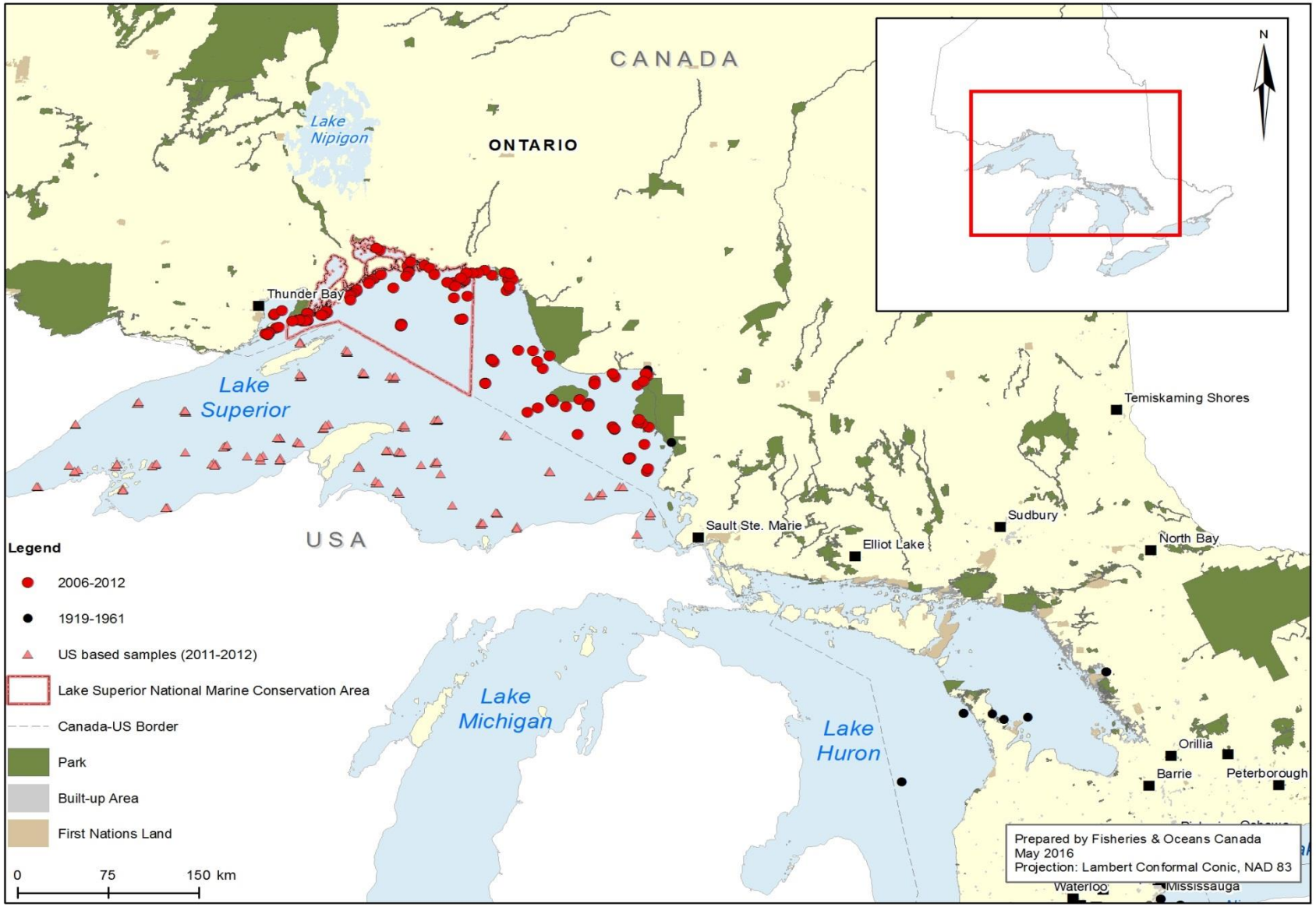

Figure 3. Canadian distribution of Kiyi, Upper Great Lakes (*Coregonus kiyi kiyi)*

Population size, status, and trends

Global population size, status, and trends: Globally, the Kiyi is considered vulnerable with a G3 status[3], while also ranked vulnerable in Ontario (NatureServe 2011) (Table 1).

Table 1. Global, national and sub-national ranks for the Kiyi

Rank	Jurisdiction Rank
Global (G)	**G3** (last reviewed 09 September 1996)
National (N)	
Canada	**N3?**
U.S.	**N3**
Sub-national (S)	
Canada	Ontario (**S3**)
U.S.	Minnesota (**S3**), Michigan (**S3**), Wisconsin (**S3S4**)

Source: NatureServe (2011) (accessed October 3, 2011).

Kiyi appears to be widely distributed within Lake Superior and to be a significant component of the offshore (>80 m) pelagic fish community (Gamble et al. 2011a), while sparse in the nearshore (<80 m) fish community (Gamble et al. 2011b). As Kiyi has not been targeted with extensive or sequential sampling, estimating population sizes and trends is not possible at this time. The use of commercial catch records to construct historical abundance measures has not been successful as, typically, no separation of cisco species was recorded. Gorman and Todd (2005) determined that Bloater and Kiyi have increased in abundance (comparing historical data from the early 1920s and 1950s with surveys they conducted from 2001–2003) at the expense of Shortjaw Cisco in most Lake Superior ecoregions. Bloater was the predominant cisco species at depths of 40 to 160 m, while Kiyi was the principal cisco species at depths greater than 160 m. Deepwater ciscoes were often combined together in historical data and, due to morphological variability within and across populations and species, misidentification may have been common.

Sampling efforts by the USGS (May to October 2001–05) at offshore sites (>80 m) in Canadian and U.S. waters, using day and night bottom trawls, mid-water trawls and acoustics, resulted in Kiyi being captured with greatest abundance from day bottom trawl tows (Stockwell et al. 2006, 2010b). Mean density and biomass estimates were 21.0 ± 5.8 fish/ha and 0.75 ± 0.170 kg/ha for all depths sampled (80–325 m). Kiyi were most abundant from 110–225 m (30.0 ± 8.0 fish/ha and 1.04 ± 0.23 kg/ha), while very few Kiyi were caught in night bottom trawl tows. Mean density of Kiyi in the pelagic zone at night, based on acoustics and mid-water trawl tows, was 126.0 ± 40.8 fish/ha. Related sampling by the USGS in 2005–06 returned a mean density (± standard deviation, SD) from day bottom trawl tows of 76.0 ± 95.2 fish/ha, with almost no Kiyi captured in night bottom trawl tows (Stockwell et al. 2010a). Furthermore, based on acoustic surveying, pelagic density estimates of small prey fishes (presumed to be Kiyi) during the day averaged 13.9 ± 9.8 fish/ha, while the night pelagic density was estimated to be 111.0 ± 77.8

[3] The conservation status of a species or community is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). The numbers have the following meaning: 1 = critically imperilled; 2 = imperilled; 3 = vulnerable to extirpation or extinction; 4 = apparently secure 5 = demonstrably widespread, abundant, and secure. S#S#: Range rank – A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty in the status of a species or community. A S2S3 rank would indicate that there is a roughly equal chance of S2 or S3 and other ranks are much less likely. ? – Denotes inexact numeric rank. Refer to Global Conservation Status Definitions .

fish/ha. Yule et al. (2009) performed mid-water trawls and acoustic surveys in the offshore zone (>80 m) of the western arm of Lake Superior in 2006 and estimated Kiyi densities ranged from 115 to 195 fish/ha, depending on season of sampling. A lakewide survey that combined mid-water trawls with an acoustic survey estimated Kiyi biomass in the order of 2500 tonnes for the open lake (including U.S. and Canadian waters) in both 2003 and 2004 (Ebener et al. 2008). Isaac (2010) estimated Kiyi density (kg/ha ± SE) to be 3.4 ± 0.7 lakewide in 2005 and 4.5 ± 2.2 in western Lake Superior in 2006 at offshore stations (93–312 m), based on night mid-water trawls in tandem with acoustic surveys.

During the summer of 2011, the USGS conducted two lakewide surveys of Lake Superior (D. Yule, USGS, pers. comm., 2011). In early summer, bottom trawl samples were collected at 54 sites around the lake. The sampling design resulted in stratifying the lake into four bathymetric depth zones (0–30 m, 30–100 m, 100–200 m, and >200 m). By using estimates of the area for each zone (0–30 m = 387 736 ha, 30–100 m = 1 647 190 ha, 100–200 m = 3 726 890 ha and >200 m = 2 287 570 ha), a weighted mean average lakewide density of 50 $\pm$ 32 fish/ha was calculated, while the >100 m zone estimate was 64 $\pm$ 40 fish/ha. Furthermore, the length-frequency distribution of Kiyi was bimodal with modes at 135 mm and 205 mm. When they compared their previous Kiyi abundance estimates (Stockwell et al. 2010a,b) to the 2011 survey, the USGS concluded that there has been no appreciable change in Kiyi densities in Lake Superior in recent years. Furthermore, the catch of smaller individuals suggests that the population has had at least one successful recruitment event since 2005. In the latter part of the summer (2011), night acoustic and mid-water trawl samples were collected at the same sites. Kiyi abundance estimates generated from these surveys (lakewide: 47.7 fish/ha; >100m: 62.6 fish/ha) are almost identical to those recorded from the earlier summer surveys (Yule et al. 2013).

Canadian population size, status, and trends: Reliable population estimates for Kiyi in Canadian waters of Lake Superior are unavailable. The Kiyi (Upper Great Lakes) was designated as Special Concern in 2005 by COSEWIC (COSEWIC 2005) and was listed on Schedule 1 of the *Species at Risk Act* (SARA) in 2007. A comprehensive list of sampling effort is catalogued in the COSEWIC report (COSEWIC 2005). At the time the *Endangered Species Act, 2007* was enacted in the province of Ontario on June 30, 2008, the Kiyi, Upper Great Lakes was assessed as a species of Special Concern.

The USGS (Great Lakes Science Center) conducts annual daytime bottom trawl surveys each spring in Lake Superior, including stations in Canadian waters (Gorman et al. 2010a). These trawls only reach the upper portion of the common Kiyi depth range (to 80m). Since the early 20th century, the ability to detect offshore populations of Kiyi , including Canadian populations, has increased (Gorman and Todd 2005). Fisheries and Oceans Canada (DFO) conducted surveys in 2004 and 2006–2008, using gill nets to sample the cisco assemblage in the Canadian waters of Lake Superior (Pratt 2012). Bloater and Cisco were found to be the dominant cisco forms in the Canadian waters of Lake Superior. Kiyi was most abundant in the offshore zone along the north shore (i.e., within the Lake Superior National Marine Conservation Area [NMCA]), while moderate abundances were recorded in western waters. Further gill netting surveys were performed by DFO from 2007 to 2009 for the purpose of increasing life history knowledge of deepwater ciscoes (Pratt and Chong 2012). Kiyi were found to be fairly evenly distributed across the sampling areas. Currently, confident statements on the status of this species in the Canadian portion of Lake Superior are difficult to formulate in the absence of available trend or abundance data.

1.4. Needs of the Kiyi

1.4.1. Habitat and biological needs

Kiyi is typically found in deeper parts of the lake but has been captured in reduced numbers in shallow water (<10 m) (Yule et al. 2006). Gamble et al. (2011a) captured Kiyi at all nine stations sampled, ranging in depth from 85 to 305 m; Kiyi relative abundance was greatest at depths of approximately 150 m. Similarly, Pratt (2012) identified 130-150 m as peak Kiyi abundance and found Kiyi was highly related to increasing depth, but not to the other habitat variables assessed (slope, temperature, or substrate). Depth of greatest abundance is significantly affected by timing of observation as Kiyi undergo diurnal vertical migrations (DVMs) to shallower nighttime depths (typically to depths of less than 50 m) in pursuit of their principal prey, *Mysis* (Hrabik et al. 2006a; Stockwell et al. 2010a; Ahrenstorff et al. 2011). Secondary prey items include chironomids, *Bythotrephes*, calanoid copepods, clams, and *Daphnia* spp. (Gamble et al. 2011a; Isaac et al. 2012). It is interesting to note that during autumn, *Bythotrephes* was a key diet item for Cisco (*Coregonus artedi*), but seemingly not for Kiyi (Gamble et al. 2011a). Spawning habitat is unknown, but is likely to occur in deepwater areas and has been reported between 91 and 168 m depth (Scott and Crossman 1973). Many of the biological needs of Kiyi are poorly understood and will affect the success of rehabilitation efforts.

1.4.2. Ecological role

The Kiyi, which feeds mainly on invertebrates and, in turn, is preyed upon by siscowet Lake Trout (*Salvelinus namaycush*) and Burbot (*Lota lota*), is a major contributor to rerouting energy from organic matter on lake bottom (benthic detritus) to the open water (pelagic) food web component (Stockwell et al. 2010c; Gamble et al. 2011a; Gorman et al. 2012). Only Lake Superior has maintained its full species complement of the coregonine community; this ecologically important and diverse fish assemblage comprises the bulk of the offshore forage fish biomass. Cisco eggs may be an important overwinter energy source to fishes that are found in the deepest part of the lake, such as the Lake Whitefish (*Coregonus clupeaformis*) (Yule et al. 2010), and Kiyi eggs may be expected to serve a similar role. There is also some developing evidence that cisco eggs may be important to nearshore benthivores during early winter months (December-January) (D. Yule, USGS , pers. comm., 2013). Various deepwater ciscoes are being considered for reintroduction into some of their former range (Zimmerman and Krueger 2009), in which case Lake Superior would serve as a source lake for Kiyi.

1.4.3. Limiting factors

Lake Trout, through predation on Kiyi, have the greatest potential to regulate Kiyi numbers in Lake Superior and, as their numbers appear to be on the rise, a general decline in Kiyi numbers may be expected (D. Yule, USGS, pers. comm., 2012). Although factors such as predation may be deemed a threat rather than an intrinsic limiting factor, predation is considered an ecosystem limiting factor, and therefore, is addressed in this section. Though not demonstrated specifically for Kiyi, it appears that juvenile ciscoes require sufficient food and temperatures to achieve adequate growth to survive winter (Edsall and Frank 1997; Pangle et al. 2004). Warm, productive nursery habitats represent a limited resource for juvenile ciscoes in Lake Superior, which is cold and oligotrophic (Bronte et al. 2010). Deepwater ciscoes are thought to experience slow growth and highly variable recruitment success; therefore, they are slow to recover following decline (see Gorman and Todd [2005] for the case of the Shortjaw Cisco). Changes in coregonine abundance have been ascribed largely to recruitment failure (Ray et al. 2007; Gorman 2012); primary factors for the high recruitment variability observed in these species is poorly understood. Kiyi appears to be a specialist feeder that relies predominantly on *Mysis* as a prey item (Gamble et al. 2011a; Isaac et al. 2012). For example, Gamble et al.

(2011a) found ≥96% *Mysis* by mass in the stomachs of Kiyi, regardless of season or depth of capture. Hence, any changes in *Mysis* abundance could have striking consequences to the offshore food web, including Kiyi populations. Additionally, Kiyi may be limited by genetic factors, as introgressive hybridization has also been suggested as a cause for the decline of deepwater ciscoes (Smith 1964).

Recent genetic assessment of deepwater ciscoes (Reid et al. 2012) clearly supports sympatric speciation in ciscoes, meaning that different species or forms evolved independently in each lake. This has the potential to result in a taxonomic re-examination of the deepwater cisco flock across North America, and has implications for previously described species such as Kiyi.

1.5. Threats

1.5.1. Threat classification

Current and anticipated threats to Kiyi are listed in Table 2. Threats were ranked based on their relative impact, spatial extent, and expected severity. The threats have been prioritized starting with the greatest perceived threat to the survival of the species based on the strongest evidence. There may be some variability in the severity and level of concern for some threats for individual populations. Threat assessment, particularly where evidence is limited, is an ongoing process linked to both species assessment and, where applicable, management. The threat classification parameters are defined as follows:

Extent – spatial extent of the threat in the species range/waterbody (widespread/localized);
Occurrence – current status of the threat (e.g., current, imminent, anticipated);
Frequency – frequency with which the threat occurs in the species range/waterbody (seasonal/continuous);
Causal certainty – level of certainty that it is a threat to the species (High – H, Medium – M, Low - L);
Severity – severity of the threat in the species range/waterbody (H/M/L); and,
Overall level of concern – composite level of concern regarding the threat to the species, taking into account the five parameters listed above (H/M/L).

Table 2. Threat classification table for Kiyi

Threat	Extent (widespread/localized)	Occurrence (current, imminent, anticipated)	Frequency (seasonal/continuous)	Causal certainty (high, medium, low)	Severity (high, medium, low)	Overall level of concern (high, medium, low)
Invasive species	Widespread	Current/ Anticipated	Continuous	High	High	High
Water quality						
Contaminant inputs	Widespread	Current	Continuous	Low	Low	Low
Nutrient loading	Widespread	Current	Continuous	Low	Low	Low

Climate change	Widespread	Current/ Anticipated	Continuous	Unknown	Unknown	Low
Disease	Unknown	Anticipated	Continuous	Unknown	Unknown	Low
Fishing pressure	Localized	Anticipated	Seasonal	Low	Unknown	Low

1.5.2. Description of threats

The primary threat affecting Kiyi appears to be invasive species introductions and the attendant complex of ecosystem function and food web alterations. The continued appearance of invasive species plays a fundamental role in the structure and function of Kiyi populations.

Invasive species: Dextrase and Mandrak (2006) suggested that while habitat loss and degradation is the predominant threat affecting aquatic species at risk, invasive species are the second most prevalent threat, affecting 26 of the 41 federally listed species across Canada. Invasive species may affect Kiyi through several different pathways, including direct competition (i.e., for space, habitat and food), predation, and the alteration of food web dynamics. Although Lake Superior may have the fewest invasive species of all the Great Lakes, an accelerated rate of unintentional invasive species introductions to Lake Superior has been noted (Bronte et al. 2003) and the potential for deleterious effects on Kiyi populations is a cause for concern. Given that Lake Superior is the least species rich of the Great Lakes, it may be most vulnerable to ecological damage from invasive species introductions (Bronte et al. 2003), yet the lake's long-term food web structure has appeared to maintain stability (Schmidt et al. 2009) and coregonines appear to be fairly resilient to changes in food web structure (Schmidt et al. 2011). Critical to maintaining this stability is maintenance of Lake Trout stocks as they will likely control any existing invasive species abundances (L. Mohr, Ontario Ministry of Natural Resources and Forestry [MNRF], pers. comm. 2012).

If the predicted climate change-mediated rise in water temperature occurs, Lake Superior may be vulnerable to further intrusions of invasive species. Invasive species such as Sea Lamprey (*Petromyzon marinus*), Rainbow Smelt (*Osmerus mordax*), and Alewife *(Alosa pseudoharengus*) have the potential to negatively influence Kiyi populations in Lake Superior. Sea Lamprey are known to parasitize coregonines (Harvey et al. 2008), and Rainbow Smelt (Myers et al. 2009) and Alewife (O'Gorman and Stewart 1999) are known to feed on coregonid larvae.

Water quality: *Contaminant inputs* - The sources and types of contaminant inputs in Kiyi habitat vary, as do their effects on the survival of the species. With relatively limited industrial development throughout the Lake Superior watershed, atmospheric deposition is the main source of chemical loading, particularly with regard to polychlorinated biphenyls (PCBs), mercury, and toxaphene. Measured fish and water column contaminant levels have declined and are lower than those found in the other Great Lakes, with the exception of toxaphene (Glassmeyer et al. 2000; Bronte et al. 2003; Gorman et al. 2010b). Although the effects of contaminants on Kiyi are unknown, numerous studies have shown that certain chemical compounds (e.g., PCBs, polycyclic aromatic hydrocarbons [PAHs], heavy metals) can have lethal effects, while others can disrupt the endocrine system of exposed organisms, cause deformities, and create problems in reproduction and growth in many fish species (Kidd et al. 2007).

Nutrient loading - Urban development, farming, mining, and logging, resulting in physical alteration of the watershed, may result in elevated sediment and nutrient inputs and the consequent degradation of water quality. Nutrient enrichment of waterways can negatively

influence aquatic health through algal blooms and an associated reduction in dissolved oxygen concentrations. Historically, Lake Superior has been the Great Lake least affected by anthropogenic nutrient loading and, thus, eutrophication (Bronte et al. 2003). Nonetheless, continued vigilance with respect to nutrient loading is necessary with continued development occurring throughout the Lake Superior watershed.

Climate change: While climate change-mediated shifts in the distribution of marine fishes have been observed (Perry et al. 2005), long-term analysis is lacking for freshwater systems. Climate change is expected to have significant effects on the aquatic communities of Lake Superior through several mechanisms, including increases in water and air temperatures, lowering of water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, and shifts in predator-prey dynamics (Lemmen and Warren 2004; Jones et al. 2006). Lake Superior is experiencing warmer summer surface temperatures in relation to declining winter ice cover (1979–2006) (Austin and Colman 2007), but significant changes to the fish community of the lake in relation to climate change have yet to be observed (Bronte et al. 2003). Additionally, warming trends, as a result of climate change, may favour the establishment of potentially harmful invasive species that may currently be limited by cooler water temperatures. Climate change may specifically affect Kiyi through a decrease in thermal habitat volume and by the appearance of new invasive species or an expansion of existing populations of invasive species. For example, Rainbow Smelt (Nyberg et al. 2001) and Alewife (Bronte et al. 1991, 2003), two potential predators of Kiyi larvae, may increase if warming related to climate change occurs.

Disease: The introduction of pathogens can also constitute a threat for Kiyi. For example, viral hemorrhagic septicaemia (VHS), which was detected in the Lake Superior watershed in 2010, is a contagious viral disease that affects a variety of fish species in the Great Lakes basin (Whelan 2009; Bain et al. 2010). First identified in the Great Lakes in 2005 (Canadian Cooperative Wildlife Health Centre 2005), this potentially fatal disease has been linked to mass mortalities in several fish species in the region. The Canadian Food Inspection Agency (CFIA) implemented a biennial plan to monitor the presence of the VHS virus in Canadian wild fish species in 2007 (CFIA 2011). Given the restricted distribution of Kiyi in Canada, mass mortalities associated with this disease could be highly detrimental to the survival of the species.

Fishing pressure: Fish yields are relatively low in Lake Superior due to its low productivity, compared with the other Great Lakes. Historically, Kiyi have been caught in deepwater cisco commercial fishing operations (“chub fishery”) in Lake Superior. A small chub fishery continues to operate in the U.S. waters of Lake Superior (D. Schreiner, Minnesota Department of Natural Resources [MDNR], pers. comm., 2012). Although a quota still exists for this fishery in the Canadian waters of Lake Superior, chubs have not been targeted for the past number of years primarily due to economic factors (K. Cullis, MNRF, pers. comm., 2011). Due to its small size, Kiyi is not likely to be regularly captured in the typical commercial chub gill nets (6.35 to 6.5 centimetre [2 ½ and 2 $^{9}/_{16}$ inch] mesh).

1.6. Actions already completed or underway

Recent surveys: Table 3 summarizes fish surveys conducted by various agencies within areas of known Kiyi occurrence. Recently, DFO has been conducting gill net surveys to sample the cisco assemblage in the Canadian waters of Lake Superior. These efforts have increased available information on the structure of Kiyi populations and improved life history knowledge of deepwater ciscoes.

Table 3. Summary of fish surveys conducted by various agencies within Lake Superior

Survey Description
• USGS conducts annual daytime bottom trawl surveys each spring, which includes stations in Canadian waters (Gorman et al. 2011). Expansion of this annual survey to include deepwater stations has been proposed.
• In the western arm, acoustic and optical plankton counter surveys combined with mid-water and bottom trawls were performed from 2005 to 2008 to study DVM patterns (Ahrenstorff et al. 2011).
• USGS conducted day and night bottom trawls, mid-water trawls and acoustic surveys during 2001 to 2005 to study the offshore fish community (Stockwell et al. 2006, 2010b).
• USGS conducted acoustic, mid-water trawl and bottom trawl sampling in 2005 and 2006 to study DVM behaviour of coregonids (Stockwell et al. 2010a).
• USGS performed mid-water trawls and acoustic surveys in the offshore zone of the western arm of Lake Superior in 2006 (Yule et al. 2009).
• USGS, in cooperation with MNRF, performed deepwater surveys from 2001 to 2004 (Gorman and Todd 2005, 2007). Shortjaw Cisco were targeted but Kiyi were also captured.
• USGS, in cooperation with MNRF, performed acoustic surveys of Ontario nearshore and offshore waters in 2004 (O. Gorman, USGS, pers. comm., 2012).
• USGS, in cooperation with MNRF, performed acoustic surveys and mid-water trawls in Thunder Bay and surrounding areas in the fall of 2007, 2008, and 2009 (Yule et al. 2010). Pre-spawning aggregations of Cisco were targeted in these efforts but Kiyi were also captured.
• USGS conducted lakewide day bottom trawls and night mid-water trawls and acoustic surveys during the summer of 2011.
• A mid-water trawl and acoustic survey was conducted in 2003 and 2004 in the Minnesota waters of Lake Superior (Hrabik et al. 2006b).
• Lakewide surveys that combined mid-water trawls with an acoustic survey were conducted in 2003 and 2004 (Ebener et al. 2008).
• Lakewide surveys that combined night bottom and mid-water trawls were conducted in 2005 and 2006, focusing on the importance of *Mysis* to the fish community (Isaac et al. 2012).
• DFO conducted gill net surveys in 2004 and 2006–2008 in the Canadian waters of the lake, targeting ciscoes (Pratt and Mandrak 2007; T.C. Pratt, 2012).
• DFO conducted gill net surveys in 2007–2009 in the Canadian waters of the lake, targeting deepwater ciscoes. (T.C. Pratt, 2012).
• MNRF Upper Great Lakes Management Unit conducted multi-mesh gill net surveys at all depths in Canadian waters of Lake Superior from 2009 to 2012 (E. Berglund, MNRF, pers. comm., 2012).

Outreach and education: There are additional efforts underway to create awareness and monitor the increasing threat posed by invading species.

The Lake Superior Aquatic Invasive Species Complete Prevention plan is a binational initiative intended to prevent new aquatic invasive species (AIS) from becoming established in the Lake Superior ecosystem. It also provides key recommended actions to be taken by both the U.S. and Canada and has a list of AIS vectors and pathways addressed by the plan. The Lake Superior Lakewide Management Plan (LaMP) is a binational action plan for cooperatively restoring and protecting the ecosystem of Lake Superior. The Lake Superior LaMP is coordinated by a committee with membership from both Canada and the U.S., including Environment Canada and other federal, provincial, and state governments, and First Nations/tribal organizations. The Lake Superior Binational Program includes the LaMP and the Zero Discharge Demonstration Program that addresses chemical pollution in the Lake Superior

basin (Lake Superior Lakewide Management Plan - Annual Report 2012, accessed March 2013). The application of standard best management practices to mitigate potential impacts from projects on fishes, fish habitat and water quality continue to be encouraged to reduce the impacts across the landscape.

Since 1992, Ontario's Invading Species Awareness Program, a partnership between the Ontario Federation of Anglers and Hunters and the MNRF, has generated awareness and educational outreach information about invading species. This information helps educate the public about the threat posed by aquatic invasive species in our natural ecosystems and encourages participation to monitor and track the spread of new aquatic and terrestrial invaders within the province (Invading Species, accessed November 2012).

1.7. Knowledge gaps

Information gaps in understanding life history attributes, ecology, recruitment dynamics, mortality, and stock structure remain as obstacles to formulating management actions. More effort needs to be dedicated to elucidating the factors that resulted in the extirpation of Kiyi from lakes Huron, Michigan, and Ontario. In Lake Superior, constructing a sketch of the spatial distribution and abundances of Kiyi will be an important starting point to developing detailed action planning. Once there is a better understanding of the distribution and biology of Kiyi, additional information will be needed on threats to the survival of the species.

2. Management

The following management goals and objectives, and the actions required to achieve them, were developed from the COSEWIC assessment and status report on the Kiyi (COSEWIC 2005), and recent Kiyi survey and research efforts.

2.1. Goal

The long-term goal of this management plan is to ensure the long-term persistence of Kiyi throughout its current range in Lake Superior. Management should be directed toward gaining a greater understanding of its life history and the causes of its range contraction, and addressing the threat of invasive species to Kiyi populations. More quantifiable objectives relating to individual populations will be developed once the necessary sampling and analysis have been completed.

2.2. Objectives

The following short-term objectives to be considered over the next 5–10 years have been identified to assist with meeting the long-term goal:

i. To understand the health and extent of existing populations and to determine population and habitat trends;
ii. To improve knowledge of the species' biology, ecology, and habitat requirements;
iii. To evaluate and mitigate threats to the species and its habitat;
iv. To maintain and expand existing populations, where applicable,;

v. To ensure the efficient use of resources in the management of this species; and,
vi. To improve awareness of the Kiyi and engage the public in the conservation of this species.

2.3. Actions

The identified strategies within each category are required to promote the protection, maintenance, and improvement in Kiyi populations and habitat. Many of these actions can and should be performed in conjunction with other recovery and management teams dealing with individual species and ecosystem-based approaches. Ensuring that Kiyi are considered, where feasible, in surveys, outreach and educational efforts targeted at species at risk will result in more efficient and cost-effective conservation efforts.

Management priorities for Kiyi have been assigned five key categories as follows:

1. Monitoring and assessment
2. Management
3. Research and protection
4. Stewardship and restoration
5. Outreach and communication

2.3.1. Monitoring and assessment

While management actions are being developed and implemented, a monitoring program should be initiated to better understand the biology, population trends, and threats to Kiyi populations. This program should periodically be reassessed to ensure that new technologies and best scientific information are incorporated. Surveys targeting Kiyi should include the use of standardized sampling techniques. Gorman and Todd (2005) found that 1.5-inch mesh (i.e., 3.8 cm) was the most efficient mesh size for catching Kiyi. Survey design must account for spawning behaviour and diurnal migrations. For example, in 2006, Yule et al. (2009) performed trawls in three time periods (July/August, October, and November) and found a considerable reduction in Kiyi abundance during the November trawls, likely related to pre-spawning behaviour. Additionally, diurnal movements have been repeatedly demonstrated for Kiyi as they move to shallower water during the night (Yule et al. 2007), a behaviour that varies across seasons but is consistent spatially (Stockwell et al. 2010a). Acoustic surveys combined with trawling (Hrabik et al. 2006a; Yule et al. 2007) show promise in providing an index of abundance for estimating Lake Superior pelagic fishes, including Kiyi. Standard operating procedures for fisheries acoustic surveys in the Great Lakes have been developed (Parker-Stetter et al. 2009). Survey data will be added to existing distribution data and will establish baseline information upon which further management initiatives can be developed. A standardized index population and habitat monitoring program should be coordinated with existing monitoring programs where possible. A long-term monitoring program will enable assessments of changes/trends in range, population distribution and abundance, key demographic characters, and changes/trends in habitat parameters (i.e., temperature, dissolved oxygen, and nutrient levels). Additionally, as *Mysis* are such a key component of the Kiyi diet, *Mysis* surveys would be of great potential value in understanding Kiyi population dynamics.

Actions:

1. Develop consistent protocols for surveying and monitoring Kiyi populations.
2. Integrate the long-term monitoring requirements of Kiyi with existing fish community survey efforts.
3. Monitor the status of *Mysis* populations.
4. Monitor the existence and potential arrival of invasive species in Kiyi habitat. Where possible, this should be coordinated with relevant ecosystem-based programs.

2.3.2. Management

Management efforts targeting Kiyi should be coordinated with existing relevant management and recovery teams to facilitate resource and knowledge sharing, and to avoid duplication of effort and potential conflicts. Management efforts benefiting Kiyi should be included in integrated management plans where possible (e.g., Lake Superior LaMP).

As Kiyi is present in a waterbody shared by Canada and the U.S., conservation efforts underway in the U.S. may directly affect the health of populations assessed in Canada. Continued coordination with U.S. officials on survey efforts and watershed protection is imperative. Given that long-term monitoring of prey fish populations (including Kiyi) in Lake Superior has been the domain of the USGS, coordination with U.S.-based partners will be important in obtaining accurate estimates of Kiyi population dynamics.

Actions:

1. Collaborate through existing networks and relevant groups (e.g. the Great Lakes Fishery Commission - Lake Superior Technical Committee), initiatives and recovery/management teams (e.g., MNRF) to coordinate implementation of management actions of benefit to Kiyi.
2. Collaborate with U.S. researchers involved in management actions benefiting Lake Superior and those involved in regular surveys capturing Kiyi (e.g., USGS).
3. Integrate knowledge in a central database, including habitat parameters, to facilitate Kiyi data synthesis and transfer.

2.3.3. Research and protection

Current knowledge regarding general biology and threats facing the species is limited. Protection of existing populations and their habitat is the principal foundation of this management plan. To enact viable and targeted protection measures, the development of a comprehensive threat assessment to quantify the impacts of possible threats will be required. It is important to ensure that threats are differentiated by geographic area, where necessary.

Actions:

1. Ensure expansion of general Kiyi knowledge, including biology and ecology, to inform conservation planning efforts, particularly in areas where data gaps exist.
2. Determine the quantity and quality of habitat required to ensure long-term conservation of Kiyi and to support the long-term management goal.
3. Gather information on population dynamics of Kiyi and the associated fish community, including clarifying the role of Kiyi in the Lake Superior fish community and offshore food web.

4. Conduct a threat assessment to evaluate threat factors that may be impacting Kiyi (e.g., invasive species, eutrophication, disease) and develop mitigation plans to address these factors, updating as new information becomes available.
5. Develop and implement a compliance monitoring plan for activities potentially affecting Kiyi to improve awareness of Kiyi and engage people in conservation efforts for this species.
6. Determine the mechanisms that have led to the loss of Kiyi from lakes Huron, Michigan, and Ontario to inform conservation efforts for remaining Kiyi populations.

2.3.4. Stewardship and restoration

Active promotion of stewardship activities will raise community support and awareness of conservation issues regarding Kiyi and increase awareness of opportunities to improve aquatic habitats and reduce the key threat to this species, preventing the introduction of any new invasive species, and controlling the impact from existing invasive species

Actions:

1. Coordinate stewardship activities with existing programs and initiatives that promote aquatic invasive species awareness, reporting, and monitoring (e.g. Ontario's Invading Species Awareness Program).
2. Promote stewardship initiatives (e.g., federal/provincial funding programs) related to Kiyi conservation, and ensure that information related to funding opportunities for stewardship and restoration actions is available to interested groups.

2.3.5. Outreach and communication

Despite its listing under SARA, Kiyi is not widely known, and communication and education materials relating to Kiyi are limited. Therefore, it is crucial to engage the cooperation of all appropriate landholders in nutrient and invasive species control efforts and raise awareness regarding Kiyi. Kiyi should be included in existing communication and outreach programs for both ecosystem-based recovery as well as Endangered and Threatened aquatic species recovery to ensure the efficient use of resources, and to instil awareness of the importance of protecting freshwater fishes and ensuring the health of freshwater ecosystems.

Actions:

1. Include Kiyi in ecosystem-based recovery plans and promote aquatic invasive species awareness, prevention, and control programs through existing and future communication and outreach efforts.
2. Engage Aboriginal communities to include traditional knowledge to current understanding of Kiyi biology, ecology, and distribution.
3. Promote awareness with industry (e.g., shipping, commercial fishers) user groups (recreational boaters), and landowners to adopt best management practices for land and water activities that will help reduce impacts on Kiyi..
4. Develop educational materials that provide the key characteristics to distinguish the cisco species and distribute to key groups, stakeholders (e.g., shipping companies, recreational boaters, commercial fishers) that visit or reside within the Lake Superior watershed.

2.4. Other potentially applicable federal and provincial fish and fish habitat management legislation

Canada

In addition to SARA, there are other Federal statutes and related regulations that may have direct or indirect application to the management of Kiyi and its habitat within Canadian waters. These include, but may not be limited to, the following:

- *Fisheries Act,* administered by Fisheries and Oceans Canada and Environment Canada
- *Navigation Protection Act*, administered by Transport Canada
- *Canadian Environmental Assessment Act*, 2012 (CEAA 2012), administered by the Canadian Environmental Assessment Agency. In Canada, SARA and CEAA 2012 directly and indirectly address Kiyi management. Section 79 of SARA states that environmental assessments must identify the effects of a project on all species listed at risk in the area. When the CEAA 2012 applies and a species at risk has been identified as a valued ecosystem component within the scope of the review pursuant to that Act, the environmental assessment will take into account any change that might be caused to aquatic species as defined in s.2(1) of SARA. Furthermore, under s.79 of SARA, during an environmental assessment of a project under CEAA 2012, the competent minister must be notified if the project will affect a listed wildlife species.
- *Canada National Marine Conservation Areas Act (CNMCAA)*, administered by Parks Canada Agency. The Lake Superior NMCA will be subject to the *Canada National Marine Conservation Areas Act*. According to the CNMCAA, marine conservation areas shall be managed and used in a sustainable manner that meets the needs of present and future generations without compromising the structure and function of the ecosystems, including the submerged lands and water column, with which they are associated.

Ontario

In Ontario, several provincial statutes and related regulations may have a direct or indirect application to the management of the Kiyi and its habitat within the province of Ontario. These include, but may not be limited to, the following:

- *Endangered Species Act 2007, Fish and Wildlife Conservation Act, Lakes and Rivers Improvement Act, Public Lands Act, Aggregate Resources Act, Crown Forest Sustainability Act*, administered by the MNRF. Furthermore, subsection 3(5) of the *Planning Act* requires that decisions taken by various bodies "be consistent with" provincial policy statement issued under subsection 3(1) of that Act. Paragraph 2.1.7. of the Provincial Policy Statement, 2014*,* issued under subsection.3(1) of the *Planning Act* prohibits development and site alteration in "habitat of endangered species and threatened species except in accordance with provincial and federal requirements". This will indirectly benefit species of Special Concern that co-habit with Endangered or Threatened species. The Provincial Policy Statement, 2014 paragraph 2.1.6 also prohibits development and site alteration in fish habitat and on adjacent lands to certain natural heritage features (paragraph 2.1.8) except in accordance with provincial and federal requirements, which provides some protection to Kiyi habitat. The terms "development", "site alteration" and "natural heritage features and areas" have a precise definition in the Policy Statement.

- *Environmental Assessment Act*, *Environmental Protection Act,* and the *Water Resources Act,* administered by the Ontario Ministry of the Environment and Climate Change.

United States Great Lakes waters

The direct and indirect effects of federal and state laws within Great Lakes waters and bordering states in the U.S. (e.g., Minnesota, Wisconsin) may influence overall conservation efforts for Kiyi within Canadian waters.

2.5. Effect on other species

The proposed management actions are expected to have a net positive effect on other native species with overlapping distribution (e.g., Shortjaw Cisco, Deepwater Sculpin [*Myoxocephalus thompsonii*]). While there is potential for conflicts with other species at risk (both aquatic and semi-aquatic) during implementation of some management actions, this possibility will be minimized through strong coordination among the various groups, institutions, and government agencies that may be working on species at risk research, stewardship, and outreach activities within the range of Kiyi.

3. Proposed implementation schedule

DFO encourages other agencies and organizations to participate in the conservation of Kiyi through the implementation of this management plan. Table 4 summarizes those actions that are recommended to support the management goals and objectives. The activities implemented by DFO will be subject to the availability of funding and other required resources. Where appropriate, partnerships with specific organizations and sectors will provide the necessary expertise and capacity to carry out the listed action. However, this implementation schedule is intended to be advice to other agencies, and carrying out these actions will be subject to each agency's priorities and budgetary constraints. (Note that the list of participating agencies is not meant to be an exhaustive list.) The implementation of this plan will be assessed within five years after this plan has been included in the public registry (SARA s.72) with the intent to revisit it at similar intervals until objectives have been achieved.

Table 4. Implementation schedule

Action	Objectives	Priority	Threats addressed†	Participating agencies††	Approximate timeframe†††
2.3.1. Monitoring and assessment					
1. Protocol development	v	Necessary	All	DFO, MNRF	2015–2020
2. Long-term monitoring	i	Necessary	All	DFO, MNRF, PCA	2015–2020
3. Monitor *Mysis* populations	ii, iv	Beneficial	All	DFO, MNRF, PCA, AI, USGS	2015–2020
4. Invasive species monitoring	iii	Beneficial	s	DFO, MNRF, PCA	2015-2020
2.3.2. Management					
1. Collaborate	v	Necessary	All	DFO, MNRF, PCA, USGS	2016-2021
2. Coordinate management actions	v	Beneficial	All	DFO, MNRF	2016-2021
3. Data management	i	Beneficial	All	DFO, MNRF, USGS	2016-2021
2.3.3. Research and protection					
1. Species biology	ii	Necessary	All	DFO, MNRF, AI, USGS	2015-2020
2. Habitat quantity and quality	i	Necessary	All	DFO, MNRF, AI, USGS	2015-2020
3. Population dynamics	i	Necessary	All	DFO, MNRF, AI, USGS	2015-2020
4. Threat evaluation	iii	Necessary	All	DFO, MNRF, AI	2015-2020
5. Compliance monitoring	iii, v	Beneficial	All	DFO, PCA, EC, TC, MNRF, MOECC	2015-2020
6. Mechanisms of decline	i, ii, vi ,	Beneficial	All	DFO, MNRF, AI, USGS	2015-2020
2.3.4. Stewardship and restoration					
1. Coordinate stewardship activities	v, vi	Beneficial	All	DFO, MNRF	2015-2020
2. Promote stewardship	iv, vi	Beneficial	All	DFO, MNRF	2015-2020
2.3.5. Outreach and communication					
1. Existing/future communication and outreach programs	vi	Necessary	All	DFO, MNRF	2015-2020
2 Engage Aboriginal communities	vi	Beneficial	All	DFO, MNRF	2015-2020
3. Promote awareness and best management practices	iii	Beneficial	All	DFO, MNRF, PCA	2015-2020
4. Develop educational materials for cisco species	vi	Beneficial	All	DFO, MNRF	2015-2020

† See Section 1.5.2 Description of threats

†† See Section 7 for Acronyms; Actions will be conducted in partnership with other Lake Superior agencies where possible.
††† Timeframes are subject to change in response to demands for resources.

4. Associated plans

There are a number of species at risk with ranges overlapping those of Kiyi (e.g., Shortjaw Cisco, Deepwater Sculpin) that have single- or multi-species recovery strategies/management plans in development or completed. Recovery initiatives within these strategies/plans may also provide some benefit for Kiyi. Additionally, there are also numerous watershed-based management plans and initiatives that could benefit Kiyi, including Great Lakes Lakewide Management Plans, Fish and Fish Habitat Management Plans, Source Water Protection Planning, and fish-community objectives as laid out by the Great Lakes Fishery Commission.

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7. Acronyms

AI	Academic Institutions
CFIA	Canadian Food Inspection Agency
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DU	Designatable Unit
DVM	Diel/Diurnal Vertical Migration
EC	Environment Canada
ESA 2007	*Endangered Species Act* 2007
MNRF	Ontario Ministry of Natural Resources and Forestry
MOECC	Ontario Ministry of the Environment and Climate Change
MDNR	Minnesota Department of Natural Resources
PCA	Parks Canada Agency
USGS	United States Geological Survey
SARA	*Species at Risk Act*
SEA	Strategic Environmental Assessment
TC	Transport Canada
TL	Total Length
VHS	Viral Hemorrhagic Septicemia